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FROM THE DESK OF **EXECUTIVE EDITOR...**



Dear Readers,

The qualitative and timely publication of Vol. IV / Issue I (Jan-Jun 2014) of our esteemed International Journal of Engineering, Sciences and Management (ISSN: 2231-3273) has brought great joy and happiness to the entire fraternity of the journal and honorable members of the Editorial and Advisory Board. The board members rich experience and varied expertize is providing immense succour in propelling the journal to attain an envious position in areas of research and development and accentuate its visibility. The distinctive feature is indexing of the journal by Jour Informatics, Index Copernicus and DOAJ and by others namely J-Stage, Pro-Quest, Google Scholar etc is under progress. It is a matter of great pride and honor that the journal has been viewed by researchers from fifty one countries across the globe. The aim of journal which is to percolate knowledge in various research fields with erudition and hence elevate high end research is being pursued vigorously by providing an ecosystem for research and development.

Large number of research papers were received from all over the globe for publication and we thank each one of the authors personally for soliciting the journal. We also extend our heartfelt thanks to the reviewers and members of the editorial board who so carefully perused the papers and carried out justified evaluation. Based on their evaluation, we could accept fifteen research papers for this issue across the disciplines. We are certain that these papers will provide qualitative information and thoughtful ideas to our accomplished readers. We thank all the readers profusely who conveyed their appreciation on the quality and content of the journal and expressed their best wishes for future issues. We convey our deep gratitude to the Editorial Board, Advisory Board and all office bearers who have made possible the publication of this journal in the planned time frame.

We humbly invite all the authors and their professional colleagues to submit their research papers for consideration for publication in our forthcoming issue i.e. Vol. IV / Issue II / Jul-Dec 2014 as per the "Scope and Guidelines to Authors" given at the end of this issue. Any comments and observations for the improvement of the journal are most welcome.

We wish all readers meaningful and quality time while going through the journal.

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Jan 2014



10 SCOPE AND GUIDELINES FOR AUTHORS

COMPRESSIVE STRENGTH AND SURFACE ELECTRICAL RESISTIVITY OF HPC MIXTURES

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Durability investigation of concrete structures attracted significant attention in recent years to reduce the life cycle cost and increase the service life of new concrete structures. One of the possible solutions is to implement high-performance concrete (HPC) mixtures by blending different types of slags, fly ashes, silica fume and other natural pozzolans as supplementary cementitious materials (SCMs) with ordinary portland cement (OPC) in bridge decks and other highway structures. This research examined 28 different binary and ternary based cementitious mixtures containing different SCMs including the control mixture of 100 % OPC and evaluates some of their fresh properties namely slump, air content and temperature of concrete. The research investigated compressive strength and surface electrical resistivity of hardened concrete using Wenner Probe device. Compressive strength and electrical resistivity were measured for several days to determine their variation and periodic gain over time for different HPC mixtures. Results show that compressive strength of all mixtures with high SCM replacements meet most DOT's specification of 28 MPa (4000 psi) at 28 days except one mixture. Results also depicted that HPC mixtures have produced higher range of electrical resistivity at later ages and this component has a major role in the propagation stage of chloride induced corrosion process. Using different durability enhanced HPC mixtures with up to 45 to 50% ordinary cement replacements, the electrical resistivity data provides multiple options for long lasting bridge decks against chloride induced corrosion with less effort and expense.

Keywords: Durability, HPC, SCM, surface resistivity, compressive strength

1. INTRODUCTION

In last few decades durability is one of the major concerns in reinforced concrete construction practice. Several efforts have been undertaken to use cost effective materials to reduce life cycle cost. One of the possible solutions is to implement SCMs and investigate its compressive strength and other durability parameters in different binary and ternary blends of concrete mixtures. Shah et al. studied compressive strength, permeability and shrinkage cracking characteristics of high-performance concrete (HPC) and findings indicated that admixtures may improve durability without necessarily increasing strength, therefore specifications must be developed based on the desired specific performance characteristic¹. Recently, Kadri et al. has performed research on compressive strength for silica fume concrete and found that partial cement replacement up to 20% produce, higher compressive strengths than control concretes, nevertheless the strength gain is less than 15%. They also proposed a model to evaluate the compressive strength of silica fume concrete at any time².

HPC cannot be only assessed by its compressive strength but also by other durability parameters. As chloride induced corrosion is one of the major problem in concrete bridge decks and other marine structures, electrical resistance against corrosion protection needs to be evaluated for repair and retrofit of concrete structures. One of the existing methods of determination of concrete resistance to the chloride ion penetration is the electrical resistivity by Wenner Probe device. Measurement of concrete resistivity is a non-destructive test which enables fast and convenient in-place evaluation of concrete quality in the field. It was originally designed to determine soil resistivity in soil strata, but has been adapted for concrete³. Previous research suggested that SCMs can be used as a partial cement replacement to increase the electrical resistivity of mortar and concrete⁴. The Florida Department of Transportation has developed a method to standardize procedures for collection of resistivity readings⁵. Experimentation using the Wenner device on 529 sample sets was conducted by Kessler et al. at the Florida Department of Transportation to investigate whether resistivity can be used as a quality control measure in place of the RCPT⁶. Tikalsky et al. completed a recent study on different binary and ternary based HPC mixtures electrical resistivity testing and found that resistivity data is well correlated with RCPT data for different binary and ternary based HPC mixtures⁷. Marriaga et al. studied the reliability of the RCPT and resistivity test on the basis of chloride resistance of Ground Granulated Blast Furnace Slag (GGBFS) mixtures with different levels of cement replacements. They established that the electrical resistivity and the total charge passed is an indirect measure of the chloride penetration suitable for both OPC and GGBS mixtures⁸. Rupnow et al. recently showed that the better precision of Wenner Probe resistivity meter from their experimental investigation of single laboratory and multi laboratory measurements and surface resistivity test shows lower variability than rapid chloride permeability test with different HPC mixtures⁹. Darren et al. established effectiveness of electrical resistivity technique for HPC to obtain a relationship with chloride diffusivity in order to evaluate the quality of the concrete. Their findings showed a high correlation coefficient in the range between 0.94-0.99, representing the suitability of using electrical resistivity technique to evaluate the quality control of high performance concrete and prediction of corrosion rate¹⁰. Bagheri et al. conducted research on durability of binary and ternary blends based on combination of pumice and silica fume concrete and concluded that at later ages durability of ternary blends HPC mixtures was better than the binary mixtures containing pumice and control mixture with respect to electrical resistivity data and also had somewhat better durability performance than binary mixtures containing equal amounts of silica fume¹

The research presented here focused on evaluation of compressive strength and electrical resistivity of 28 different binary and ternary based cementitious mixtures on different time periods from 7 to 91 days. This study will enable researchers and different highway agencies to use electrical resistivity as a potential quality control tool in field to evaluate HPC and predict the corrosion rate. The other purpose of this study is to identify multiple design solutions in terms of strength and durability that result in the long-life bridge decks throughout the nation.



Different types of ternary, binary cementitious mixtures including the control mixture of 100% portland cement with a water/cementitious materials ratio of 0.44 were designed to give a wide range of values for this experimental program. This water/cementitious materials ratio is typical of exposed bridge deck and substructure concrete. All mixtures contained 256 kg of cementitious material with a Coarse Aggregate Factor (CAF) of 0.67. Limestone coarse aggregate of size 19 mm meeting ASTM C33 No.67 gradation and ASTM C33 silica sand were used. Tests were performed on mixtures using:

- Type II-V cement (TII-V)
- Ground granulated blast furnace slag of grade 120 (G120)
- Ground granulated blast furnace slag of grade 100 (G100)
- Class C fly Ash (C)
- Class F fly Ash (F)
- Silica fume (SF)
- Metakaolin

Twenty eight concrete mixture designs were selected for laboratory durability investigation. This selection process was based on concrete mixtures meeting basic technical properties and also representing a diverse range of solutions to long term durability. The basic mixture parameters were coded into the names of the mixtures with percentage of each cementitious material, e.g. 75TII-V/20F/5SF means 75% Type II-V Cement, 20% Class F fly ash and 5% Silica Fume. It is recommended to use Type II-V cement in California as different parts of California has severe to moderate sulfate problems and this Type II-V cement is moderate sulfate resistant cement. A High-range water reducing admixture (Glenium 7500) and an air entraining agent (MBVR AE90) were used to meet better workability and other durability performance specifications. All the mixtures were cast according to ASTM C192 practice and 100 mm x 200 mm (4 in x 8 in) cylinders were prepared for compressive strength and electrical resistivity testing. The cylinders were demolded after 24 ± 2 hours and they were continuously cured in lime water in a tank. 3 cylinders per mixture were prepared for compressive strength was performed on 1, 7, 14, 28, 56 and 91 days and electrical resistivity testing was carried on 7,14,28,56 and 91 days.

3. EXPERIMENTAL INVESTIGATION

3.1 Fresh property and compressive strength Some fresh concrete properties namely slump; air content and temperature are investigated in this research. ASTM C143, C1064 and C231 were followed for slump, temperature and air-content testing. Compressive strength was determined using ASTM C39 specification. 3 cylinders were used for experimental investigation of compressive strength for each concrete mixture and average values were reported for strength determination. Results for compressive strength and fresh properties are shown in Tables 1 and 2. Figures 1-5 show periodic gain of compressive strength for different groups of HPC mixtures including the control OPC mixture from 7 days to 91 days.

MUD	61		Concrete
MIXID	Slump (cm)	Air Content (%)	Temperature (°C)
100TII-V	6.4	4.3	23.2
80TII-V/20C	8.9	5.9	19.5
80TII-V/20F	14.0	3.5	20.5
60TII-V/20C/20F	7.6	4.5	24.5
60TII-V/30C/10F	11.4	4.8	22.3
60TII-V/30F/10C	16.5	6.9	17.5
75TII-V/20C/5SF	12.7	2.9	18.5
75TII-V/20F/5SF	12.7	3.5	23.0
65TII-V/35G120S	11.4	2.9	20.4
60TII-V/35G120S/5SF	12.7	3.3	18.5
50TII-V/35G120S/15C	11.4	4.6	23.8
50TII-V/35G120S/15F	16.5	4.6	18.8
95TII-V/5SF	16.5	4.9	19.2
93TII-V/7SF	11.4	4.9	20.1
65TII-V/5SF/30C	15.2	4.7	22.8
65TII-V/5SF/30F	19.1	4.3	23.8
55TII-V/5SF/40G120S	17.8	5.6	21.1
45TII-V/40G120S/15C	17.8	5.1	23.5
45TII-V/40G120S/15F	16.5	5.0	22.9
65TII-V/35G100S	15.2	5.1	22.8
60TII-V/35G100S/5SF	16.5	5.9	22.0
50TII-V/35G100S/15C	19.1	4.8	19.0
50TII-V/35G100S/15F	17.8	5.5	20.4
45TII-V/35G100S/20F	16.5	5.8	23.8
60TII-V/35G120S/5M	16.5	5.8	23.8
60TII-V/35G100S/5M	12.2	3.0	28.7
75TII-V/20F/5M	8.9	4.5	29.1
75TII-V/20C/5M	16.5	4.5	28.9

TABLE 1. Fresh property of HPC and control mixtures

TABLE 2. Con	pressive strengt	h of HPC and	control n	nixtures on 7	and 28 d	ays
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Mix ID	7 day strength	28 day strength	28 days:7 days
100TU V	(Mpa)	(101pa)	1.8
80TU V/20C	15.8	24.5	1.8
80111- V/20C	15.7	24.3	1.5
60TH V/20C/20E	15.7	20.1	1.8
60TH-V/20C/20F	18.6	29.2	1.0
60TH V/30E/10C	16.8	30.0	1.7
75TU V/20C/5SE	14.3	48.1	3.4
75TH-V/20E/5SE	24.0	46.1	1.5
65TU V/35G120S	24.0	50.2	1.5
60TH V/35G120S/5SE	12.2	43.6	3.6
50TIL-V/35G1208/15C	19.5	43.0	2.2
50TH V/35G1203/15E	26.1	42.3	1.6
95TH V/5SE	36.4	54.1	1.0
93TIL-V/7SF	36.0	52.0	1.5
65TII-V/58F/30C	23.5	48.7	2.1
65TII-V/58F/30F	15.2	40.5	2.1
55TIL-V/58F/40G1208	13.6	34.8	2.7
45TII-V/40G1208/15C	22.0	31.7	1.4
45TII-V/40G120S/15E	6.4	35.7	5.6
65TII-V/35G100S	20.5	40.1	2.0
60TII-V/35G100S/5SF	21.2	35.4	1.7
50TII-V/35G100S/15C	17.5	38.8	2.2
50TII-V/35G100S/15F	16.8	28.2	1.7
45TII-V/35G100S/20F	16.1	27.8	1.7
60TII-V/35G1208/5M	25.6	40.3	1.6
60TII-V/35G100S/5M	28.7	43.7	1.5
75TII-V/20F/5M	11.2	32.4	2.9
75TII-V/20C/5M	13.4	36.2	2.7



Fig. 1. Compressive strength of fly ash mixtures



Fig. 2. Compressive strength of slag 100 mixtures



Fig. 3. Compressive strength of slag 120 mixtures



Fig. 4. Compressive strength of silica fume mixtures



Fig. 5. Compressive strength of metakaolin mixtures

3.2 Surface electrical resistivity The concrete resistance to chloride penetration can be evaluated using a rapid but destructive method such as the RCPT following ASTM C1202 specification. However, the monitoring of the nondestructive methodology such as change of the surface electrical resistivity provides much more data about concrete properties in different conditions as a quality control indicator in a simple way. In this study, Florida testing method was used for electrical resistivity measurement on 7, 14, 28, 56 and 91 days for 100 mm x 200 mm (4 in. x 8 in) cylinders except the curing condition and the probe spacing. All the cylinders were cast and then demolded within 24±2 hours. After demolding, the cylinders were placed in a lime water tank. All the cylinders were removed from lime water tank on the specified testing days and tested in surface saturated dry (SSD) condition by 4 point Resipod Wenner Probe meter. Readings were taken at 4 corners of the cylinders at 0, 90, 180 and 270 degree angles. The data in this research were collected using a probe spacing of 50 mm (2 inches), instead of 37.5 mm (1.5 inches) as recommended by FDOT. The probe spacing could not be changed as it came from the manufacturer with 50 mm (2 inches) spacing. The whole experimental process took less than half hour to complete. Figure 6 shows experimental set up for Wenner 4 Probe meter for measurement of surface electrical resistivity. Six cylinders were tested for each concrete mixture. Large numbers of data points (6*4=24) were obtained from 6 cylinders to establish variation for distribution of electrical resistivity over extended time periods. The electrical resistivity reading was multiplied by 1.1 factors as suggested by DOTD designation TR 233 for lime water curing conditions as lime water reduces electrical resistivity to some extent¹². Figures 7-11 show statistical distribution of variation of the surface electrical resistivity of different group of cementitious mixtures from 7 days to 91 days. Table 3 shows average values of the electrical resistivity for all mixtures on different time periods.



Fig. 6. Wenner 4-probe meter

3.2 Geometric correction factor and experimental resistivity The Wenner probe device measures the electrical resistivity of concrete and this technique uses a series of four probes. A known current is passed between the two outer probes and the resulting voltage drop across the two inner probes is measured. The spacing of the probes is constant (a=50 mm (2 inches)). The theoretical concept for determining the resistivity using the Wenner probe device is shown in Equation (1),

$$\rho_{measured} = 2 * \pi * a * \frac{V}{I}$$
(1)

where "a" is the distance between probes.

When resistivity is measured on a rounded cylinder using the Wenner probe device, the outer two probes measures the current and two center probes measures the potential drop. In field investigation, probe is applied on a wide concrete slab where slab width is substantially larger than the probe spacing and there is no interference from the reinforcing steel. On the other hand, in laboratory investigation probe is generally applied on a finite shaped cylinder body. Morris et al. developed an adjustment factor (K) to convert the experimental lab resistivity data performed on concrete cylinder to eliminate the geometrical shape difference between a wide thick slab and concrete cylinder¹³. The experimental resistivity values obtained by using the Wenner Probe device need to be divided by the proper adjustment factor, which was equal to K = 2.63 for 50 mm probe spacing and 100 mm x 200 mm (4 in x 8 in) cylinder¹³. Experimental resistivity data needs to be considered with this adjustment factor for understanding in-situ bridge deck slab data. The Florida Department of Transportation also used this adjustment as expressed in Equation (2) to develop the limits for the FDOT resistivity testing method. As an example, geometrically adjusted resistivity 7, 14, 28, 56 and 91 days for all the mixtures are shown in Table 3.

$$\rho_{real} = \frac{\rho_{measured}}{K}$$

4. RESULTS AND DISCUSSIONS

(2)

4.1 Fresh properties and compressive strength All mixtures met the slump, temperature and air content requirements set forth by specifications for portland cement concrete. The compressive strength results show that a wide range of binary and ternary combinations will meet most of the DOT's compressive strength requirements of 28 MPa (4000 psi) at 28 days. Only one mixture 80TII-V/20C did not meet the expectation. It can be observed that most of the HPC containing SCMs achieved higher target compressive strength (more than 35 MPa (5000 psi) at 28 days with some exceptions. It is also evident that HPC mixtures containing different SCMs gain strength slowly in the beginning and achieved their full pozzolanic reaction by 56 to 91 days. It is observed from Figures 1-5 and Table 2 that grade 120 slag combined with other pozzolans performed better in compressive strength compared to fly ash and grade 100 slag mixtures. Silica fume mixtures always gained early strength due to their high pozzolanic reactivity caused by its superior fineness and their long term 91 days strength (more than 45 MPa) are also significantly higher compared to other binary and ternary mixtures except some slag 120 mixtures. Metakaolin mixtures combined with slag 100 or Class C mixtures gained compressive strength very slowly up to 14 days. It has been observed that long term gain of compressive strength for metakaolin mixtures are not significant from 28 to 91 days and in some situations compressive strength even decreases (60TII-V/35G120S/5M and 75TII-V/20F/5M). More tests are needed to justify actual reason. The results also indicate that the mixtures will continue to achieve strength due to the pozzolanic reaction based on the pattern of the strength gain curves. Most of the HPC tested had 28 days: 7 days ratios of compressive strength between 1.4 and 3.6 except one mixture of 45 TII-V/40G120S/15F, which is the typical range. In general, high replacement levels of SCMs with OPC can delay strength gain, so early age strengths are little lower than a 100% portland cement mixture in some situations. However, by 28 days, most of the binary and ternary based HPC mixtures combinations had higher compressive strengths than the 100% OPC mixture; they continue to gain more strength on 56 and 91 days. This is significant achievement of these durable HPC mixtures in terms of their implementation in concrete bridge deck slabs and pavements.

4.2 Statistical distribution of long term electrical resistivity data Figures 7-11 represent the statistical variation of electrical resistivity for all mixtures in their respective group including 100% OPC mixture (100 TII-V) from 7 days to 91 days. Six cylinders were used for each mixture and 6*4=24 data points were obtained from each mixture for electrical resistivity measurement. Average values of each cylinder were taken into account for preparation of box plot of electrical resistivity for all the mixtures in their respective group. The whole rectangular box in the box plot on each day for each group of mixture represents the range of electrical resistivity those lay between the first quartile (Q₁) and the third quartile numbers (Q₃) for each category of mixtures. Thus, the bottom most line of the box represents the first quartile number (Q₁) and the topmost line represents the third quartile number (Q₃). The horizontal line inside the box represents the median value of electrical resistivity. The vertical line below and above the box represent the remaining values of electrical resistivity excluding the outlier. Outlier is shown as a symbol of (*) in their respective group obtained directly from statistical analysis software. Name of the mixtures in each group is also provided in Figure 7-11 for better understanding. It is observed that grade 120 slag, grade 100 slag and silica fume mixtures gained higher electrical resistivity compared to

Class C and Class F mixtures from the beginning of the experimental study at 7 days. Some of the silica fume mixtures combined with Class C and Class F mixtures did not perform well compared to other silica fume mixtures. High pozzolanic reaction at later ages (specially 56 and 91 days) helped most of the ternary and binary based HPC mixtures for their remarkable performance on electrical resistivity compared to the control mixture (100TII-V). It is also evident from Figures 7-11 and Table 3 that Class F and silica fume mixtures have wide range of variations of surface electrical resistivity at later ages. These Class F and silica fume pozzolans combined with Class C fly ash in ternary blends provide very little benefit in electrical resistivity gain whereas they provide excellent benefit when mixed with each other or with slag 120 or slag 100 as SCM. Overall, most of the ternary and binary based cementitious mixtures attained electrical resistivity higher than 21 kohm-cm on 56 days except some mixtures namely 80TII-V/20C, 60TII-V/20C/20F, 60TII-V/30C/10F, 60TII-V/30F/10C. These four fly ash based ternary mixtures mentioned above did not also provide satisfactory results on 91 days. Overall, these values of electrical resistivity for all the HPC mixtures satisfy the Florida Testing (FM5-578) standard for low to medium chloride ion permeability class of concrete. More outliers are obtained slag 100 and slag 120 group in Figure 9. This is due to the reason that slag 100 and slag 120 mixtures when combined with metakaolin, they show exceptional increase in surface electrical resistivity compared to other mixtures in the same group from 14 days to 91 days and they fall in outlier group as a result of statistical analysis. Similar outlier trends are also observed in Class C group mixtures as only metakaolin improve electrical resistivity extensively when combined with Class C fly ash. It is evident from Figure10 and 11 that most of the silica fume and metakaolin group of mixtures gain electrical resistivity significantly from early ages (7 days) to long term period (up to 91 days). It has been observed from Figure 7 to 11 that Class F, slag100, slag 120, silica fume, metakaolin mixtures show considerable improvement in electrical resistivity compared to 100 % OPC and Class C mixtures in terms of median values on 56 and 91 days.

It is essential to incorporate geometrically adjusted resistivity for computation of the corrosion propagation time in service life model for in-situ bridge decks. It is observed from Table 3 that the values of geometrically adjusted resistivity on 91 days are comparatively low, but the values are still higher than 10 Kohm-cm for most of the cementitious mixtures except some Class C fly ash mixtures. It needs to be remembered that all of these HPC bridge decks will achieve significant gain in electrical resistivity values before active corrosion starts in bridge decks and it will reduce the corrosion potential remarkably. For this reason, long term monitoring of the electrical resistivity of the bridges is the only key strategy of the success of this philosophy of extending the service life of the infrastructure.

Mix ID]	Electrical F	Resistivity (Kohm-c	m)			
	7 day	7 day geomterically adjusted	14 day	14 day geomterically adjusted	28 day	28 day geomterically adjusted	56 day	56 day geomterically adjusted	91 day	91 day geomterically adjusted
100TII-V	16.49	6.27	16.76	6.37	20.04	7.62	25.04	9.52	28.03	10.66
80TII-V/20C	10.62	4.04	12.88	4.90	15.98	6.08	17.74	6.75	21.41	8.14
80TII-V/20F	11.48	4.36	13.65	5.19	15.13	5.75	21.96	8.35	28.85	10.97
60TII-V/20C/20F	9.65	3.67	11.99	4.56	14.39	5.47	19.38	7.37	20.30	7.72
60TII-V/30C/10F	8.75	3.33	9.74	3.70	11.78	4.48	13.69	5.20	18.22	6.93
60TII-V/30F/10C	9.32	3.54	10.63	4.04	11.90	4.53	14.97	5.69	15.67	5.96
75TII-V/20C/5SF	9.38	3.57	10.54	4.01	12.82	4.87	25.38	9.65	34.40	13.08
75TII-V/20F/5SF	10.46	3.98	17.58	6.69	24.05	9.14	30.11	11.45	44.83	17.05
65TII-V/35G120S	14.46	5.50	17.71	6.74	22.28	8.47	24.57	9.34	29.92	11.37
60TII-V/35G120S/5SF	13.94	5.30	17.59	6.69	26.35	10.02	32.92	12.52	52.47	19.95
50TII-V/35G120S/15C	10.12	3.85	13.30	5.06	19.64	7.47	22.94	8.72	27.50	10.45
50TII-V/35G120S/15F	13.24	5.03	18.63	7.08	29.16	11.09	32.05	12.19	43.36	16.49
95TII-V/5SF	11.45	4.36	13.32	5.07	17.80	6.77	28.52	10.84	36.20	13.76
93TII-V/7SF	10.56	4.02	13.03	4.95	19.62	7.46	32.78	12.46	44.04	16.75
65TII-V/5SF/30C	7.76	2.95	9.29	3.53	13.37	5.09	21.45	8.16	30.11	11.45
65TII-V/5SF/30F	7.74	2.94	9.42	3.58	13.65	5.19	47.75	18.16	68.97	26.23
55TII-V/5SF/40G120S	14.48	5.51	18.85	7.17	21.48	8.17	42.40	16.12	64.12	24.38
45TII-V/40G120S/15C	10.88	4.14	16.47	6.26	17.79	6.76	26.11	9.93	29.42	11.19
45TII-V/40G120S/15F	12.51	4.76	17.46	6.64	20.70	7.87	34.89	13.27	36.90	14.03
65TII-V/35G100S	10.73	4.08	16.96	6.45	19.58	7.45	25.72	9.78	25.93	9.86
60TII-V/35G100S/5SF	10.40	3.95	17.38	6.61	24.22	9.21	37.32	14.19	53.97	20.52
50TII-V/35G100S/15C	10.58	4.02	14.06	5.34	20.03	7.62	24.55	9.34	29.83	11.34
50TII-V/35G100S/15F	11.48	4.37	14.97	5.69	20.41	7.76	29.51	11.22	38.69	14.71
45TII-V/35G100S/20F	12.58	4.78	16.34	6.21	25.96	9.87	38.29	14.56	48.77	18.54
60TII-V/35G120S/5M	14.68	5.58	31.17	11.85	38.95	14.81	67.97	25.84	95.39	36.27
60TII-V/35G100S/5M	16.24	6.17	30.11	11.45	51.34	19.52	78.56	29.87	105.85	40.25
75TII-V/20F/5M	15.36	5.84	21.17	8.05	29.54	11.23	41.47	15.77	57.43	21.84
75TII-V/20C/5M	13.35	5.08	19.51	7.42	23.24	8.84	36.45	13.86	47.11	17.91

Table 3. Electrical Resistivity of HPC Mixtures on Different Time Periods



Fig. 7. Distribution of electrical resistivity of OPC (100 TII-V) mixture from 7 to 91 days



Fig. 8. Distribution of electrical resistivity of Class C and Class F fly ash mixtures from 7 to 91 days



Fig. 9. Distribution of electrical resistivity of slag 100 and slag 120 mixtures from 7 to 91 days



Fig. 10. Distribution of electrical resistivity of silica fume mixtures from 7 to 91 days



Fig. 11. Distribution of electrical resistivity of metakaolin mixtures from 7 to 91 days



- The research presented here demonstrates the role of long term compressive strength and surface electrical resistivity as potential durability criteria for binary and ternary based HPC mixtures.
- All HPC mixtures with moderate to high cement replacement by different SCMs meet compressive strength requirement set by most of the DOT's specification and achieved higher strength at later ages.
- Statistical analysis showed that Class F, slag100, slag 120, silica fume, metakaolin mixtures show considerable increment in electrical resistivity in long term compared to 100 % OPC and Class C mixtures in terms of median resistivity values on 56 and 91 days.
- Combination of Class C pozzolan with Class F, silica fume and ordinary portland cement is not always satisfactory. It will be more beneficial if the Class C and Class F fly ash are blended with slag 120 and slag 100 SCMs. Better durability performance of silica fume ternary blends can also be achieved when mixed with slag 120 and slag 100. In future, more microstructural investigation is required for precise justification.
- Analysis results also support the use of Wenner probe device as a possible quality assurance/quality control (QA/ QC) tool in concrete field testing. Several external factors namely moisture, temperature of concrete, presence of reinforcements needs to be considered during field practice of Wenner Probe device.
- Overall, the findings of the electrical resistivity for binary and ternary based mixtures can provide an insight into

the beneficial effect of HPC mixtures in delaying corrosion induced cracking and an essential input component in service life model of concrete bridge decks. In future, the long-term monitoring of the electrical resistivity can be carried out in different regimes simulating service life conditions.

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COMPARATIVE STUDY OF EFFECTIVE RADIATED POWER MEASUREMENT TECHNIQUES FOR ACTIVE PHASED ARRAY

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ABSTRACT

Two different techniques for Effective Radiated Power (ERP) measurement for Active Phased Array in anechoic chamber has been presented in this paper. The ERP is an important parameter in the characterization of Active Phased Array as it defines the amount of power effectively radiated by an active aperture. These techniques are verified by comparing the measured results with the theoretically calculated values. These techniques are quite simple and can be implemented in all sorts of anechoic chamber.

Keywords: Active Phased Array, Anechoic Chamber and Effective Radiated Power.

1. INTRODUCTION

In conventional systems, a high power microwave vacuum tube is employed for the feeding of antenna elements in array. The power from the tube based amplifier is divided with the help of power dividers to feed each and every antenna element. The power dividers introduce the insertion loss which reduces the overall system of ERP. To overcome this Active Phased Arrays are used in which each antenna element is fed by a solid state amplifier to improve the overall ERP of the system. Effective Radiated Power (ERP) of any transmission link is defined as the product of transmitted power and the gain of the transmitting antenna. ERP defines the actual RF energy transmitted after subtracting all losses from the input power and adding gains provided at different stages of the link. The losses are produced by the transmission lines in the form of attenuation while the gain is introduced by amplifier and antenna. The ERP [1] of a transmission link is given as: ERP = $P_t G_t$ (1)

 P_t = transmitted power or power input to transmitting antenna (Watts) G_t = gain of transmitting antenna

In most of the practical cases, the power fed to the transmitting antenna (P_t) is not same as of the input power (P_{in}) fed to the link. The difference between input power (P_{in}) and transmitting antenna (P_t) is equal to the attenuation of the transmission line employed between the power source and antenna. To overcome loss due to attenuation, amplifier is used just before the transmitting antenna. A typical transmission link is shown in Fig. 1.



Fig. 1 A typical Microwave Transmission Link

2. DETAILS OF PAPER

In an Active Phased Array, each antenna has a solid state amplifier which feeds the amplified RF signal to the antenna. If the total number of antenna elements in the active phased array is N then the total radiated power and total gain will be given as: (2)

.... (3)

 $P_t = NP$

 $G_t = NG$

Where,

N = number of elements

P = power output from each solid state amplifier (Watts)

G = gain of each antenna element

The overall ERP from an Active Phased Array [2] [3] can be obtained by substituting values from Eq. (2) & (3) in Eq. (1)

 $ERP = N^2PG$ (4)

 $ERP (dB) = 20 \log N + P (dB) + G (dB)$(5)

Eq. (5) provides the formula for theoretical calculation of ERP for an Active Phased array in decibels.

Two techniques were used in the measurement of ERP. These techniques are:

Direct Method

Indirect Method

a) Direct Method: In direct method, the power output at each solid state amplifier is measured with the help of either power meter or spectrum analyzer. A typical measurement setup is shown in Fig. 2.



Fig. 2 Measurement of ERP by direct method

For the setup shown in Fig. 2, the power transmitted at any frequency is given as:

 $P_t (dBm) = P_{in} (dB) - P_1 (dB) + G_s (dB) - P_2 (dB) \dots (6)$

Where,

 P_1 (dB) and P_2 (dB) are cables attenuation at a specific frequency.

 $G_s(dB) = Gain of solid state amplifier$

The transmitted power (P_t) in dBm is measured at every specific frequency step by tuning the spectrum analyzer to that frequency.

The next step is to measure the gain (G_t) of the transmitting antenna element. The gain of the transmitting antenna element is measured in an anechoic chamber by using the antenna substitution method. In antenna substitution method, the gain of an antenna element is measured with the help of a calibrated antenna (or antenna with known gain) often known as "Golden Antenna". The gain of the antenna [1] [4] at a specific frequency is given as:

$$G = \frac{4\pi A_p}{\lambda^2} \dots (7)$$

Where,

G = gain of the Antenna

 $A_e = effective aperture of Antenna$

 λ = wavelength corresponding to operating frequency

The Effective Radiated Power is measured as:

 $ERP (dBm) = P_t (dBm) + G_t (dB) \qquad \dots \qquad (8)$

b) Indirect Method: Indirect method of ERP measurement is based upon the Friis Equation which gives a relationship between received power and ERP as:

ERP (dBm) = P_r (dBm) - G_r (dB) + L_p (dBm) ... (9) Where, G_r = gain of the receiving Antenna P_r = received power at receiving Antenna

 $L_p = path loss$

The test setup is shown in Fig. 3 where a receiving antenna is located in an anechoic chamber at distance R (in meters) and the waves received at receiving antenna with negligible reflections.



Fig. 3 ERP Measurement by indirect method

3. CONSLUSION

The measurement has been done for an active phased array with power input 30 dBm and gain varying from 2-6 dB over 8-12 GHz frequency. The calculated ERP from Eq. (1) as: ERP (dBm) = 30+2 = 32 dBm for 8 GHz

ERP (dBm) = 30+6 = 36 dBm for 12 GHz (10)

The measured ERP with direct and indirect method along with the theoretical calculations is presented in Fig. 4.



Fig. 4 Measured ERP

Fig. 4 suggests that the ERP measured through indirect method is closer to the calculated ERP than the ERP measured by direct method. The reason could be the reflections occur while measuring the power through direct method in laboratory set up. In case of indirect method, all the measurements are carried out in anechoic chamber where reflections from walls are negligible. Moreover, the losses in indirect method are calculated at each frequency step and properly counted while taking the measurement.

In this way, it can be concluded that while measuring the ERP, indirect method gives more accurate results and can be implemented in an anechoic chamber.



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CO-WORKING OF SERIES-CONNECTED SUPER -CAPACITOR AND BATTERY FOR RIDE-THROUGH CONDITIONS IN LOAD

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This paper deals with energy aspects in case of ride-through conditions in armature of DC motor fed by battery supported by super-capacitor. The simulation on MATLAB points out the advantages in terms of reconnecting super-capacitor, from parallel to series, for faster transfer of energy.

Keywords – Battery, Supercapacitor, DC motor, switching unit, series/parallel combination



This scheme represents DC motor which is supplied by a combination of battery and supercapacitor. The supercapacitor-bank is connected in series with battery. It provides initial high energy required during motor-starting. It also relieves the battery from overstrains during ride-through conditions from load-side. This paper deals with faster utilization of super-capacitor-energy by using series / parallel reconnection of supercapacitors.

The scheme is based on a paper authored by Shane Colton of MIT, USA, published in March-2009 [1][5]. In this, the authors deals with series combination of battery and supercapacitor for feeding a D.C. motor, in which, the advantages of series combination of super capacitor has been explained in details. P.R. Sawarkar et al, have applied for an Indian Patent under GHRLabs, in 2012, in which the authors have dealt with the series/parallel combinations for super-capacitor-bank for resistive load, for faster exchange of energy, for a typical case of capacitor-bank made of 8 units[2]. Concept of design for hybrid electric vehicle with motor drive integration[7] has been developed with more efficiency and utilization specially for ride through condition[6]. On the basis of that, switching system has been developed in this scheme. In this work, initially simulation is carried out using only the battery for motor load. Next, supercapacitor is placed in series with battery to feed the motor load. On studying the results of simulation, it is observed that after sufficient discharge of energy, continuously connected super-capacitor is not advantageous during series combination. Hence, super-capacitor is disconnected after specified level of discharge. In next simulation, super-capacitor is reconnected, from parallel to series, after fifty percent of energy-discharge. It helps in faster exchange of energy. It is also a better utilization of supercapacitor-

energy. This paper deals with simulations of all these aspects and shows the various outcomes mainly related to energy. Hardware has been fabricated to study power, speed, current and voltages.

2. PROPOSED SCHEME

As discussed in introduction, three parameters have already been simulated and reported by student and faculty at G H Raisoni College of Engineering, Nagpur [3], in which, main focus is on voltage variation, effect on current waveform and variation in power due to recombination within super-capacitor-bank. Variation of energy as a function of time in such cases is the focus of this paper.



Figure 1: supercapacitor recombination circuit in series with battery for motor load

Figure (1) shows battery and supercapacitor bank connected in series for DC motor load. Reconfiguration means change-over from series to parallel connection. Discharging of Super Capacitor has been studied in previous case. In case of no reconfiguration, two fully charged capacitors of 12V, 0.1F are connected and time required for complete discharge and time required for voltage dropping up to 50% of supercapacitor is measured. In case of reconfiguration, two fully charged capacitors of 12V, 0.1F are connected in parallel. After 50% discharge, parallel connection of Super capacitor will be reconfigured to have series combination, and connected to same load. Now the time required for complete discharge and time require for voltage dropping up to 50% of load voltage is measured. Later, the capacitor bank is disconnected from system.

It is observed that, supercapacitor is utilized upto 3V instead of 6V. That is further discussed in details. Different readings of time for which the super-capacitors are operative, in these cases, are compared.

3. SIMULATION AND COMPARISON

I. Only battery with motor load.



Figure 2: Battery connected to motor load

II. Supercapacitor connected in series with battery for motor load



Figure 3: Supercapacitor connected in series with battery for motor load





Figure 4: Supercapacitor bank connected in series with battery for motor load with supercapacitor series parallel recombination system

Initially both supercapacitor connected in parallel combination and after 50% of capacitor voltage they are connected in series with each other. Voltage is get added. This provide again rated voltage to motor load. Maximum utilization and fast energy exchange of supercapacitor is obtained by using this operation. The results are as already shown in last paper [3][4]. Only comparative result of energy waveform are shown below with addition of voltage across motor,



Figure 4(b): supercapacitor voltage with series parallel recombination system



Figure 4(c): Motor current



Figure 4(d): Power provided by battery and combination of battery and supercapacitor



Figure 4(e): Energy provided by battery and combination of battery and supercapacitor



Figure 4 (f) Hardware Model



Figure 4 (g) Motor Voltage



Figure 4 (h) Motor Current



Figure 4(i) Motor Current

Table 1

DC MOTOR SPECIFICATION	
MOTOR TYPE	WOUND
ARMATURE RESISTANCE (R _a)	2 ohm
ARMATURE INDUCTANCE (La)	0.2 H
FIELD RESISTANCE(R _f)	24 ohm
FIELD INDUCTANCE(L _f)	12 H
MUTUAL INDUCTANCE(Laf)	0.6 H
TOTAL INERTIA	1 Kgm ²

Voltage across the motor is initially 24V. Parallel connection of supercapacitor in the bank starts delivering energy and gets discharged. When voltage across supercapacitor falls to pre-set value (=6V), series connection within the bank is done. The motor voltage rise to 24V at this instant. The supercapacitor continuous to fed its energy to motor and its voltage gradually falls. Anticipating sufficient discharge of supercapacitors, the motor is connected to battery alone. Various waveform during recombination are carried out. It is directly shown that voltage is get added and again 24V is applied across motor load. But variation in current is less.

4. CONCLUSIONS

As suggested by MIT researchers in 2009 and as innovated by GHRCE staff in 2012, it is concluded that supercapacitor bank connected in series with the battery reduces burden on battery during starting of motor and again series/ parallel recombination of supercapacitor bank provides maximum utilization and faster exchange of energy. The energy comparison between second scheme and third scheme directly shows that energy provided through recombination of supercapacitor is much higher than that without recombination.

Hardware model has been successively carried out for both cases. Recombination of supercapacitor from parallel to series has been found to be useful, based on the simulation results .

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DEVELOPMENT OF AN ASSISTIVE WRIST BRACE FOR A PATIENT WITH CEREBRAL PALSY

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In an effort to ease some of the challenges that people with disabilities face, a novel type of assistive wrist brace was proposed and developed. It is a solution to the issues of currently available braces for patients suffering from Cerebral Palsy and severe Arthritis. The braces, currently available in the market do not position the user's wrist properly. The wrist angle places the person's hand parallel with their forearm, causing substantial discomfort, which results in pain while using crutches and therefore a limited time for people to be able to use crutches comfortably.

Keywords - assistive devices, cerebral palsy, clay forming, hand cast, thermoforming process, wrist brace

1. INTRODUCTION

During the semester long Mechanical Design Applications II course, a new learning strategy environment was created, by introducing the students to a team challenge where they were asked to design an assistive device for a particular person who is disabled. The students were introduced to local non-profit agencies that train and find employment opportunities for disabled people. During this semester, the students have been working in teams and in collaboration with specific disabled person, with physical therapists at the local hospitals, as well as with the disability services at Texas A&M University to better understand the barriers faced by the disabled on a daily basis. In what follows we describe the development of a novel assistive wrist brace prototype for patients suffering from Cerebral Palsy. It is worth to note that this device offers simple, comfortable and cost-effective design.

Mrs. Williams is an employee in the Division of Student Affairs at Texas A&M University. She is the Accommodations Counselor in the Department of Disability Services and suffers from Cerebral Palsy and severe Arthritis. These conditions affect her ability to utilize her hands for tasks such as operating her crutches. She is currently limited in the workplace by her dependence on these wrist braces. There are three main limitations regarding the wrist braces. First, they prevent Mrs. Williams from gripping objects due to an aluminum reinforcement that runs along the bottom of the wrist and extends into the center of the palm. The second lies in her need of assistance to don and remove the wrist braces. This means that not only is Mrs. Williams dependent upon her assistant for mobility (i.e. using her crutches), but also for the ability to perform a large portion of her regular office tasks. The third limitation is that the braces that Mrs. Williams is currently using do not position her wrist properly. The angle of her wrist places her hand too parallel with her forearm causing substantial discomfort. This results in pain while using her crutches and therefore a limited time for her to be able to use the crutches comfortably.

After reading materials, regarding hand and hand function [1-6], we met with Ms. Williams and interviewed her (see Appendix). During the design stage, our solution has gone through three significant design revisions. Initially we designed an aluminum exoskeleton utilizing several four-bar linkages to be mounted over the user's hand. Measurements were taken of Mrs. Williams hand, with her permission (see Table 1), to design the device with a custom fit (see Figure 1). The linkages would have been moved using an additional linkage connected to the user's upper arm. This would have transferred the motion of the elbow joint and arm into the actuation of the finger linkages to open and close the hand. The second design involved using a pulley and cable actuated system of 3-bar linkages arranged in a similar exoskeleton configuration (see Fig. 2).

Table	1	Measurements	of the	customer	hand
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MEASUREM	ENT OF C	CUSTOME	ERS HANI	D COMPC	ONENTS
(Units In Inches)	1	2	3	4	5
Metacarpal:	1.5	2.25	2.5	2.75	2.0
Proximal Phalanges:	1.25	1.25	1.5	1.5	1.25
Middle Phalanges:		0.875	1.0	1.125	0.875
Distal Phalanges:	1	0.875	0.875	0.75	0.625



Figure 1. Solid Works drawing of the four bar

Figure 2. The three-bar linkage design.

The final design was a direct result of Mrs. William's opinion and assessment of our first two designs. Mrs. Williams expressed in a meeting that she had sufficient strength and ability to manipulate objects with her hands and that it was simply the wrist brace (see Figure 3) restricting the finger travel of her hand that prevented the manipulation of small objects. In addition she stated that the wrist brace did not position her wrist comfortably while using her crutches due to the aluminum piece hitting the crutch itself. It was also evident that her assistant was necessary to don and remove the braces. After showing her drawings of our initial designs she asked that we design for her a similar but different wrist brace. She requested that the brace should:

- correctly position her wrist for crutch use
- distribute weight comfortably for crutch use
- be easy to use with no interference with crutch.

From Ms. Williams needs we were able to derive the major functional requirements of the device as follows:

- be detachable from the crutch
- lightweight, medical grade material, and comfortable
- custom fitted
- simple, low cost, and easy to manufacture
- safe to use.



Figure 3. Ms. Williams old brace, which restricts the finger travel of her hand that prevented the manipulation of small objects.

I. SOLUTIONS

1. Cost The cost for developing the prototype for this device went a significant amount over the originally planned \$300 budget.

This was still considered a success in that it was necessary to purchase extra material to test with and to allow for errors in manufacturing. This material included three different thicknesses of plastic sheet and enough mold and cast material for four castings [7]. Were this device to be made commercially, much of these extra costs could be eliminated. It is estimated that a production model would cost between \$50 and \$100. The bill of materials to develop several prototypes, including the test prototype can be seen in Table 2.

2. Simplicity and Ease of Use and Implementation The design of this device was focused on simplicity, ease of use and safety. If a device is too complicated it will end up becoming more of a hassle to the end user than an improvement. With this in mind the device was designed to function similarly to the device Mrs. Williams currently uses but with the following major design improvements:

- customer's ability to use them easily and comfortably
- avoid interference with natural hand function.

The most difficult aspect involved with these goals was to align her wrist into a more natural and comfortable position. To have an idea of where this exact position is, we used 3D Motion capture system data, shown in Figure 3(a).

Trajectori	ies																
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	1 0	-1	49.067	410.876	-0.88815	-132.55	1 347.806	27.5443	-109.7	309.06	38.8258	-92.8661	284.588	42.0068	-79.9888	268.868	46.6508
	2 (-1	49.153	410.881	-0.91645	-132.58	9 347.832	27.5249	-109.719	309.046	38.8367	-92.8925	284.578	42.0458	-80.0046	268.857	46.6311
	3 (-1	49.159	410.881	-0.89501	-132.60	2 347.833	27.5314	-109.72	309.041	38.848	-92.8909	284.535	42.036	-79.9967	268.855	46.6072
	4 0	-1	49.114	410.88	-0.87175	-132.58	1 347.835	27.5453	-109.7	309.048	38.845	-92.8491	284.525	42.0058	-79.9654	268.86	46.575
	5 (-1	49.067	410.888	-0.88583	-132.52	2 347.854	27.5548	-109.664	309.065	38.8183	-92.7624	284.585	41.9735	-79.9155	268.871	46.5386
	6 0	-1	49.043	410.914	-0.92891	-132.4	6 347.878	27.5565	-109.627	309.084	38.7827	-92.6691	284.689	41.9496	-79.8576	268.883	46.5118
	7 (-1	49.026	410.943	-0.96093	-132.42	9 347.893	27.5623	-109.606	309.098	38.7586	-92.5908	284.771	41.9313	-79.802	268.889	46.4989
	8 (-1	49.016	410.951	-0.95345	-132.42	2 347.897	27.5707	-109.598	309.103	38.7533	-92.5159	284.775	41.9189	-79.755	268.89	46.493
	9 (-1	49.011	410.942	-0.89533	-132.42	4 347.892	27.5764	-109.593	309.099	38.7686	-92.4643	284.723	41.9221	-79.718	268.897	46.4925
1	.0 0	-1	49.001	410.934	-0.81889	-132.41	5 347.891	27.6021	-109.589	309.096	38.7981	-92.4663	284.711	41.961	-79.687	268.916	46.5091



Figure 3(a): 3D Example of the Motion Capture data of Alex's Thumb, Index, and Middle Finger.

3. Safety Safety was a main driving factor in the design process for this device. The reason for abandoning the original exoskeleton style power-actuated designs was mainly for the safety of the user. It was determined to be unfeasible to limit the travel of the exoskeleton linkage. Without these limits, having the users hand in between the object to be gripped and the device would then present the possibility of injury. For this reason the solid brace design was developed to meet Mrs. Williams' needs in a more simple and safe way. The device allows for Mrs. Williams to don and remove the braces without assistance. This eliminates the potential safety hazard of her being unable to use her crutches because no assistance was present to help her put on her braces for crutching.

II DESIGN OF THE PROTOTYPE

1. Construction Quality and Accuracy The prototype for the device was developed using a four- step process. First, a mold chamber was constructed with internal fixtures and grips to allow Mrs. Williams to position her hand and wrist in the ergonomically correct and most comfortable position for using her crutches. Second, a mold was cast of her hand using Alja-Safe. Alja-Safe is a biodegradable alginate mold material similar to silicone but is fast setting, safe for skin contact, easy to clean, and water soluble (see Figure 4).



Figure 4. Modeling clay form of Ms. William's wrist (on the left). Shape refinement of cast (on the right).

This material was chosen with Mrs. Williams in mind to reduce mold making time and prevent potential reactions to the mold material. The third step was to cast a model of Mrs. William's hand for use in custom fitting the brace (see Figure 4). The casting material used was Smooth-Cast 385 mineral filled urethane casting resin. This material was chosen for its high strength and post-cure heat resistance. These two properties allowed the machining of vacuum flow holes through the casting. These flow holes allowed the vacuum thermoforming of the brace material over the resin-cast model, which was the fourth step. Kydex, an acrylic polyvinylchloride alloy commonly used in medical braces, knife sheaths, and pistol holsters was intended to be used for the brace. Kydex was chosen for its good thermo-formability, high impact resistance, and high rigidity. It is also resistant to heat, chemicals, abrasion, and impact. However, Kydex was ultimately not used for many reasons. A thermoformed Polystyrene brace plate was used in the finished product (Figure 5) because the thermoforming machine in our lab was not a quality built machine. One main issue with the machine was the inability to pull a vacuum well enough to form the Kydex well.



Figure 5. Pictures from the thermoforming process and the thermoformed brace plate



Figure 6. The thermoformed Polystyrene brace plate, used in the prototype.

2. Accurate Function The function of this brace was not only to position Ms. Williams' wrist properly but also to eliminate the obstructions caused by an Aluminum piece inside of it (in the middle of the palm area) while holding the crutch. This was done by manufacturing a shorter Aluminum piece, and bending it with respect to Ms. Williams' palm position, while holding the crutch. To help support the patient's wrist in a comfortable and useful manner thermoformed Polystyrene brace bracket was utilized.

3. Evaluation The brace was tested on Dr Nina Robson, a female Adjunct Assistant Professor and our advisor, with a similar hand and wrist structure as the patient Donna Williams. Dr. Robson wanted to make sure that the developed prototype correctly positions the wrist for a crutch use, distributes weight comfortably for crutch use and is easy to use with no interference with crutch. The major functional requirements of the device were met, i.e. to be detachable from the crutch, lightweight, medical grade material, and comfortable, custom fitted, simple, low cost, and easy to manufacture and safe to use. Donna Williams is eager to start using her new brace at our meeting with her next week.

2. CONCLUSION

A novel type of assistive wrist brace was proposed and developed. It is a solution to the issues of currently available braces for patients suffering from Cerebral Palsy and severe Arthritis. The braces, currently available in the market do not position the user's wrist properly. The wrist angle places the person's hand parallel with their forearm, causing substantial discomfort, which results in pain while using crutches and therefore a limited time for people to be able to use crutches comfortably.

Mrs. Williams is a disabled lady that should be as comfortable as possible while doing everyday tasks. One of the easiest things for an average human to do throughout the day (walking) is a very hard task for Mrs. Williams in dealing with her Cerebral Palsy. With a great effort from our team at Texas A&M University we are able to help comfort this patient in doing an inevitable task. Through trial and error, designing and redesigning to fit her needs and wishes, a prototype was fabricated to help Mrs. Williams walk with her crutches. This prototype has a shorter brace member on the bottom side of a new wrist brace to eliminate the obstructive characteristics of her current bottom brace with her crutches she uses every day. This aluminum bottom brace also is shaped in a more extreme manner to better assist her hand to be placed in the correct "back" position. The thermoformed polystyrene brace that is positioned on top of the wrist limits the wrist and helps shape the wrist to a better configuration for Mrs. Williams to use her crutches more easily (see Figure 7). As mentioned before, the whole prototype was tested on a woman of similar wrist structure. Our future intention for Mrs. Williams and her new device is to let her use the bracing device next week in the workplace. After giving ample time for her to become use to the new device, our team will meet with her and discuss future improvements of the brace if need be.

The feature of this design that sets it apart from others is the fact that it is cost effective and simple. The design is made to have a low manufacturing cost while also maintaining a high standard of quality. The ease of manufacture comes from the simple geometry used in the design. The prototype will require no CNC machining and will be easily achieved by only moderately experienced machinists in the group. If moved to a production level, the parts could be even more cheaply and simply made using injection molding of polymers. The device we designed is easy to maintain, and will require little effort and education to install. If it were to ever fail or be damaged in any way replacement parts are very simple and easy to replace.



Figure 7. Ms. Williams using her new wrist brace

Product	Vendor	Quantity	Price/unit	Total Price
Kydex Textured Plastic Sheet Black 118 Thick 12" Width 24" Length	Plastics 2000	1	\$55.57	\$55.57
ABS Textured Plastic Sheet White 1/8" Thick 12" Width 24" Length	Plastics 2000	1	\$16.87	\$16.87
Kydex Textured Plastic Sheet Black .093 Thick 12" Width 24" Length	Plastics 2000	1	\$41.40	\$41.40
Kydex Textured Plastic Sheet Black .060 Thick 12" Width 24" Length	Plastics 2000	1	\$29.02	\$29.02
Alja-Safe Alginate - 3 lbs.	Reynolds Advanced Materials	2	\$21.83	\$43.66
Smooth-Cast 385 - 1 Gallon Unit	Reynolds Advanced Materials	1	\$61.30	\$61.30
Ease Release 200 - Aerosol Can	Reynolds Advanced Materials	1	\$13.20	\$13.20
Mold Tube/Fixture: 6" PVC Pipe	Donated	1	\$0.00	\$0.00
PVC S40 6" Cap Slip	Valley Valve & Pipe Supply Company	2	\$28.37	\$56.74
Hex Bolt: 8"x3/8"-16	Home Depot	4	\$1.29	\$5.16
Hex Nut: 3/8"-16	Home Depot	8	\$0.12	\$0.96
Silicone Sealant: 2.8 FL OZ	Home Depot	1	\$4.97	\$4.97
Full Round: 12" x 1 1/4"	Home Depot	3	\$1.33	\$3.99
Homer Bucket: 5 Gallon	Home Depot	2	\$2.54	\$5.08
Air Dry Clay: 5 lbs	Michaels	1	\$9.99	\$9.99
Krylon "Clear Glaze" Spraypaint	Wal-Mart	1	\$3.24	\$3.24
Futuro Splint Wrist Brace	CVS/pharmacy	1	\$20.99	\$20.99
Polystyrene Sheet: 12" x 12"	Donated	1	\$0.00	\$0.00
Mixing Containers	Donated	2	\$0.00	\$0.00
6061 Aluminum Sheet: 10"x12"-1/8"	Donated	1	\$0.00	\$0.00
Thread-All: 24"x3/8"-16	Donated	1	\$0.00	\$0.00
Plywood Sheet: 12"x12"x3/4"	Donated	1	\$0.00	\$0.00
Measuring cup	Donated	1	\$0.00	\$0.00
		SUB	TOTAL	\$372.14
		Shi	ipping	\$44.70
		GRAN	D TOTAL	\$416.84

What is	your most difficult task?Picking up a coin.	
What is	your second most difficult task? <u>Holding on to her</u>	_
	rutches when walking.	
Which	s your dominant hand?	
V	Left hand	
	Right hand	
	Ambidextrous	
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Are you I Why is Can you Are you How ef What si	r grasping difficulties present throughout your arms or just within your have vary's. Her forceron muscles some times become grasping difficult? Joint pain. <u>Muscular pain.</u> <u>Lack of muscle control.</u> Other: <u>Artheitus</u> , <u>Mrists are beat slightly</u> . if fully extend your hand? Yes No Left hand Right hand it is able to make a fist with your hands? Yes No Left hand ective can you squeeze a stress ball? Well Moderately Poor ze glove do you wear? <u>Extra-Small</u> <u>Small</u> <u>Mathematical Small</u>	ands?
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STUDY OF PARTICLE DISTRIBUTION IN METAL MATRIX COMPOSITE BY CENTRIFUGAL CASTING

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Metal Matrix Composites (MMCs) have been used in several applications in aerospace and automotive industries as it is light in weight. In the present study centrifugal casting of aluminium melts with Aluminium Silicon Carbide particles has been studied. During centrifugal casting process of metal matrix composites segregation of particle occurs due to centrifugal process to outer part of the casting as the density of the particle is greater than the density of base alloy. It is difficult to determine the particle distribution during centrifugal casting process because of opaque nature of mould. Therefore to determine the particle distribution in case of centrifugal casting of metal matrix composites is analysed by analytical methods. The results obtained by the theoretical calculations are compared with the experimental result.

Keywords: MMC, Centrifugal casting, Aluminium, Silicon Carbide.



1.1 Centrifugal casting Centrifugal casting is done by pouring molten metal into a rotating mould. The centrifugal force acting on the mould helps in feeding and positioning the metal in the mould. Mould rotation is continued till after the metal is solidified. Centrifugal casting results in denser and cleaner metal as heavier metal is thrown to parts of the mould away from the centre of rotation and the lighter impurities like slag, oxides and inclusion are squeezed out to the centre.

1.2 Metal matrix composite Metal matrix composite have played a more and more important role in the area of aerospace, automobile, military and other industries because of their excellent physical and mechanical property.

2. EXPERIMENTAL SETUP

2.1 Fluid flow Fluid flow plays a major role in a centrifugal casting system, and understanding the complex flow process is a must for the production of defect-free castings. In the real-life casting process, it is impossible to study the fluid behaviour because of the opaque nature of melt and mould. The melt poured initially into the mould has low viscosity, and as the molten metal cools, its viscosity increases and the melt tends to lift along the rotating cylindrical surface. At the same time, it has a tendency to fall off the mould top until the mould attains a critical rotational speed. Another main factor affecting centrifugal casting is rotational speed of the mould. Excessive speed of rotation produces very high tensile stress in the outer

periphery of the casting which results in longitudinal cracks. Furthermore, very high rotational speeds cause the mould itself to fail. Sometimes due to lower speed the formation of the cylinder is very poor, and sometimes in high rotational speed there will be no formation of uniform cylinder. Therefore determination of optimum speed is very much essential in centrifugal casting.

Some of the terms considered during the casting are:

Viscosity: Viscosity plays a vital role in formation of liquid cylinder. It is found that for low viscosity liquids, the formation of cylinder occurs at higher rotational speeds. For high-viscosity fluids, the cylinders form at lower rotational speed.

Aspect Ratio (Mould Dimension): If the length is small compared with diameter or for smaller aspect ratio the fluid flow is disturbed. With an increased aspect ratio (increase in length), the effect of disturbance is less significant. The full cylinder formation takes place at higher rotational speed for smaller aspect ratio. The formation of a complete hollow fluid cylinder in large diameter moulds are expected take place at reduced speeds of rotation.

Thickness of Fluid Cylinder: The rotational speed required to form a full cylinder increases with the increase in thickness of the fluid cylinder because of reduced drive. It shows that for lower volumes, the fluid will not cover the length of the cylinder easily. It requires a higher rotational speed to form flow. But with increased volume, the liquid will settle at the lower part of the horizontal cylinder all along the axial direction during pouring. Hence, a thin layer gets lifted when the mould starts rotating.

2.2 Casting A steel mould of inner dimensions 81 mm in diameter and 88 mm in length with a wall thickness of 6 mm used for the casting which is connected to a motor of 2HP through a shaft. Al-Sic is used as study material here, Aluminium is melted in a furnace to a super heated of 200°c, in the other side Silicon carbide particle are pre heated to 300°c. After that particles were added to furnace and waited till the formation of vertex to avoid floating of particle. After a few seconds the motor was turned off and casting pulled off. This material was prepared to study how the Sic particles are distributed in case of the Al alloy. The melt was centrifugal cast in a steel mould at different rotation speeds and the thickness of the cast was controlled by taking calculated amount of metal. These castings were made for different speeds and for cast thickness of 6 mm.



Fig 1: Figure of 6 mm thickness casting



3.1 Theoretical analysis of the particle gradient distribution

3.1.1 Particle segregation The particle segregation occurs during centrifugal casting owing to difference in density between molten metal of base alloy and particles. Then a particle which is suspended in molten metal is submitted to a vertical acceleration due to gravity g and a centrifugal acceleration $\Upsilon^{=}$ ²r. The vertical moving of a particles can be ignored because of centrifugal acceleration is much greater than gravity which allows the vertical displacement of the particle.[6]



Figure 2: Forces acting on the particle

Hence the force balance equation on the particle can be expressed as

$$\mathbf{F}_{\omega}-\mathbf{F}_{\vartheta}-\mathbf{F}_{\mathrm{R}}=\mathbf{F}_{\mathrm{net}}$$

Where F_{net} is the net force on particle, F_{ω} is the force due to centrifugal acceleration, F_{ϱ} is viscous force and F_{R} is repulsive force. The repulsive force is significant only on those particle that or in vicinity of a solid wall or the solid liquid interface. Therefore the force balance for the particle that is not under the influence of a solid interface is given as follows;

$$F_{\omega} - F_{\vartheta} = F_{net}$$

Assuming that the fluid flow is laminar ($\text{Re} \leq 1$), the force balance equation becomes

$$\frac{4}{3}\pi R_p{}^3 (\rho_p - \rho_l) \omega^2 r - 6\pi \vartheta R_p \frac{dr}{dt} - F_R = \frac{4}{3}\pi R_p^3 \rho_p \frac{d^2 r}{dt^2}$$

The above equation is further solved to get the position of a particle at any time t as

$$r(t) = r_{o} exp\left[\frac{2\omega^{2}(\rho_{p}-\rho_{1})R_{p}^{2}t}{9\vartheta_{c}}\right]$$

Where \mathbf{r}_{o} position of the particle at t=0 the viscosity $\boldsymbol{\vartheta}_{c}$ of the molten metal containing particle is given as follows.

$$\vartheta_{c} = \vartheta \left[1 + 2.5 V_{f}(t) + 10.5 V_{f}^{2}(t) \right]$$
²

By solving the above equation a thickness of particle rich region under various speed and time has been estimated. Therefore variation of volume fraction due to particle moving at the liquid region are calculated in time t= t+ Δt [1, 6]

$$V_{f}(t + \Delta t) = V_{f}(t) \left[\frac{\{1 - r(t + \Delta t)\}}{1 - r(t)} \right] + V_{f}(t)$$
3

By considering the equations 1, 2 and 3, the position of the particle at time t and t+ Δ t are calculated with the initial volume fraction as 15%. The graph is drawn to show the particle movement depending on the density of the particles added to the base alloy.

Properties of Material

$$p_{p} = 3200 \text{ kg/m}^{3} (\text{sic}), 2250 \text{ kg/m}^{3} (\text{Gr})$$

 $p_{1} = 2360 \text{ kg/m}^{3}$
 $R_{p} = 50 \ ^{\mu} \text{m}$
 $t = 0,1,2,3,4,5,6 \text{ sec}$
 $\vartheta = 0.324 \text{ Pa s}$
 $\omega = 800,1000,1200,1400 \text{ rpm}$
 $R_{=} 1.5*10^{-2} \text{ m/s}$



Fig 3: For casting thickness of 6mm, with initial volume fraction as 15% for SiC par

3.2 Micro structure and Micro hardness Micro structural studies were conducted in order to investigate the distribution of SiC particles retained in the metal matrix. Samples were taken to reveal the particle distribution on a macroscopic scale. Micro structural characterization studies were conducted on prepared samples. This was accomplished by using a microscope. The composite samples were metallographically polished prior to examination. Characterization was done in etched conditions. Etching was accomplished using Keller's reagent. There should be no cracks in the test specimen when examined immediately after it is removed from the solution, rinsed with water and wiped off. The material packed in boxes, so as to ensure the safe transportation of the material and avoid damage in transit. Material samples were prepared to standards of IS 7739, and here equipment used for the micro structural study is Nikon Microscope LV150 Clemex Image Analyser.

Micro hardness measurements were carried out in order to investigate the influence of SiC particles on matrix hardness. The load applied was 0.3kgF and micro hardness measurements were made on the particle and in its vicinity.



Casting outer surface





Centre



200X Centre 100X Outer Diameter

Fig 5. Microstructure of sample containing 5% SiC by weight, 800rpm.

Micro structure is given above for casting thickness 6mm, with mould rotation speed of 800 rpm for Al-5% SiC. Microstructure at inner diameter & centre consists of fine eutectic silicon needles and At the outer diameter primary silicon cuboids & eutectic silicon dispersed in the matrix of aluminium solid solution.



Fig 6. Microhardness of the 5% SiC weight ratio in Aluminium alloy.



- Experiments were conducted to determine the distribution of SiC particle in Aluminium alloy. As the density of the SiC particle is greater than the Aluminium, volume fraction increases at the outer surface.
- Volume fraction of Silicon carbide particles at the inner and outer periphery of the cylinder is strong function of a speed of the mould rotation. Maximum of 52% volume per cent Sic can be concentrated at the outer periphery at a speed of 1400 rpm.
- Gradient of particle distribution increases with increase of radius r for $\Delta \rho > 0$ and decrease with increase of radius r for $\Delta \rho < 0$.
- Microstructure at inner diameter & centre consists of fine eutectic silicon needles and At the outer diameter primary silicon cuboids & eutectic silicon dispersed in the matrix of aluminium solid solution.
- Hardness increased at outer surface compared to inner surface, hardness obtained at the outer surface is 76 and at inner surface it is 68.

Nomenclature

 ρ_p : Density of the particle

 ρ_l : Density of the liquid

R. Particle radius

- ϑ : Viscosity of aluminium
- $\boldsymbol{\vartheta}_{\mathbf{x}}$: Viscosity of molten metal containing particle

 $\mathbf{V}_{\boldsymbol{\epsilon}}$: Volume fraction of particle

 $V_f(t + \Delta t)$: Volume fraction at time $(t + \Delta t)$

 $r_i(t + \Delta t)$: Position of the particle at time

 $(t + \Delta t) d$, : Diameter of the particle

 $r_i(t)$ Position of particle at time t

rm : Internal radius of mould

- r : Radial coordinate
- : Angular velocity
- R: Solidification rate

 $\rho_p - \rho_l$: Difference of density

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PERFORMANCE EVALUATION OF A REAL TIME AND LOW COST 1D PHOTONIC CRYSTAL BIO-SENSING STRUCTURE

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Recently, the research interest in novel architecture of bio-sensor is increasing. But the high cost of experimental setup, design and fabrication stops many researchers to investigate with novel architectures. Moreover, the experiment oriented studies may block our focus from key behavioral aspect of the sensor. In this paper, for the first time, a system-level simulation of the novel Photonic Crystal based power based sensor has been performed. Here, we have verified the published experimental result with LUMERICAL finite difference time domain (FDTD) simulation suite. Then we use the simulator to do the detailed analysis of that new sensing structure – by taking different design parameter into consideration. The design parameter of the sensing structure are – number of teeth, length of each period, height of the teeth and the width of the teeth. These system level simulations plays a vital role during design process and can guide us with the design trade off relating among transmission slope, sensitivity, Dynamic range, filter Bandwidth and readout alignment.

Key words: Label Free Bio-sensor, Photonic- Crystal, Evanescent field, Photonic sensing structure, Power based sensor

1. INTRODUCTION

Label free optical biosensors are becoming more and more important as they facilitate real time monitoring with high sensitivity and have vast applications in biomedical research, healthcare, pharmaceuticals, environmental monitoring, homeland security, and the battlefield. Having fast, efficient, and reliable sensing devices is essential in many fields, such as medical diagnostics, food safety control, environmental control, and drug detection ^[1]. During last decades, the interest in developing highly sensitive biosensors to identify and quantify a wide range of molecules has remarkably been increased. Various kinds of the optical biosensors are proposed and demonstrated, including surface plasmonic resonance-based devices ^{[2],[3]}, optical interferometers ^{[4],[5]}, optical fiber devices ^{[6],[7]}, grating and photonic crystal structures ^{[8],[9]}, and microresonator (micro-disk, microsphere, micro-ring) biosensors ^{[10],[11]}. Label-free biosensors have the unique advantage of providing real-time quantitative information on the progress of the biochemical reaction under study and its rate without any risk of undesired effects. These effects could be due to the interference of signals produced by different labels and to the experimental uncertainty deriving from a specific particle orientation preventing the collection of the expected signal contribution. The label free sensing technique is also immune to electromagnetic interference, capable of performing remote sensing and can provide multiplexed detection within a single device ^{[2],[4]}.

Most of the integrated label free optical sensors works on evanescent field based detection principle that allows the direct monitoring of small changes in the optical properties ^{[5],[7]}. In this method bio-recognition molecules, such as antibodies are immobilized onto the surface of the optical waveguide. The evanescent field of the guided light in the waveguide extends into the surrounding medium and interacts with the bio-molecules near the waveguide surface. A small change in refractive index near the waveguide surface when target analytes are captured causes shift in the optical signal at the output and this shift acts as the sensing signal. Since the sensing signal is accumulative in nature, a longer light-analyte interaction length results in a higher sensitive sensor ^{[4],[7]}. Among different evanescent wave based label free refractive index (RI) sensing technique- the following - (1) surface plasmon resonance based biosensors; (2) optical ring resonator based biosensors; (3) photonic crystal based biosensors have major research focus. Our focus in this paper is only on novel

1 D photonic crystal power based sensor ^{[12],[13]} and we will present detailed Lumerical finite difference time domain (FDTD) simulation results on the behavior of the novel sensing structure when different structural parameter i.e. number of teeth, teeth height, teeth width etc are changed.

2. WORKING PRINCIPLE

This power based sensing technique works on the sensing structure that has transmission slope and shows spectral shift with background refractive index change. Any type of structure that demonstrates both transmission slope and spectral shift will have potential application as a power based sensor. Fig. 1 and Fig. 2, below shows the operating principle of the power based sensor- where spectral shift due to interaction of evanescent field with the medium is transferred into power change and that power change is indirectly transferred to refractive index change of the medium. The more the interaction with the evanescent field the more is the spectral shift and hence the power change from a refractive index change and the more sensitive the sensor becomes.



Fig. 1: Interaction of evanescent field with bio-molecule results in spectral shift

Here, an input optical signal with a given bandwidth (generally broadband) and a constant power density is used as excitation for the photonic sensing structure. The sensing structure filters the optical source, and the overlap of spectra of filter and source can be directly measured at the output using a simple power meter. When a variation of the refractive index (RI) of the surrounding medium occurs, it induces a shift in the spectral response of the photonic sensing structure. This is translated into a shift in the position of the spectral edge, and thus to a change in the optical power measured at the output.



Fig. 2: Power based sensing approach: spectral shift is measured as power

An increase in the RI of the surrounding medium will reduce the measured optical output power. The spectral shift can be induced both by the bulk RI variation of the surrounding medium or by the binding of a target analyte, such as a protein or DNA strand, on the sensor surface. This power variation is directly used to perform the sensing, without the need to obtain the transmission spectrum of the structure using expensive tunable laser and detector. Moreover, since the output power can be continuously monitored (several power values per second can be measured), a real-time sensing is performed, which allows an instantaneous observation of the interactions taking place in the sensing structure.

3. FDTD VERIFICATION AND SYSTEM MODEL

The classical FDTD approach is based on Yee's explicit formulation in ^[14]. Mathematical theorems for the FDTD formulation, concerning issues such as accuracy, convergence, dispersion, computational complexity and stability are provided in ^{[15], [16]}. The FDTD method has been extensively applied to simulate and analyze WGM of isolated micro-disks, micro-disks and micro-rings ^{[17], [18], [19]}. The general FDTD simulation method considers a two-dimensional (2D) problem where the z-directed optical field is normal to the x-y plane of the grid. In the simulation, the perfectly matched layer (PML) absorbing boundary condition (ABC) were introduced, providing the means to terminate the calculated grid space with extremely low reflection ^[20].



Fig. 3: Verification of the reported experimental result in [13] using Lumerical FDTD simulator

System modelling is very broad terms that include various techniques and approaches to describe a system and predict its behaviour, from simple flow charts to graphs, mathematical models or agent based modelling. To model the reported power based sensor system in ^{[12],[13]}, we designed the structure in LUMERICAL and setup an environment for FDTD simulation that give a match. From simulation we had found that the behavior of this photonic crystal based structure is heavily dependent on the fabrication uncertainty. Keeping all other simulation parameter constant, only the slight structural variation that may arise from fabrication causes two times degradation of the transmission slope as shown in left side image.



Fig. 4: Verification of the reported experimental result in [12] using Lumerical FDTD simulator

Thus, we can predict that with more stringent fabrication of sensing structure we can ensure better performance from the sensor. From FDTD simulation, we had found that the results reported in ^{[12],[13]} is in agreement with our simulation of the structures as shown in fig. 3 and fig. 4.

4. RESULTS AND DISCUSSION

As we mentioned earlier we had found that the reported result in ^{[12], [13]} is in good agreement with the LUMERICAL FDTD simulator model. And we used that model to find out the effect of different structural parameter on the key performance parameter of the sensor i.e. transmission slope.



Fig. 5: Lumerical Simulation that shows the effect of teeth height variation of the power based structure

We had found that with the increase of the periodic structure teeth height the slope of the transmission increases. But the increment of teeth width has negligible effect on the slope of transmission but it shows a down trend in slope. Most significant design component for transmission slope of the structure is the number of teeth in it.



Fig. 6: Variation of the transmission slope of the sensor when number of period is changed



Fig. 7: Variation of the transmission slope of the sensor when width of the sensor teeth is varied

As the number of teeth increases, the slope of the transmission increases very significantly but the downside is the increases of the footprint of the sensor. So to reduce the footprint for the sensor we need to select an optimum dimension that gives us a reasonable slope, beyond which the performance improvement is very negligible.



Fig. 8: Variation of the transmission slope of the sensor when height of the sensor teeth is varied

5. CONCLUSION

In summary, we had modeled the low cost, compact novel power based sensing technique in FDTD simulator LUMERICAL and matched the simulation result with the experimental reported result. We had used that model for the performance analysis of the novel system when the dimensions of the structural parameters are varied. We had found that the impact of number of periodic element in the structure play the most vital role in determining the performance of the structure. The other design dimension i.e. width of the teeth and the height of the teeth does not play a very significant role in determining the transmission slope. So, for optimum dimension of the sensing structure we should have high number of periodic element with optimum width and height.



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ATTRACTIVE & REPULSIVE PARTICLE SWARM OPTIMIZATION, ADAPTIVE PARTICLE SWARM OPTIMIZATION AND BIOLOGICAL PARTICLE SWARM OPTIMIZATION FOR SOLVING REACTIVE POWER OPTIMIZATION PROBLEM

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Reactive Power Optimization is a complex combinatorial optimization problem involving non-linear function having multiple local minima, non-linear and discontinuous constrains. This paper presents Attractive and repulsive Particle Swarm Optimization (ARPSO) the modified model uses a diversity measure to have the algorithm alternate between exploring and exploiting behaviour , Adaptive Particle Swarm Optimization (APSO) new evolutionary optimization model based on the particle swarm optimization algorithm that incorporates the flocking behaviour of a spider and Biological Particle swarm Optimization (BPSO) eliminating inferior population and keeping superior population, is helpful to make full use of population resources and speed up the algorithm convergence . All the above said algorithms is used to overcome the Problem of premature convergence. ARPSO, APSO& BPSO is applied to Reactive Power Optimization problem and is evaluated on standard IEEE 57, practical 191 test Bus Systems. The results show that BPSO prevents premature convergence to high degree but still keeps a rapid convergence. It gives best solution when compared to ARPSO & APSO.

Key words: Attractive and repulsive, particle Swarm, adaptive particle, biological particle swarm, Reactive Power Optimization.

1. INTRODUCTION

The reactive power optimization problem has a significant influence on secure and economic operation of power systems. The reactive power generation, although itself having no production cost, does however affect the overall generation cost by the way of the transmission loss. A procedure, which allocates the reactive power generation so as to minimize the transmission loss, will consequently result on the lowest production cost for which the operation constraints are satisfied. The operation constraints may include reactive power optimization problem. The conventional gradient-based optimization algorithm has been widely used to solve this problem for decades. Obviously, this problem is in nature a global optimization problem, which may have several local minima, and the conventional optimization methods easily lead to local optimum. On the other hand, in the conventional optimization algorithms, many mathematical assumptions, such as

analytic and differential properties of the objective functions and unique minima existing in problem domains, have to be given to simplify the problem. Otherwise it is very difficult to calculate the gradient variables in the conventional methods. Further, in practical power system operation, the data acquired by the SCADA (Supervisory Control and Data Acquisition) system are contaminated by noise. Such data may cause difficulties in computation of gradients. Consequently, the optimization could not be carried out in many occasions. In the last decade, many new stochastic search methods have been developed for the global optimization problems such as simulated annealing, genetic algorithms and evolutionary programming.

A major problem with evolutionary algorithms (EAs) in multi-modal optimization is premature convergence (PC), which results in great performance loss and sub-optimal solutions. As far as GAs is concerned, the main reason for premature convergence is a too high selection pressure or a too high gene flow between population individuals. With PSOs the fast information flow between particles seems to be the reason for clustering of particles.

Diversity declines rapidly, leaving the PSO algorithm with great difficulties of escaping local optima. Consequently, the clustering leads to low diversity with fitness stagnation as an overall result.

Recently R. Ursem has suggested a model called the Diversity-Guided Evolutionary Algorithm (DGEA) [1]. He redefines the traditional mutation operator, the Gaussian mutation, to be a directed mutation instead. The important issue is that this directed mutation, in general, increases the diversity, whereas normal Gaussian mutation is not likely to do this, because it simply adds random noise from some distribution with a mean of zero, normally N(0; s2). Consequently, the DGEA applies diversity-decreasing operators (selection, recombination) and diversity-increasing operators (mutation) to alternate between two modes based upon a distance-to-average-point measure. The performance of the DGEA clearly shows its potential in multi-modal optimization. As [1] rightfully pinpoints, the diversity measure is traditionally used to analyze the evolutionary algorithms rather than guide them. We are great believers of adaptive controlling; that measuring and using different properties of the swarm/population while running, adds significant potential to the algorithm. We have therefore adopted the idea from Ursem with the decreasing and increasing diversity operators used to control the population into the basic PSO model. We find, it is a natural modification of the PSO, and the idea behind it is surprisingly simple. The modified model uses a diversity measure to have the algorithm alternate between exploring and exploiting behaviour. We introduce two phases attraction and repulsion. By measuring the diversity we let the swarm alternate between these phases. As long as the diversity is above a certain threshold dlow the particles attract each other. When the diversity declines below dlow the particles simply switch and start to repel each other until the threshold dhigh is met. With this simple scheme we obtain our modified model, which we have chosen to call the ARPSO model - the attractive and repulsive PSO. APSO [6] new evolutionary optimization model based on the particle swarm optimization (PSO) algorithm that incorporates the flocking behavior of a spider. The search space is divided into several segments like the net of a spider. The social information sharing among the swarms are made strong and adaptive. The main focus is on the fitness of the swarms adjusting to the learning factors of the PSO. The traditional Particle Swarm Optimization algorithms converges rapidly during the initial stage of a search, but in course of time becomes steady considerably and can get trapped in a local optima. On the other hand in the proposed model the swarms are provided with the intelligence of a spider which enables them to avoid premature convergence and also help them to escape from local optima. The particle swarm optimization (PSO) algorithm originally was developed by Kennedy and Eberhart in 1995 [19]. PSO is suitable to both scientific research and engineering applications [20]. Moreover very few parameters are needed to be adjusted, which makes it particularly easy to implement. However, it is pointed out that although PSO can show significant performance in the initial iteration, it might encounter problems in reaching optimum solutions efficiently for several approximation problems. It is obvious that the particle swarm loses its diversity and all the particles are attracted towards the best position so far by any of particles. A lot of research work is made in order to overcome the disadvantage of PSO. Parsopouls K.E., Plagianakos V.P., Magoulas G.D., and Vrahatis M.N., [21] proposed a 'stretching' function, which consists of a two-stage transformation of the objective function, to alleviate the local minima problem. Silva A., Neves A., and Costa E [22] presented a predator prey model to maintain diversity in the swarm and prevent premature convergence to local minimum. He S., Wu O.H., Wen J.Y., Saunders J.R., and Paton R.C., [23] introduced a PSO model with passive congregation to help individuals to avoid misjudging information and becoming trapped by poor local minima. Other studies on dealing with this issue were undertaken using multiple populations in [24] and survival density concept in [25]. Inspired by the natural phenomenon of multiplication of biological population, a population multiplication particle swarm optimization (BPSO) is presented. The proposed algorithm (BPSO) has four phases of migration, selection, elimination and reproduction, evolution. Using searching optimal model of PSO in the migration phase; introducing LEVEL SET theory dividing population to be able to facilitate the selection operation in the selection phase; speeding up the algorithm convergence by abandoning the inferior population, reproducing superior population and making full use of population resource in the phase of elimination and reproduction; creating new population to keep the diversity to avoid monotone of the algorithm in the last evolutionary phase. The proposed approaches have been evaluated in standard IEEE 57 bus, practical 191 test systems.

2. PROBLEM FORMULATION

The objective of the reactive power optimization problem is to minimize the active power loss in the transmission Network as well as to improve the voltage profile of the system. Adjusting reactive power controllers like Generator bus voltages, reactive Power of VAR sources and transformer taps performs reactive Power scheduling.

$$= \sum_{i=1}^{NB} P_i(X, Y, \delta) \qquad \dots \qquad (1)$$

Subject to

min PL

i)	The	control	vector	constraints
- 1	1 110	control	100101	constraints

	$X_{min} \leq X \leq X_{max}$	(2)
ii)	The dependent vector constraints	 (2)
	$Y_{min} \leq Y \leq Y_{max}$	 (3)

and

iii) The power flow constraint	
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W

horo	F(X, Y, d) = 0	 (4)
liere	X = [VG, T, QC] $Y = [Qg, VL, I]$	 (5) (6)

NB Number of buses in the system. Vector of bus phase angles d Pi Real Power injection into the i

th bus

VG	-	Vector of Generator	Voltage Magnitudes

Т Vector of Tap settings of on load Transformer Tap changer.

- OC Vector of reactive Power of switchable VAR sources.
- VL Vector of load bus Voltage magnitude.
- Ι Vector of current in the lines.
- PL Vector of current in the lines.

3. BASIC PSO MODEL

The basic PSO model consists of a swarm of particles moving in an n-dimensional, real valued search space of possible problem solutions. For the search space, in general, a certain quality measure, the fitness, is defined making it possible for particles to compare different problem solutions. Every particle has a position vector x and a velocity vector v. Moreover, each particle contains a small memory storing its own best position seen so far p and a global best position g obtained through communication with its fellow neighbor particles. This information flow is obtained by defining a neighborhood topology on the swarm telling particles about immediate neighbors.

The intuition behind the PSO model is that by letting information about good solutions spread out through the swarm, the particles will tend to move to good areas in the search space. At each time step t the velocity is updated and the particle is moved to a new position. This new position is simply calculated as the sum of the previous position and the new velocity:

(7)

$$\vec{x}(t+1) = \vec{x}(t) + \vec{v}(t+1)$$

The update of the velocity from the previous velocity to the new velocity is, as implemented in this paper, determined by:

$$\vec{v}(t+1) = \omega \cdot \vec{v}(t) + \phi_1(\vec{p}(t)) + \phi_2(\vec{g}(t) - \vec{x}(t)),$$
(8)

where f1 and f2 are real numbers chosen uniformly and at random in a given interval, usually [0,2]. These values determine the significance $\vec{p}(t)$ and $\vec{g}(t)$ of respectively. The parameter w is the inertia weight and controls the magnitude of the old velocity in the $\vec{v}(t)$ calculation of the new velocity $\vec{v}(t+1)$.²

4. ATTRACTIVE AND PARTICLE SWARM OPTIMIZATION (ARPSO)

We define the attraction phase merely as the basic PSO algorithm. The particles will then attract each other, since in general they attract each other in the basic PSO algorithm because of the information flow of good solutions between particles. We define the second phase repulsion, by "inverting" the velocity-update formula of the particles:

$$\vec{v}(t+1) = \omega \cdot \vec{v}(t) - \phi_1(\vec{p}(t) - \vec{x}(t)) - \phi_2(\vec{g}(t) - \vec{x}(t)).$$

(9)

In the repulsion phase the individual particle is no longer attracted to, but instead repelled by the best known particle position vector g(t) and its own previous best position vector p(t).

In the attraction phase the swarm is contracting, and consequently the diversity decreases. When the diversity drops below a lower bound, dlow, we switch to the repulsion phase, in which the swarm expands due to the above inverted update-velocity formula (9). Finally, when a diversity of dhigh is reached, we switch back to the attraction phase. The result of this is an algorithm that alternates between phases of exploiting and exploring – attraction and repulsion – low diversity and high diversity. The pseudo-code for the ARPSO algorithm is shown in Fig. 1 and 2.

Program PSO init();; while not done do setDirection(); //new! update Velocity(); newPosition (); assginFitness(); calculateDiversity(); // new!

Figure 1: The ARPSO algorithm.

Function setDirection if (dir > 0 && diversity < dLow) dir = -1; if (dir > 0 && diversity < dHigh) dir = 1;

Figure 2: setDirecton

The first of the two new functions, setDirection determines which phase the algorithm is currently in, simply by setting a sign-variable, dir, either to 1 or -1 depending on the diversity. In the second function, calculateDiversity, the diversity of the swarm (in the pseudo-code stored in the variable "diversity"), is set according to the diversity-measure:

diversity
$$(S) = \frac{1}{|S| \cdot |L|} \cdot \sum_{t=1}^{|S|} \sqrt{\sum_{j=1}^{N} p_{ij} - \overline{p}_{j}}^{2},$$
 (10)

where S is the Swarm, [S] is the swarmsize, [L] is the length of longest the diagonal in the search space, N is the dimensionality of the problem, pij is the j'th value of the I'th particle and pj is the j'th value of the average point p. Note that this diversity measure is independent of swarmsize, the dimensionality of the problem as well as the search range in each dimension.

Finally, the velocity-update formula, eqn. (9) is changed by multiplying the sign-variable direction to the two last terms in it. This decides directly whether the particles attract or repel each other:

$$\upsilon(t+1) = \omega .\upsilon(t) + dir\left(\phi_1(p(t) - x(t)) + \phi_2(g(t) - x(t))\right).$$
(11)

5. ADAPTIVE PARTICLE SWARM OPTIMIZATION (APSO)

Three modifications have been performed on the PSO algorithm to form the new algorithm named Adaptive Particle Swarm Optimization (APSO).

A. First Modification The whole search space is divided into several segments like the net of a spider. Thus, the new algorithm generates an initial population with a uniform distribution of solutions such that every segment has solutions. By the traditional methods the initial population was created randomly where they are very much dependent on mutation operator.

By dividing the whole search space into several segments

Improves the search capability of the proposed algorithm instead of just relying on the use of a mutation operator. Having individuals in every segment would give better searching capability.

B. Second Modification In the proposed model – the information sharing part of the swarms are made very strong. Every swarm shows interest or takes information from all other swarms that have better fitness value than its own. The swarms that have better fitness value will guide other swarms to improve their fitness value. As it is not considering only the global best solution, there is a very little chance of this model to be trapped by local optima. This idea is taken from the flocking behaviour of a spider. For instance, to minimize a function four individuals a, b, c, d is considered and their fitness values are shown fig 3.

Individual	а	b	с	d
Fitness value	10	25	50	75

Fig 3. Individual and fitness

C. Third Modification The new algorithm uses the fitness value to adjust the learning factors (c1 and c2) of the swarms. In the traditional PSO, the fitness is never used. But in the proposed model - how much interest a swarm should show on others, is based on the fitness value of the swarm. All the swarms will be ranked according to their fitness value. The swarm having smallest (in the case of function minimization) fitness value is ranked 1, and the others will be ranked in this way. When a swarm is followed by some other swarms – it shows interest according to their ranks.

D. The velocity update equation of Adaptive PSO:

The velocity update equation of the APSO is as follows

 $Vi = Vi * wi + 1/rank(i) * rand() * (pbest[i] - Xi) + Social_Information(i);$

```
Xi = Xi + Vi;
```

```
Where,
Social_Information(i)
{
    posx ← 0.0
    for each individual k of the population
        if pFitness[k] is better than fitness[i]
        posx ← posx + 1 / rank(k) * rand() *
        ( pbest[k]- Xi );
```

```
if(posx > Vmax) return Vmax;
else return posx; }
```

Here pFitness[k] represents the best local fitness value seen by individual k. fitness[i] indicates the current fitness value of the swarm. The Social_Information() module gives the direction of the swarm by sharing information with all other individuals that have better fitness value. Vmax have been set with a small value to prevent a jump. The value of the posx may be very large. Rather than getting the value of posx, the proposed algorithm is more interested to get the direction from the Social_Information() module. The value of Vmax is automatically assigned to the swarm. If a swarm has less rank, then its Vmax would be assigned with less value, and If the swarms rank is large, then it's Vmax will be assigned with larger value. By assigning the value of Vmax in this way, the swarms are ensured to have a good local search, and can come out from the worse position very fast.

6. BIOLOGICAL PARTICLE SWARM OPTMIZATION

In nature, each population will search food in order to multiply. As we all know that the rule of survival of the fittest, original but effective, exits in the process of searching food. In this paper, we introduced this rule to PSO algorithm eliminating inferior population and keeping superior population. It is helpful to make full use of population resources and speed up the algorithm convergence. In the selection phase, classifying successfully by using LEVEL SET theory make the algorithm accord with the principle of survival of the fittest. At the same time, we also take into account the evolution of population to keep the diversity of the population which can prevent the monotone and prematurity of the algorithm. Finally, the algorithm is applied to some test functions to verify its feasibility and effectiveness.

Standard particle swarm optimization (SPSO)

PSO was presented by Kennedy and Eberhart [19] in 1995. In the PSO system, a number of particles coexist and cooperate to find optimization. Each particle "flies" to a better position in problem space in accordance with its own "experience" and the best "experience" of the adjacent particle swarm, searching the optimal solution.

Mathematical notation of PSO is defined as follow: Assume searching space is D-dimensional and the total number of particles is n. The ith particle location is denoted by the vector: Xi=(xi1, xi2,..., xiD); The past optimal location of the ith particle in the "flight" history (that is, the location corresponds optimal solution) is Pi=(pi1, pi2,..., piD). The past optimal location Pg of the gth particle is optimal in all of Pi(i=1,2,...,n); The location changing rate (speed) of the ith particle is denoted by the vector Vi=(vi1, vi2,..., viD). The location of each particle changes by the following formula:

vid(t+1)=wxid(t)+c1rand()(pid(t)-xid(t))+c2rand()(pgd(t)-xid(t))	(12)
$Xid(t+1)=xid(t)+vid(t+1), (1 \le i \le n, 1 \le d \le D)$	(13)

c1, c2 are positive constants called accelerating factor; rand() is a random number between 0 and 1; [Xmin, Xmax] is the changing range of particle location. [vmin, vmax] is the changing range of speed. If the location and speed exceed boundary range in iteration, given boundary value. w is called inertia factor; w, setted a litter bigger , is suited to a wide range of exploration to solution space while smaller is suited to a small range.

B. The shortcomings of conventional PSO algorithm As shown in Fig. 4, each particle of PSO closes to historical optimal location and global optimal location. This makes PSO algorithms have many advantages, such as that their computational complexity doesn't increase with the rising of the dimension of the problem, and rapid convergent speed, etc. However, they still have some shortcomings, which are listed as follows:

Shortcoming 1: When the conventional PSO searches, the particles tend to get close to the better particles. This property would make the algorithm find out the optimal solution as soon as possible, however, this property is also a flaw that could result in premature convergence. That is, when all the particles constantly get close to the better ones, all the particles in the system would be probably concentrated in a local optimal solution. At this situation, it is a pity that all the particles cannot jump out of the local optimal solution they have approached. Fig. 5illustrates such phenomenon: From Fig. 5, it can be seen clearly that particles don't find the global optimal solution but concentrate to a local optimal solution. At this time, they no longer have the abilities to get rid of the attraction of the local optimal solution, and result in premature convergence.

Shortcoming 2: The speeds of particles are too great. When particles are located in some local, the objective function is quite sensitive to the slight changes of particles. Thus, at this time, too great speed of the particle is not suitable; meanwhile, too little speed would influence the speed of convergence. We can see from Fig. 6 that though particle is attracted by the optimal solution, and motion toward the optimal solution. Nevertheless, because the speed of particle is too great, it would easily miss the optimal solution.



Fig 4. Sport of the particle



The above shortcomings in PSO algorithm are like some flies in the ointment. To make up those weaknesses existing in PSO, the following text would give some concrete schemes, which include MDPSO algorithm to overcome the first shortcoming as well as numerical level weight to control the speed for deal with the second shortcoming.

A. PSO ALGORITHM BASED ON BIOLOGICAL POPULATION MULTIPLICATION

Biological population multiplication

In nature, populations search food in order to multiply. As we all know the rule of survival of the fittest, original but effective, exits in the process of searching food. First of all, we assume that some biomes are dotted in a region. Each of them migrates to search food as well as a more suitable place for survival. In the Fig. 7, this article assumes that there are four communities, p1, p2, p3, p4, in a region, Because of the need looking for food, community migration is called respectively: P1, P2, P3, and P4. And after that, the survival of the fittest begins. Among them, P3 and P4 successfully accepted the test to continue to survive, besides P3 takes further reproduction to extend the community due to good environment; P1, tortured by the nature, evolves eventually to become P1' adapting to the environment; but P2 has to be eliminated because it is hard to find suitable places to survive. This mode of biomes multiplication not only washes out the inferior population and keeps the superior ones, but also stimulates the evolution of population to adapt to the survival environment. For this right mode, hundreds of thousands of biological communities could survive and continue.



B. Improved PSO Algorithm Based on the Population

Multiplication

We know that in PSO algorithm, each particle moves towards the global optimal location and the optimal location of individual history as a criterion to find a better location for survival. This model allows algorithm has a good convergence, but also maintains a good searching performance. In Fig. 8, after a round of movement, the particles all have new locations A1, B1, C1, D1, E1 and F1. However, each new particle continues to search optimization directly without the process of survival of the fittest in the next movements, illustrated as shown in Fig. 9. However, this movement in PSO makes some inferior particles continue to reproduce to become inferior communities unable to be eliminated which affects the algorithm convergence rate. At the same time the resource of particle swam cannot be fully utilized. That is because the quantity of particles affects the algorithm efficiency while the quality of particles does the same. In order to overcome this disadvantage, the paper presented an improved PSO algorithm with the principles of biologic population multiplication. The algorithm is divided into four phases: migration, selection, elimination and reproduction, evolution.

Migration

We introduce the concept of migration to the new algorithm. The population migration is similar to the changes of the particles location in PSO, one changes for the survival of population while the other is for a better location. And the migration of population is also affected by two factors: history experience and communication experience. The history experience just means searching the optimal location of individual and communication experience is for the global optimal location in PSO.



Fig 8 . The movement of first generation particles, each of them moves to search a better place



Fig 9 . Traditional PSO algorithm: Each particle gets location of the next particle after the previous round and continues to move

So at this phase, the new algorithm and PSO algorithm look like the same (maybe only the name is different). We will still use the speed changing (12) and location changing (13) of PSO. In the (12), the value w is fixed. w, set a litter larger, is suit to a wide range of exploration to solution space while smaller is suit to a small range. At the early convergence, the larger w can speed up the convergence, while in the latter the smaller w can improve the capacity of searching optimization. Therefore, this paper defines the w as follow:

```
w(i)=wmax-i(wmax-wmin)/N
```

(14)

Here, w(i) is alterable (maybe degressive more exactly), wmax, wmin $\in (0, 1)$.

Selection

At selection phase, we need to judge which population will be eliminated and reproduce and how much they reproduce. This requires that all population should be divided into two parts: the superior ones and the inferior ones. LEVEL SET theory is introduced here. For the tth-generation P(t) = (P1, P2, ..., Pn), n denotes the number of particles, the fitness function of of particles is set to fi(x), order

$$\hat{\mathbf{f}} = \sum_{i=1}^{n} \frac{f(\mathbf{x}_i)}{n}$$
(15)

 $Hft= \left\{ x_{j} \in P(t) | f(x_{j}) \leq \mathbb{D}t , 1, 2, ..., n \right\}$

(16)

Where t denotes tth-generation ft, H is called the level set about f relative to P(t). After that the population of each generation can be divided two parts [26].

Selection steps are as follows:

a) Set the initial population for X = (X1, X2, ..., Xn);

b) Calculate the fitness of each population;

c) Calculate the mean of fitness

d) According to the method of Step c), Xb is divided into Xc and Xd, between them Xc stands for the better population, and Xd for the poorer population.

e) The population number in Xd is nd. So we select randomly nd-pm in Xa+Xb+Xc for reproducing. pm is the number of evolution population discussed below.

Elimination and Reproduction

When population arrives in a new environment, which is too bad to adapt to, the entire population has to be extinct which is called elimination. However, when they arrive an eminent environment, they will be developed and reproduce. This concept introduced in new algorithm is completely different with the PSO algorithm. Fig. 9 has illustrated the particle change of PSO algorithm, changes of the improved PSO algorithm is as follows in Fig. 10:



Fig 10. Particle movement in the BPSO

The difference between Fig. 9 and Fig.10 is B1, D1, and F1 are all eliminated and disappear while A1, C1, and E1 take a further reproduction because of good environment and continue to the next migration. At the reproduction phase, combining the merits of PSO algorithm (memory individual information) and the characteristics of biomes multiplication (population reproduction) makes the post-breeding population memory the mother possible. For example C1 reproduces two populations: C1' and C1", both of them will inherit the memory of C1 (memory includes the individual optimal location and current location of C1), and then migrate respectively to get C11 and C12.

Evolution

The reason why biological population is able to keep balance is not only the extinction of population but also the evolution of population. This constant evolution creates a lot of new population, which makes the whole system keep

balance. This evolution is worth thinking, the phase of that is also contained in our algorithm. It makes the number of population hold the line, of course, more important; it will not become the monotonous population. Mentioned above, it is said that there are pm populations to evolve, that is to say, it will creates pm new populations. However, we know that only the location can distinguish the differences in solution space. So pm populations evolve means generating randomly pm new solutions.

Algorithm of BPSO

- a) Initialize parameters and set the number of evolution population for pm;
- b) Initialize population X = (X1, X2, ..., Xn);
- c) Calculate the fitness of each population;
- d) Selection operation;
- e) Reproduction and elimination operation;
- f) Evolution operation;
- g) Migration operation according to (2);
- h) End if the migration algebra arrived; otherwise go to c.

7. ALGORITHM FOR REACTIVE POWER OPTIMIZATION

Step 1. Initial searching points and velocities of agents are generated.

Step 2. Ploss to the searching points for each agent is calculated using the load flow calculation. If the constraints are violated, the penalty is added to the loss (evaluation value of agent).

The fitness function of each particle is calculated as:

$$f_{n} = P_{L}^{n} + \alpha \sum_{j=1}^{NG} Q_{G,j}^{\lim, n} + \beta \sum_{j=1}^{NL} V_{L,j}^{\lim, n} ; n = 1,2.., N_{n}$$

$$\dots \qquad (17)$$

a, b = penalty factors PnL = total real power losses of the n-th particle

$$Q_{G, j}^{\lim, n} = \begin{cases} Q_{G, \min} - Q_{G, j}^{n} & \text{if } Q_{G, j}^{n} < Q_{G, \min} \\ Q_{G, j}^{n} - Q_{G, \max} & \text{if } Q_{G, j}^{n} > Q_{G, \max} \end{cases}$$
.... (18)

and

$$V_{\mathrm{L},j}^{\lim,n} = \begin{cases} \left| V_{\mathrm{L},j}^{n} \right| - V_{\mathrm{L},\max}, & \text{if } \left| V_{\mathrm{L},j}^{n} \right| > V_{\mathrm{L},\max} \\ 0 & \text{otherwise} \end{cases}$$

(19)

Step 3. Pbest is set to each initial searching point. The initial best evaluated value (loss with penalty) among pbests is set to gbest.

Step 4. New velocities are calculated .

Step 5. Update the velocity from previous velocity to the new velocity.

Step 6. To new function applied.

i. setdirection

ii. calculateDiversity to control swarm.

Step 7. Ploss to the new searching points and the evaluation values are calculated.

Step 8. If the evaluation value of each agent is better than the previous pbest, the value is set to pbest. If the best pbest is better than gbest, the value is set to gbest. All of gbests are stored as candidates for the final control strategy.

Step 9. If the iteration number reaches the maximum iteration number, then stop. Otherwise, go to Step 4. If the voltage and power flow constraints are violated, the absolute violated value from the maximum and minimum boundaries is largely weighted and added to the objective function (1) as a penalty term. The maximum iteration number should be determined by pre-simulation. As mentioned below, PSO requires less than 100 iterations even for large-scale problems.

8. SIMULATION RESULTS

The proposed ARPSO, APSO & BPSO based RPO problem has been tested on standard IEEE 57, 191 (practical) bus test systems.

Vmin - 0.95, Vmax - 1.05, Tmin - 0.9, Tmax - 1.1,

For IEEE 57-Bus

NG = 7, NB = 57, NTR = 17 NQ = 5

Table 1. Optimum Reactive Power schedule values obtained For IEEE 57-bus system

	ARPSO	APSO	BPSO
No. of iteration	169	161	153
Population size	24	24	24
Time (sec.)	30.03	29.05	25.11
Loss (MW)	25.452	24.992	22.899



Figure 11. Convergence characteristics of IEEE 57-bus system

For Practical 191-Bus NG = 20, NL = 200, NB = 199 NTR = 55

Table 2. Optimum Reactive Power schedule values obtained for practical 191 utility (Indian) systems.

	ARPSO	APSO	BPSO
No. of iteration	232	226	219
Population size	24	24	24
Time (sec.)	62.5	54.4	49.9
Loss (MW)	145.391	144.287	142.192
200 150 3 100 50 0 50	 100 150 terations	200	— Arps — Apso — Bpso

Figure 12. Convergence characteristics of practical 191 utility system

	VG1		1.05		
	VG2		1.03		
	VG3		1.04		
	VG4		1.03		
	VG5		1.03		
	VG6		1.02		
	VG7		1.02		
T1	1.05		T1	1	0.99
T2	0.93		T1	2	0.94
Т3	0.92		T1	3	0.90
T4	0.93		T1	4	0.93
T5	0.93		T1	5	0.94
Т6	0.90		T1	6	0.93
Т7	0.92		T1	7	0.97
T8	0.91				
T9	0.93				
T10	0.91				
Q1	Q2	Q3		Q4	Q5
0.04	0.02	0.05		0.04	0.07

Table 3. Optimal Control values of Standard IEEE 57-bus system

Table 4. Optimal Control values of Practical 191 utility (Indian) systems

VG1	1.19	VG 11	0.91
VG 2	0.83	VG 12	1.02
VG 3	1.07	VG 13	1.06
VG 4	1.01	VG 14	0.99
VG 5	1.11	VG 15	1.01
VG 6	1.19	VG 16	1.09
VG 7	1.13	VG 17	0.90
VG 8	1.03	VG 18	1.01
VG 9	1.11	VG 19	1.14
VG 10	1.06	VG 20	1.11

T1	1.02	T21	0.90	T41	0.90
T2	1.08	T22	0.98	T42	0.93
Т3	1.09	T23	0.99	T43	0.97
T4	1.10	T24	0.98	T44	0.99
T5	1.03	T25	0.95	T45	0.98
Т6	1.08	T26	1.00	T46	0.92
Τ7	1.05	T27	0.97	T47	0.98
Т8	1.07	T28	0.94	T48	1.06
Т9	1.06	T29	1.07	T49	0.95
T10	1.03	Т30	0.93	T50	0.96
T11	0.98	T31	0.97	T51	0.99
T12	1.07	Т32	0.94	T52	0.97
T13	1.09	T33	1.07	T53	1.03
T14	1.04	T34	0.93	T54	0.94
T15	1.01	T35	0.90	T55	0.91

9.CONCLUSION

In this paper ARPSO, APSO & BPSO algorithm has been developed for determination of global optimum solution for reactive power optimization problem. The BPSO introduces the survival of the fittest rules of biomes multiplication to PSO algorithm, eliminating inferior population and keeping superior population. It is helpful to make full use of population presources and speed up the algorithm convergence. At selection phase, the successful classification of the population by LEVEL SET theory makes the algorithm accord with the principle of survival of the fittest. At the same time, taking into account the evolution of population can make it keep diversity, which prevents the algorithm becoming monotonous and precocious. These new improvements enhance optimization accuracy and convergence speed of the traditional PSO as well as the capacity PSO algorithm solves complex problems. The performance of the proposed algorithm demonstrated through its evaluation on standard IEEE 57, practical 191 utility bus power systems. Results show that BPSO is able to undertake global search with a fast converges rate and a future of robust computation. From the simulation study it has been found that BPSO converges to the global optimum than ARPSO and APSO.



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PUBLIC KEY INFRASTRUCTURE AND TRUST OF WEB BASED KNOWLEDGE DISCOVERY

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ABSTRACT

A variety of authentication methods to verify the identity of valid users can be implemented with digital certificates, including shared secret and token cards. For a large extranet implementation, the easiest method is public key infrastructure (PKI) using digital certificates. Digital certificates and cryptography are functions that are often not managed appropriately. Cryptography keys must be handled carefully from purchase to installation, proper handling and secure destruction. Thousands of keys typically have to be managed on desktops and servers. Compromise of cryptographic keys is a serious breach of trust. It is difficult for support users to identify when cryptographic keys have been hacked. This paper presents PKI and trust for knowledge discovery based on web data.

Keywords: PKI, Knowledge Discovery, CA, Web of Trust, X.509

1. INTRODUCTION

Public key cryptography is suitable for distributed and dynamic environments, with a medium or big number of communicating parties sending data through insecure channels. In fact, it provides a secure communication method for recipients not previously known each other. Crucial to the operation of a global public key cryptosystem on the Internet is a practical and reliable method for publishing the public keys, called a PKI [1] [3]. Trust management and negotiation is becoming an important aspect of secure knowledge management. When knowledge is shared across and within organizations, the parties involved have to establish trust rules for collaboration. Therefore, trust management plays an important role in knowledge management. The computer science community is responding to both the scientific and practical challenges presented by the need to find the knowledge adrift in the flood of data. Knowledge discovery is the nontrivial extraction of implicit, previously unknown, and potentially useful information from data. A pattern that is interesting (according to a user-imposed interest measure) and certain enough (again according to the user's criteria) is called knowledge. The output of a program that monitors the set of facts in a database and produces patterns in this sense is discovered knowledge. Knowledge discovery developed out of the data mining domain, and is closely related to it both in terms of methodology and terminology. The most well-known branch of data mining is knowledge discovery, also known as Knowledge Discovery in Databases (KDD). Just as many other forms of knowledge discovery it creates abstractions of the input data. The knowledge obtained through the process may become additional data that can be used for further usage and discovery. Web mining, defined as "the application of specific algorithms to a web data set for the purpose of extracting data patterns", focuses on improving the utility of large web data sets as well as IR response. Web mining, in particular the algorithms used in web mining, has received a lion's share of attention in the development of Decision Support Systems (DSS), Data Mining and RDMS research because results are often immediately applicable in high-payoff decision-making industries such as insurance, sales, and financial and medical services [2]. While this paper provides an overview of secure knowledge management, it focuses mainly on PKI, trust, and privacy aspects. Section 2 provides an overview of Digital

Certificates and PKI as well as aspects of CA, Simple PKI and Web of Trust. Aspects of web based knowledge discovery are discussed in Section 3. The paper is concluded in Section 4.

2. DIGITAL CERTIFICATES AND PKIS

In cryptography, A PKI is an arrangement that binds public keys with respective user identities by means of a certificate authority (CA). Public Key Infrastructure is an architecture introduced to increase the level of security for data exchanged over the Internet. Basically, the term PKI can be defined in two ways, one is the method, technology and technique used to create a secure data infrastructure, and another is the use of the public and private key pair to authenticate and to proof the content. Generally, A PKI is a set of hardware, software, people, and procedures needed to create, manage, store, distribute and revoke public key certificates. PKI uses a mathematical technique called public key cryptography which uses a pair of related cryptographic keys in order to verify the identity of the sender (through signing) and/or to ensure privacy (through encryption of data). A public key certificate (also known as a digital certificate or identity certificate) is an electronic document which uses a digital signature to bind a public key with identity information such as the name of a person or an organization, their address, and so forth. The certificate can be used to verify that a public key belongs to an individual. A digital signature is a unique encrypted numerical value. A digital signature differs each time it is generated and is mainly used in relation to signing documents of data, picture software and so on thus proving the ownership or copyright of the data [4].



Fig. 1 Digital Signature

To create a digital signature, the signing transmitter creates a Manipulation Detection Code (hash) of the message and then uses an exclusively transmitter-owned private key to encrypt the hash. This is the digital signature and it is attached to the real message (message expanding). A user of the popular encryption software Pretty Good Privacy (PGP) has the ability to generate own digital certificates. These certificates are called self-signed certificates because it is signed by the user of the software him/herself and does not need to go to a separate identity certifying authority like the government, post-office, international chamber of commerce, etc. in order to certify that their identity is valid. The main benefits of PKIs are:

- Users have a certainty of the quality of data sent and received electronically.
- They have assurance of the source and destination of the data.
- Users also have the assurance of the time and timing of the data provided the source of time is known.
- They have certainty of the privacy of that data.
- They also have the assurance that the information may be introduced as evidence in a court of law.

The term trusted third party (TTP) may also be used for CA. The term PKI is sometimes erroneously used to denote public key algorithms, which do not require the use of a CA. There are three approaches to getting PKI trust [5]:

Certificate Authority A third-party organization or company that issues digital certificates those have to create digital

signatures and public-private key pair. The role of CA in the process is to guarantee that the person really unique certificate. Usually, this means that CA is like a credit card company, which it claims to confirm the identity of a person provides information as to an arrangement with a financial institution. CA is a key component in data security and electronic commerce because they are guaranteed that the two parties exchanging information are really who they claim to be. As part of a PKI, a CA checks with a registration authority (RA) to verify information provided by the requestor of a digital certificate. If the RA verifies the requestor's information, the CA can then issue a certificate. A CA performs the following main functions:

- Issues users with keys/Packet Switching Exchanges (PSEs) (though sometimes users may generate their own key pair)
- Certifies users' public keys
- Publishes users' certificates
- Issues certificate revocation lists (CRLs)

PGP Web of Trust PGP is a widely used E-mail security package that relies heavily on public-key encryption. The tool that enables widespread use of PGP is the public key certificate, which has the following essential ingredient: the public key. A user ID which includes the name and E-mail address of the owner of the key and one or more digital signatures for the public key and User ID. To manage public key certificates, PGP supports a 'web of trust,' in which individuals sign each other's keys and create an interconnected community of public-key users. PGP was released by Phil Zimmerman in the early 1990s. It has the following characteristics, as described by Dwaine Clarke in [6]:

- 1. It is egalitarian: There is no hierarchical structure in PGP and all public keys are free to issue certificates. In comparison to X.509, every public key in PGP is a Certification Authority.
- 2. Binding names to public keys: PGP also suffers from the flaws of X.509 where it looks to bind a global name to a public key. This is usually a user's email address.
- 3. Web of Trust: PGP users build paths of trust among themselves in a distributed manner. Users may trust other users to vouch for the authenticity of certain public keys. Thus, PGP users actually function as CAs themselves, while still allowing any user to issue certificates for any other PGP user. Consequently, there are a number of certification paths leading through different CAs. Trust is truly distributed in this case.

PGP implements that model by allowing people to sign each other's keys assigning to each of the keys a level of trust and validity. PGP assumes that a certificate binds a key to a person. That person chooses a name to identify them self and also provide an email address as a global identifier. When a user signs another user's key, the signing user is asserting that they have verified that the key truly belongs to the listed user and that it is valid. This method of signing keys leads to an ad-hoc network of trust. Because of the shape of the resulting graph, Phil Zimmerman called this system the "Web of Trust". The system allows users to specify how much trust to place in a signature by indicating how many independent signatures must be placed on a certificate for it to be considered valid [7].

2.3 Simple PKI The Simple Distributed Security Infrastructure (SDSI) [8] was designed in 1996 by Ron Rivest and Butler Lampson at the Massachusetts Institute of Technology. Its main goal, according to [6], was .to facilitate the building of secure, scalable, distributed computing systems.. Around the same time, the Simple Public Key infrastructure (SPKI) [9] was proposed by Carl Ellison for a simple public key infrastructure authorization model. These two proposals were merged in 1998 to form SPKI/SDSI.

One of the main reasons SPKI/SDSI was proposed was to provide a flexible and lightweight authorization model as compared to X.509. Moreover, the model was to be public key centric so that principals would be truly unique. SPKI/SDSI works by combining a public key with a set of attributes to form an authorization certificate, unlike its counterpart X.509 which forms an Attribute Certificate by binding a Distinguished Name to a public key. SPKI/SDSI can also create Identity certificates binding names to public key but they are not used for authorization decisions.

Kind of Certificate	Certification Authority Characteristics	Kind of Identifier
X.509	Cross-Certification, Naming authority hierarchies, Cer- tification Practice Statement	Global by original definition, but local in practice (X.500 Distinguished Name, chosen by and hopefully unique to the issuing CA)
PGP	Web of Trust = multiple path of certification, to achieve fault tolerance in compensation for the fact that amateur certifiers are signing certificates	Global (e-mail name, globally unique but maybe not persistent)
SPKI/SDSI	Key Centric, Egalitarian, Groups, Delegation, Authori- zation Flow, S-Expressions	Local (arbitrary)

Table 1 Comparison of Certificate Types

3. WEB BASED KNOWLEDGE DISCOVERY

Data mining term is used interchangeably with KDD. In reality, it is one of the steps in the whole process of knowledge discovery in databases. Data Mining needs a well defined business case and a diligent data preparation and has to be followed with a detailed evaluation of the discovery results. When knowledge discovery based web data that time it relate Web Mining. Knowledge about the content of the database can also help make the discovered knowledge more meaningful to the end user. Because discovery is computationally expensive, additional knowledge regarding the form and content of data, the domain(s) described by the database, the context of a particular discovery episode and the purposes being served by discovery are often used to guide and constrain the search for interesting knowledge. We refer to this form of information as domain knowledge or background knowledge. Domain knowledge assists discovery by focusing search. However, its use is controversial because by telling a system what to look for and where to look for it, domain knowledge restricts search and can deliberately rule out valuable discovery. Background knowledge can take on a number of different forms [10]. Data dictionary knowledge is the most basic and least controversial form of domain knowledge. Interfiled knowledge, such as weight and height being positively correlated and interinstance knowledge, such as knowing that federal regulation requires the largest charge for handicapped customers be no more than the average charge for regular customers, are closely related to the data but move toward the semantics of the domain. According to data dictionary knowledge, one shouldn't add age to hair-color, but it's a matter of domain knowledge that taking the sum of age and seniority makes sense, but adding age to weight does not. Knowledge about the content of the database can also help make the discovered knowledge more meaningful to the end user. Domain knowledge is usually provided by a domain expert, although it is possible for domain knowledge to be discovered, suggesting a bootstrapping approach.

The knowledge discovery process (KDP), also called knowledge discovery in databases, seeks new knowledge in some application domain. It is defined as the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data. The process generalizes to non-database sources of data, although it emphasizes databases as a primary source of data. It consists of many steps (one of them is Data mining), each attempting to complete a particular discovery task and each accomplished by the application of a discovery method. Knowledge discovery concerns the entire knowledge extraction process, including how data are stored and accessed, how to use efficient and scalable algorithms to analyze massive datasets, how to interpret and visualize the results, and how to model and support the interaction between human and machine. It also concerns support for learning and analyzing the application domain. The KDP model was first discussed during the inaugural workshop on Knowledge Discovery in Databases in 1989 [11].



Fig 2 Knowledge Discovery Processes

4. CONCLUSION AND FUTURE WORK

PKI is a complex subject and still evolving in terms of its utilization in the knowledge discovery. Although the underlying technology is quite sound, issues exist in area such as interoperability and performance. Nonetheless, PKI offers considerable benefits to those in need of the basic security services described in this paper. In order to use PKI, we must possess a digital certificate. We have stressed that security has to be incorporated into the knowledge-management lifecycle.

There are many areas that need further work. First, we need to develop a methodology for secure knowledge management. Finally, privacy issues need to be investigated further.



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HEAT MODEL ANALYSIS DURING MACHINING OF AI-AI₂O₃ MMC BY YTTERBIUM FIBER LASER: A REVIEW

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This paper presents a review of experimental study of heat model during machining of $Al-Al_2O_3$ MMC by of Ytterbium fiber laser. A comprehensive mathematical model for correlating the interactive and higher-order influences of Ytterbium fiber laser machining parameters such as laser power, modulation frequency, gas pressure, wait time, pulse width on metal removal rate and tapering phenomena has been developed for achieving controlled over fiber laser machining process. Test results reveal that near centre of the drilled hole some thermal stress is developed. *Key word: Ytterbium fiber laser machining, thermal stress, conduction, convection, radiation*

1. INTRODUCTION

Due to excessive thermal erosion from the kerf sites Laser machining of a thick $Al-Al_2O_3$ MMC sheet, results in poor product quality. In this paper, micro holes have been drilled by ytterbium fiber laser in 5 mm thick $Al-Al_2O_3$ MMC. A mathematical heat flow model has been developed. Scanning electron microscopy (SEM) is carried out to examine the micro hole.

An Ytterbium laser machine YLR 1000 with CNC system RP 3015 was used for experiments. The experimental scheme has been designed in such a way as to explore the influence of the various predominant laser machining process parameters, based on response surface methodology to obtain the optimal scheme for multi-variable experimentation and to perform investigations for exploring the interactive and higher order effects of the various parameters on the most important machining characteristics. Fig.1 shows Ytterbium laser drilling setup used for drilling of Al/15 wt%Al₂O₃-MMC workpiece.



Fig.1 : Experimental set up of ytterbium fiber laser machining



Fig. 2 : Ytterbium laser drilling is done on Al-Al_2O_3 MMC





2. FUNDAMENTALS OF HEAT TRANSFER

The analysis of the laser machining process involves a number of heat transfer phenomena occurring while the laser beam interacts with the work piece material. There are three fundamental modes of heat transfer: **Conduction:** A temperature gradient within a homogeneous substance results in an energy transfer rate within the medium (fig.1) which can be calculated by

 $q = -kA \partial T / \partial x$

Eq (1)

where $\partial T/\partial x$ is the temperature gradient in the direction normal to the area A, and q is the rate of heat transfer across area A. The thermal conductivity k is a material property and it may depend upon temperature and pressure. The minus sign in Fourier's law (Eq 1) is required because energy transfer resulting from a thermal gradient must be from a region of relative high temperature to a region of relative low temperature [1].

The thermal conductivity of the solid phase of a metal of known composition is primarily dependent only upon temperature. In general, k for a pure metal decreases with temperature; alloying elements tend to reverse this trend. The thermal conductivity of a metal can usually be represented over a wide range of temperature by

 $k = k_0 (1 + b\theta + c\theta^2)$ Eq (2)

where θ =T-T_r and k₀ is the conductivity at the reference temperature T_r. For materials in engineering applications, the range of temperature is relatively small, a few hundred degrees, and

 $k = k_0 (1+b\theta) \qquad \qquad Eq \quad (3)$

The thermal conductivity of a non homogeneous material is usually dependent upon the apparent bulk density, where is the mass of the substance divided by the total volume occupied. This total volume includes the void volume, such as air pockets within the overall boundaries of the piece of material. As a general rule, k for a non homogeneous material increases both with increasing temperature and increasing apparent bulk density.

For some liquids of engineering importance, k is usually temperature dependent but insensitive to pressure. Thermal conductivities of most liquids decrease with increasing the temperature. The exception is water, which exhibits increasing k up to about 145°C and decreasing k thereafter. Water has the highest thermal conductivity of all liquids except the so-called liquid metals. The thermal conductivity of a gas increases with increasing temperature but is essential independent of pressure for pressure close to atmospheric. For high pressure (i.e. pressure of the order of the critical pressure or greater), the effect of pressure is significant.

Steady-state heat transfer occurs whenever the temperature at every point within the body, including the surfaces, is independent of time. If the temperature changes with time, energy is either being stored or removed from the body. This storage rate is

 $q_{\text{stored}} = mcp\partial T/\partial t$ Eq (4)

where m is the mass of a body with uniform density ρ , cp is the specific heat and $\partial T/\partial t$ is the rate of temperature change in the body. The specific heat per unit mass of a substance is a measure of the variation of its stored energy with temperature. From thermodynamics the two important specific heats are:

specific heat at constant volume: $c_v = (\partial u / \partial T)V$	Eq (5)
specific heat at constant pressure: $c_p = (\partial h / \partial T)P$	Eq (6)

Here u is the internal energy per unit mass and h is the enthalpy per unit mass. In general, u and h are the functions of two variables: temperature and specific volume, or temperature and pressure. For substances which are incompressible such as solids and liquids, c_p and c_v are numerically equal. For gases, however, the two specific heats have different values. For solids, specific heat is only weakly dependent upon temperature and even less dependent on pressure. Specific heats of liquids are influenced by temperature not pressure. Gas specific heat values exhibits a strong temperature dependence and can be affected by pressure near the critical state [2].

Convection: Whenever a solid body is exposed to a moving fluid having a temperature different from that of the body, energy is carried or convicted away by the fluid. Convection heat transfer is actually a subset of conduction; heat is conducted from the solid surfaces to the fluid, which then removes the thermal energy through mass flow. If the ambient temperature of the fluid away from the surface is $T\infty$, the surface temperature of the solid is Ts, and the surface area exposed to the fluid A, the heat transfer per unit is given by,

q=hA(Ts-T∞)

Eq (7)

which is known as Newton's law of Cooling. This equation defines the convective heat-transfer coefficient h as the constant of proportionality relating the heat transfer per unit time and unit area to the overall temperature difference. h is a function of flow geometry, flow velocity and fluid properties [3].

Radiation: The third mode of heat transfer is due to electromagnetic wave propagation, which can occur in a total vacuum as well as in a medium. Experimental evidence indicates that radiant heat transfer is proportional to the fourth power of the absolute temperature, whereas conduction and convection are proportional to the linear temperature difference. In some cases, an idealized surface can be assumed to absorb all of the incoming radiation; in this case, the body of the surface is termed a black body and the radiation heat transfer from this body follows the Stefan-Boltzmann law.

 $q = \sigma AT^4$

Eq (8)

where T is the absolute temperature, a the surface area and σ is the Stefan's Boltzmann constant, which is independent of surface, medium, and temperature its value is $6697 \times 10^{-8} \text{W/m}^2\text{-k}^4$.

A real surface, however, absorbs less energy than a black body and is modelled as a gray body by specifying an emissivity value, which ranges from zero to one. Additionally, if wave propagation occurs through a gas or vapor, the medium may absorb a portion of the thermal radiation. In this case, the medium cn be modelled as a gray gas. The radiation heat transfer for gray bodies and gases follows the relationship:

q=εσAT⁴

Eq (9)

3. GENERAL CONDUCTION HEAT EQUATION

The objective of a conduction heat transfer analysis is to estimate the temperature distribution and heat transfer rate within a solid, liquid and gas with no relative motion within the body. From Eq.(1), the heat transfer rate can be related to the local temperature gradient. In some cases the temperature gradient can be easily derived through physical

measurements of temperature at predetermined locations within the body. However, in more complex cases such as the ones occurring during laser machining, the temperature gradients can only be established by considering an energy balance equation, which determines the temperature distribution within a region [4]. From the temperature distribution, the temperature gradient at any desired location within the material can be formed and consequently the heat transfer rate may be calculated. Consider a control volume consisting of a small parallelepiped, as shown in Figure 4. This may be an element motion between the macroscopic material particles. Heating of the material results in an energy flux per unit area within the control volume. This flux is, in general, a 3-D vector. For simplicity, only one component, q_x , is shown in Figure [5].



Fig. 4 : Heat flow due to conduction

In the x-direction the two terms may be grouped to form

$q_{x1}-q_{x2}=\Delta y \Delta z [\Delta x \partial \partial x (k \partial T / \partial x) + \dots$	Eq (10)
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Similarly for y and z directions,

$q_{y1}-q_{y2}=\Delta x \Delta z [\Delta y \partial / \partial y (k \partial T / \partial y) + \dots$	Eq (11)
$q_{z1}-q_{z2}=\Delta y \Delta x [\Delta z \partial / \partial z (k \partial T / \partial z) + \dots$	Eq (12)

The internal energy storage per unit volume and per unit temperature is the product of density and specific heat, so

$$\partial U/\partial t = \rho c (\Delta x \Delta y \Delta z) \partial T/\partial t$$
 Eq (13)

Therefore, the general conduction equation:

$$\partial/\partial x(k\partial T/\partial x) + \partial/\partial y(k\partial T/\partial y) + \partial/\partial z(k\partial T/\partial z) + q''' = \rho c_p \partial T/\partial t$$
 Eq (14)

for the temperature T as a function of x,y,z and t. Here, k is the thermal conductivity, ρ is the density, c is the specific heat per unit mass, and q''' is the rate of internal energy conversion("heat generation") per unit volume.

In most engineering problems k can be taken as a constant, and Eq(14) reduces to

$$\partial^2 T/\partial x^2 + \partial^2 T/\partial y^2 + \partial^2 T/\partial z^2 + q'''/k = 1/\alpha \partial T/\partial t$$
 Eq (15)

where α , defines as $\alpha = k/(\rho c_p)$ is the thermal diffusivity. Thermal energy diffuses rapidly through substances with high α and slowly through those with low α .
4. HEAT MODEL DEVELOPMENT

The laser power range has been selected between 400 W to 1000 W during Ytterbium fiber laser machining of Al/Al₂O₃MMC. For a certain laser power keeping other parameters constant i.e. modulation frequency 800 Hz, gas pressure 17 bar, wait time 0.2 s, pulse width 90%, the experimental investigation was carried out and effect of laser power on the available surface temperature from machine was plotted in Fig.5. From Fig. 5 it is clear that with the increased of laser power the temperature of the hole surface is also increased. When the laser power is increased from 400 W to 1000W, the temperature of the hole surface for Al/5wt%Al₂O₃MMC is increased from 1305^oC to 1703^oC. The reason is at high laser power, the laser beam has more energy which is absorbed by the material for melting and vaporization.



Fig. 5 : Laser power (W) vs Surface temperature (^{0}C)

Al/10wt% Al ₂ O ₃ MMC Properties	Condition / Tested value
Phase	Solid
Density(p)	2.8 g.cm ⁻³
Melting point (T _m)	1260 ⁰ C
Specific heat (c)	0.95 J/g K

Table I, properties of fabricated Al/5wt% AI_2O_3 MM
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Fig. 6 : Messing of work piece of 46 mm diameter and 5 mm thick

Fig.6 shows the meshing of the work piece model. Fig7 shows the temperature distribution by using ANSYS software. From Fig7 it is clear that maximum temperature is obtained in around the hole and with increasing the distance from the hole the temperature is decreased.



Fig. 7 : Temperature distribution along work piece of 46 mm diameter and 5 mm thick

5. CONCLUSION

Thermal analysis of the hole is done by using ANSYS software. In fig 5, messing is done for thermal stress analysis. It is seen in fig 6 that maximum temperature is accumulated around the drilled hole. With increasing of the distance from the centre of the drilled hole, temperature distribution is less.



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COST EXTERNALISATION IN FARMER MANAGED IRRIGATION SYSTEMS DUE TO RIVERBED EXCAVATION AND EXTRACTION OF CONSTRUCTION MATERIALS IN THE TINAU RIVER BASIN, RUPANDEHI, NEPAL

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The major problem in Sorha-Chhattis Mauja and Chaar Tapaha Farmer Managed Irrigation System (FMIS) was the increase in external cost. Therefore, the main objective of this study was to quantify the external cost incurred in Sorha-Chhattis Mauja and Chaar Tapaha Farmer Managed Irrigation System due to riverbed excavation and extraction of construction materials in Tinau River basin, Rupandehi, Nepal. The study was conducted during the period of March 2011 to July 2012 and was done on the basis of field survey in both irrigation systems. The structured questionnaires were designed for sample survey. Focus group discussions, interactions, workshops, and seminars were conducted during the survey among the irrigators' communities. The study showed the decrease in agricultural production, pasture land, livestock farming, and dairy co-operatives during the period of over extraction of riverbed materials from both bed and bank of the river. In addition, the labor cost for canal repair and maintenance was found to be increased by many folds due to the lowering of the riverbed level. As a whole, extraction of riverbed materials from Tinau River has raised the external cost and it has not been recovered by the revenue collected from the riverbed materials of the same river.

Key words: External cost, Riverbed Extraction, Chaar Tapaha, Sorha-Chhatis Mauja, and Farmer Managed Irrigation System (FMIS), Nepal

1. INTRODUCTION

1.1 Background The history of irrigation in Nepal dates back to the 17Th century [1]. The practice of strengthening farmer managed Irrigation system (FMIS) started in the past 18th century during dynasty of King Ram Shah [2]. It continued in the period of Rana regime too. The main region of development of FMIS in Nepal during Rana Regime was to collect more revenue. The more revenue could be collected by the irrigated land. Thus, Rana rulers upgraded some FMISs and collected more revenue [2]. Evidence on the extent and development of irrigation in Nepal prior to 1950 is scanty. Numerous small raj kulos' in the government sector first appeared in and around Kathmandu valley in the seventeenth and eighteenth centuries. Up to the end of 1921, there was no agency managed irrigation system (AMIS) in Nepal. The first large public sector irrigation canal system (the Chandra Canal System/Chandra Nahar) with a net command area of 10,000 ha was constructed in 1922 and is still in operation [1]. It is already known that the Government of Nepal is involved in the sector of irrigation since decades. It has newly constructed a few huge irrigation projects like Sunsari-Morang, Baghmati, Mahakali, and so on. Some of these are still under construction since 15-20 years and some of them are not well functioning and not meeting the targeted irrigation facility [3]. However, most of the FMISs are functioning well throughout the country. There are various factors, which influence the FMIS in Nepal. One of the most important influencing factors is considered as the cost externalization from businessmen. Similarly, the next one is the government intervention through incompatible rules and regulations [4]. When a businessman transfers some parts of its cost to the community people or degrades the prevailing environment for his profit, the process is called cost externalization. For example, if a brick factory exposes the dust and smoke, it adversely affects the health of the people in the surrounding area. Similarly, any mining factories can also cause the same impacts. Another example is the cement factory, which can make nuisance in the surrounding area degrading the aesthetic value of the environment and health of the people living nearby area. Extraction of riverbed materials also degrades the existing environment and produce smoke, dust and sound pollution. Furthermore, this activity lowers the riverbed level and makes it difficult to divert water into the canal if there is not permanent headwork. There are lots of such irrigation canals having temporary headwork in Nepal, which have been constructed by the farmers at their own cost; such as *Sorha-Chattis Mauja*² and *Chaar Tapaha*³ Farmer Managed Irrigation System (FMIS). There exist two big farmer managed irrigation systems and these systems had no permanent head works till 2010.

Tinau River is being extracted for long as the river possesses high quality of riverbed materials. These FMISs had trouble to divert the water into the canals due to extraction of riverbed materials, which lowered riverbed levels. Extraction of riverbed materials can cause the extra economic burden of the people, which producers/manufactures do not bear; instead they transfer this economic burden to the community people. Such economic burden is the external cost and the whole process is termed as cost externalization.

There are over 6000 rivers and rivulets in Nepal. Tinau River is one of them. This river originates from Palpa district at mountainous region and flows through the Rupandehi district and joins the west Rapti River in India, which is one of the tributaries of the river system of the Ganga **[5]**. This river is potential for construction materials like boulders, cobbles, pebbles, gravels and sands. Therefore, local administrative bodies such as Village Development Committee (VDC), Municipality and District Development Committee (DDC) started extraction of riverbed materials in a massive way using excavators since the enforcement of Local Self Governance Act(1999) and Regulations (2000) **[6]**. Construction materials of Tinau River serve the whole Rupandehi district and surrounding districts for the development of various engineering infrastructures such as roads, bridges, canals, buildings and so on. Furthermore, the materials are exported to India and they generate an adequate amount of revenue annually.

Extraction of riverbed materials is the common feature in Nepal because it is the major source of income generation of the local administrative bodies and even of the country. Therefore, mining of riverbed materials from river channels, banks and floodplains have been continuing for a long time. There is no historical record of the riverbed extraction in Nepal. However, the extraction of riverbed materials awarding contract was started from 1963-1964 [7]. But in the case of Tinau River, massive extraction was started from the year 2004 [6].

raj kulos¹: Canal made by the ancient kings of Nepal Sorha-Chattis Mauja²: Name of the canal which feeds water to the eastern part of Tinau River River Chaar Tapaha³: Canal, which distributes into four branch canals from a single main canal and feeds water to the western part of Tinau River River

The total length of the Tinau River is 95 Km from the source to tail. Similarly, the total catchment area is 1081 Km² [8]. The catchment area is divided into two parts viz mountains and plains. As the river passes through the mountains and hills of the Palpa district, it carries plenty of sandy sediments with it. The major sources of sediments in Tinau River are landslides, erosion and rock falls [8]. As the Tinau River enters into the Terai, the stream power decreases significantly further downstream causing wide spread deposition of sediments in the form of alluvial fan. The sediments are useful for the construction of engineering infrastructures and are being used since time immemorial. The sediment faces in the fan includes channel bar and point bar, which serve as natural levees of around 3 m high [6].

Tinau River is one of the important rivers of Western Nepal for construction materials. This river is serving Rupandehi district for water supply, irrigation, hydropower generation and recreation. However, the major revenue generation from this river is the riverbed materials. Thus, there are lots of crusher plants along the banks of the Tinau River starting from Butwal municipality to the Bethari, 26 km downstream from the Butwal city. The total number of crusher industries established along the bank of Tinau River is 70 and their total annual capacity is nearly 28 million cubic meters [8]. This volume is much less than the annual deposited volume of 0.98 million cubic meters [6]. Hence, the devastation started due to disequilibrium of extraction and deposition in this river especially in the Terai (Rupandehi district).

As the extraction of riverbed materials is more than the deposited volume, lowering of riverbed level is a common fact. Therefore, there is significant degradation of bed level at Butwal to further downstream. Butwal city is an important historical, industrial and business centre of the west Nepal. Therefore, Butwal municipality including some other Government agencies has been constructing various types of protection works to conserve the health of the River. Similarly, on the left bank of Tinau River, there exists a historical FMIS called *Sorha-Chhattis Mauja* irrigation canal and on the right bank *Chaar Tapaha* FMIS. The history of these FMISs is not well known (There is no exact written document). But some researchers have mentioned that these systems are about 150 years old [5, 9].

1.2 Transfer of External Cost and Choice of FMIS for the Study Mining of riverbed materials from the bed, banks and the floodplains of Tinau River has transferred the external cost to the various agencies such as government, semigovernment and non –government. Government agencies especially Department of Irrigation (DOI), Department of Water Induced Disaster Prevention (DWIDP), Department of Roads (DOR) and District Development Committee (DDC), Municipality and some Village Development Committees (VDCs) aim at conserving the health of Tinau River. The above organizations are constructing various types of protection works to conserve the health of Tinau River. Some nongovernmental organizations also organize different awareness programs in the community. However, the river valley environment is being degraded day by day. The Ministry of Environment (MOE) and the Ministry of Forest and Soil Conservation (MOFSC) have also managed the watershed area of Tinau River for years. Extraction activities have transferred the cost to the irrigators' community of *Sorha-Chhattis Mauja* and *Chaar Tapaha* FMIS. As there is significant devastation of the River, the people residing on the flood plains have adversely affected from the pollution like dust, smoke and sound. They have been suffering from skin diseases, throat pain and respiratory problems but the details of the impact in depth are beyond the scope of this study and it needs further investigations.

The research focuses on the effects of riverbed extraction on FMIS only. As both FMISs are using water for irrigation from Tinau River for more than 150 years and they have the water rights. Furthermore, these FMISs are historical social capital and they reflect the socio-cultural value of that area. The extraction activities lowered the riverbed level and made difficult to divert water into the canal along with the increment of significantly higher number of labors for canal repair and maintenance during past decade (Fig. 11). There are various effects of riverbed extraction in Tinau River. But this study aims at finding the cost externalization in FMIS and some other relevant components. Extraction of riverbed materials has adversely impacted the headwork of both FMISs - *Sorha-Chhatis Mauja and Chaar Tapaha*. There is no provision of cost internalization in the project of extraction of riverbed materials from Tinau River. Revenue generated from the riverbed materials is being received by VDCs, DDC and Municipalities but the cost of canal repair and maintenance is transferred to the irrigators' community.

1.3 AMIS, FMIS and General Features of *Sorha-Chhattis Mauja* and *Chaar Tapaha FMIS* Generally there are two types of irrigation systems in Nepal. These are agency managed irrigation system (AMIS) and farmer managed irrigation systems (FMIS). In AMIS all costs are borne by the Government (Through Government agencies like Department of Irrigation), whereas in FMIS all costs are borne by the farmers themselves. In such systems, government interventions are negligible. In the AMIS, there will not be people's participation during construction, operation and maintenance of the canals. While in the FMIS, all construction, operation and maintenance is done by the irrigators' community. Farmers make plan and programs for water acquisition, allocation and distribution. Social equity can be observed in those systems run by the farmers along with social norms and values. In the FMIS, they have own culture, rules and regulations, which may or may not be compatible with the national standards **[5].** Community themselves make constitution to make the system sustainable. If someone breaks the rules, they punish and even exclude from the system without delay.

With the increase in population, there is a need to grow more food throughout the country by constructing irrigation systems either agency managed or farmer managed [10]. Farmer managed irrigation systems (FMISs) have got higher priority in the country. The existing socio-culture including norms and values of the society can be observed in those systems where community has the full right for water acquisition, allocation and distribution but in FMIS, the incompatible government rules and regulations are disturbing and eroding them [4]. Haphazard extraction of riverbed materials which causes damage of headworks constructed by the farmers is an example of incompatible rules and regulations of the government and unsustainable development. The sustainable development of irrigation system can only be done through mutual co-operation of farmers and government [11, 12].

Total land occupied by Nepal is 1,47,18,100 ha. Out of this area only 26, 41,000 ha are cultivable. All cultivable land is not irrigable. The irrigable land is 17, 66,000 ha and it includes the land of mountains, hills, valley and Terai plains [3]. The FMIS occupies 70% of total irrigated land, whereas remaining 30 % isoccupied by AMIS [13]. As the major portion of the irrigated land covered by the FMISs, it has contributed to the food security in the country significantly.

The modes of irrigation systems differ from region to region even in system to system depending on the volume of water and size of command area **[1]**. The traditional knowledge of the farmer is still important as it plays a vital role to keep the irrigation system functioning well. The government in recent time is working for repair and maintenance of FMIS in many parts of the country. The selected FMISs in this study are the examples of historical systems made by the farmers. These systems help to irrigate substantial area of land and produce more food, which preserves the food security in the region and even in the country too. Thus, these historical systems are very important for us and for the future generations. The general features of the selected FMISs of this study are presented in the Table 1.

Table 1: Major features of the Sorha-Chhattis Mauja and Chaar Tapaha FMIS, Source:

S.N.	Description	FMIS						
1.	Name of Canal	Sorha – Chhatis Mauja	Chaar Tapaha					
2.	Command Area, ha	3500.00	2450.00					
3.	Cattachment, km ²	560	560					
4.	Design Discharge, lps	10000.00	7000.00					
5.	Longitude	83°25'-83°33'	83°24'-83°33'					
6.	Lattitude	27°34'-27°42'	27°34'-27°42'					
7.	No. of Branch canal	2	4					
8.	Coverage Municipality and VDCs	Butwal municipality, Anandaban, Shankarnagar, Tikuligadh, Karahiya, Makrahar, Gangoliya, Madhwaliya VDCs	Butwal Municipality, Motipur, Semlar, Sauraha Pharsatikar, P. Amawa, Khada- wa Bangai VDCs					
9.	Total household	5220	5311					
10.	Total Population	47054	33377					
11.	Ethnicity	Brahmin, Chhetri, Gurung, Newar, Majhi, Yadav, Tharu	Brahmin, Chhetri, Tharu, Gurung, Yadav					
12.	Major Crops	Paddy, what, oilseed, pulses, maize, vegetables	Paddy, wheat, oilseed, pulses, maize, vegetables					
13.	Total production per annum, NRs.	6,40,78,500.00	3,89,77,100.00					
14.	WUA Registration	Exits	Exits					

Over extraction of riverbed materials causes pollution and affects peoples' livelihood by degrading agricultural land [6]. Similarly, over mining sand and gravels from the bed and banks of the river can cause numerous off site effects including habitat destruction [6]. The construction industrialists can take direct benefit from the business but at the cost of public. This can be observed in the case of Tinau River, which has transferred the cost to irrigators' community and it has broken the existing socio-culture, socio-capital and common pool resources [4]. The illegal and haphazard extraction of riverbed materials is harmful and can damage the overall river environment including quality of water [15]. Thus, the natural resource committee of the constituent assembly (CA) recommended extracting the materials after the preparation of either Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) report with detailed environmental management plan [16]. As a result, DDC Rupandehi also prepared an EIA report to identify the overall environmental degradation due to extraction of construction materials. The EIA report suggested stopping the extraction activities from Butwal to Manigram [6].

2. MATERIALS AND METHODS

The study area is located at Rupandehi district, Western Development Region of Nepal. The study was conducted during the period of March 2011 to July 2012. Two FMIS Sorha- Chhattis Mauja and Chaar Tapaha were chosen for this study (Fig. 1). The questionnaire was designed to carry out the field survey. The survey with the people of the selected FMISs was mainly focused on cost of canal repair and maintenance including other impacts of riverbed extraction like production and productivity, livestock farming and impacts on human health due to pollution of extraction as well as diseases on human health. Questionnaire survey, frequent field observation, interaction with the farmers, attendance and participation in the meetings organized by water users committee, conduction of seminar and workshop were also conducted during the study period. Total numbers of 216 respondents were selected for sample survey from both FMISs (108 form Sorha-Chhattis Mauja and 108 from the Chaar Tapaha). The respondents were so organized that the old experienced inhabitants, executive members of the FMIS, and workers like *Meth Mukhtiar*⁴, chairpersons of the Village Development Committees (VDCs) of the command area and local political leaders were chosen and questioned. During study two national level seminars cum workshops were organized and invited number of people of the concern area as well as experts from outside. Representatives of the FMIS presented the papers related to the problem they faced in the past. The main focus in the seminar and workshop was to find the problems induced by the riverbed extraction and lowering of riverbed level. The problems they raised in the workshops, seminars, and in the interaction were noted down. Frequent field visits and sample survey were also the judging tools. Finally, the data were analyzed on the basis of field visits, interactions, workshops/seminars, sample surveys and the official records of the systems.

*Meth Mukhtiar*⁴: chief of field level water management committee of the canal



Figure.1: Map showing command area of Sorha-Chhattis Mauja and Chaar Tapaha FMIS, Source [17]

3. RESULTS AND DISCUSSION

The Local Self Governance Act [18] and Local Self Governance Regulations [19] have provided the rights to extract riverbed materials in their territory. However, the rules and regulations do not explain anything about the external cost and the project of riverbed extraction does not incorporate it. Furthermore, this is the major source of income of local administrative bodies (LABs). During the period of 2005-2012, LAB collected adequate revenue from the riverbed materials. During past decade LAB collected 1,383.7 millions of Nepalese rupees (NRs.) from the riverbed materials (13.054 Million US\$). But such activities invited the erosion of bed and banks of the river. Therefore, government as well as the local administrative bodies is investing a huge amount of money to protect the river. During past decade, they all have already spent millions of Nepali rupees (NRs.) for the protection works in Tinau River. This cost is the external cost induced by the extraction of riverbed materials. Ten numbers of village development committees (VDCs), one municipality and district development committee (DDC) are generating revenue from the construction materials of Tinau River (Fig. 2).



Figure 2: Map showing benefitted LABs from the riverbed materials [14]

With the view of collecting more revenue, the LABs started to extract riverbed materials as much as possible. The massive extraction of riverbed materials was started from the year 2004 [6]. Tinau River is in aggrading stage upstream that changes to degrading stage after entering into the Terai. The deposition of sediments from different sources in Tinau River increases when the river flows towards the Terai especially from Butwal to Bethari about 26 km downstream from the Highway Bridge of Tinau River at Butwal [6] and it has disturbed the aquatic environment due to disequilibrium of sediment supply and extraction [20] (Fig. 3).



Figure 3: River-bed extraction during the period of 2004-2012 [6]

During past decades river course is changing. Change is general but the study reach is shifting toward west. The malicious station of Tinau River is Indian canal headwork (Hattisund weir). The shift of the river course is presented in Fig. 4



Figure 4: Indian canal head work and shift scenario of the River [21]

The weir was built about 45 years ago. This can cost millions of rupees in recent price. The river shifted due to flooding in the Tinau River in 1969 **[5].** By then, it became defunct. However, it could be a safeguard for riverbed degradation and could save substantial amount of money for protection works and even ensure the safety of Tinau River Bridge upstream. Now the headwork has got damaged due to over extraction of riverbed materials and the foundation of the bridge is exposed about 3.5 m including many damages and wash out of the minor structures constructed for the protection of the Tinau River **[22, 23].** All this has caused the increase in external cost but the details of these externalities are to be further investigated.

The effects of the riverbed extraction were explored during field survey. Many respondents including the irrigators' community reported differently during sampling, interaction, work-shops and seminar held in this study. This is presented in Fig. 5.



Figure 5: Various effects of riverbed extraction

All these effects are further dealt in the following paragraphs systematically.

The results of this study showed that the livestock farming in the study area decreased after sand and gravel extraction from the Tinau River. The major causes of decrease in livestock farming were encroachment of floodplain area, over extraction and foreign employment (Fig.6). Due to decrease in livestock farming, the dairy co-operatives also decreased (Fig.7).



Figure 6: Livestock farming in the study area before and after extraction

The study showed that the FMIS area was negatively affected by the extraction activities. There are various causes of decrease in livestock farming. However, the field survey showed that the major causes are foreign employment of the youth, encroachment of floodplain area of Tinau River and over extraction of riverbed materials. The result is presented in Fig. 7.



Figure 7: Causes of decrease in livestock farming

As the livestock farming is decreased the registration of dairy co-operatives also decreased. Some of the registered dairy co-operatives have already cancelled their registration, some are inactive and new registration is also in decreasing trend as compared to the past. The result of the details of dairy co-operatives is presented in Fig. 8 and 9.



Figure 8: Trend of registration of dairy co-operatives, source: [25]

The data of registered co-operatives were analyzed from 1991 to 2012. The study showed that within the command area some co-operatives are defunct, some are inactive and some have already been cancelled (Fig. 9).



Figure 9: Present status of co-operatives, source: [24]

If the co-operatives do not function well, there will be an economic loss of the country. But the loss is not easily predictable. By and large, the indirect external cost has been laden on the head of the community due to decrease in dairy co-operatives.

The major effect of riverbed extraction is the increased cost of labors for canal repair and maintenance in both FMISs. Due to over extraction of the riverbed materials the bed level of Tinau River at the diversion point significantly lowered and the farmers faced problem of water diversion into the canals. The farmers of both FMISs had to invest more labors for annual repairing and maintenance of the canals during the period of 1996 -2010. During this period the cost for canal repairing and maintenance was increased by many folds (Fig.10).



Figure 10 Labor cost for canal repair and maintenance during 1996-2011, Source: [25]

Total extracted volume of riverbed materials during past decade was 1383.7 million cubic meters and LABs generated total revenue of NRs.1.4 billion **[6, 15, 25, 26]**. Extraction and deposition of riverbed materials should be in equilibrium condition to keep the river unchanged but extraction of riverbed materials exceeds by 51.23% **[6]**. This means there is over extraction of riverbed materials during past decade. Excessive extraction of riverbed materials caused river incision. Due to river incision, massive numbers of labors were engaged for water diversion. Statistical analysis of correlation between number of labors for canal repair and maintenance and extracted volume of riverbed materials of past decade was performed and it showed that there exists highly significant positive relation (r= 0.794, p= 0.033). Riverbed lowered by 11 m in intake point of Chaar Tapaha FMIS and 5 m in intake point of 36 Mauja FMIS **[6]**. Ultimately, there was a need of heavy protection work to conserve the health of the river and save further degradation.

Due to high demand of the people and need felt development of this area, bed and bank protection works along Tinau River was started by different agencies. The major agencies and institutions involving for the protection works were:

Butwal Municipality, District Development Committee (DDC), Department of Irrigation (DOI), Peoples Embankment Programme (PEP) and Department of Water Induced Disaster Prevention (DWIDP). The total amount they invested for the protection of bed and banks of Tinau River during past decade is presented in Table 3.

S.N.	Name of the Organization	Investment, NRs., Million
1	Butwal Municipality	25.098
2	DDC	2.567
3	DOI	99.000
4	PEP	72.400
5	DWIDP	31.500
Total NRs.		230.565

Table 3: Investment made for	protection works of the	Tinau River River.	Source: [2	27, 28, 29, and 30
Tuble et mit estiment made for	protection works of the	I maa Iurer Iurer	Source.	, 1 0, 1 , 1

The data in Table 3 shows that the investment for protection work is quite enough and this is the external cost imposed by the extraction of riverbed materials from Tinau River River.

There are many other external costs imposed by the extraction activities. For example, farmers reported that the discharge of the canal decreased, and due to this, the production was decreased by 25 %. There were some local *Gholas*⁵ and wet lands. Due to decrease in water discharge in the canals and lowering of riverbed level these *Gholas* and wet lands could not be recharged through the canal and river. Thus, they dried. Similarly, about 1000 shallow tube wells and some dug wells of shallow aquifers stopped discharging water due to lowering of riverbed level [31, 32]. All above events have increased the external cost. But there is lack of proofs for this and it needs further investigation.

Gholas⁵: The small stream originating from the farm land. Generally this is a ground water fed stream in the Terai region. This type of stream can be seen only in lowland of Terai region in the context of Nepal

The external cost can easily occur if there is no co-ordination between the government agencies and the local community people for the use of common pool resources [4, 14]. Riverbed materials are the common pool resources and people living in the periphery of the river have the rights to use it. If there is participation of the people during the period of contract for extraction of riverbed materials, it would not have been the destruction of river environment and external economic burden like in these FMISs. The government intervention through incompatible rules and regulations has made the erosion of the common pool resources like over extraction of riverbed materials in Tinau River [4].

The extraction should be guided by a technical manual. The river warden could be appointed and all resources could be done in a scientific way [8, 17]. The environmental costs induced due to over extraction of riverbed materials should be incorporated in the projects [32, 33]. However, in Nepal, there is no such provision while awarding contract of the river for riverbed extraction. Ultimately, it has damaged the traditional FMIS. Sustainable irrigation system should be developed through people's participation. The farmers are not well educated and not known to the rights and duties. The system maintenance and rehabilitation must be done through their involvement [34] but in many cases such practices are not adopted by the government.

Riverbed materials cannot only be beneficial for the revenue collection but also for the overall social development if we use it scientifically. In some cases it is the protection of catastrophic event. For example, the high flood of Tinau River in 2009 was dangerous for Butwal city. If the river had not been lowered, it could have caused the damage of the city including surrounding areas of the river channel [17, 35].

River resources like sand, and gravels were used by the ancient people in the pre-historic age. This is one of the reasons that many ancient civilizations flourished on the bank of rivers. Butwal at the bank of Tinau River is also considered as one of the ancient cities of this region [8]. Similarly, the use of riverbed materials is considered as an old practice but the negative consequences were not thought in the past. In Tinau River also, the use of riverbed materials started from the pre-historic age but the massive extraction started from the year 1992 [6].

In the beginning, the machines were not used, but from 2004, excavators were used to extract the riverbed materials **[22, 36].** Therefore, the river channel and flood plains were over extracted. As a result, it caused the disequilibrium of deposition and extraction. The bed level of the river significantly lowered and it became safe to live in the flood plain area. During field observation and interaction with people, they reported that the people from the different corner of the country including Butwal Municipality started to occupy the floodplains in an organized way. There are about 2000 households on the flood plain of Tinau River from Butwal to Bethari **[6, 24].** Therefore, on the one hand lowering of

riverbed level due to extraction of construction materials is beneficial but on the other hand, it creates many unseen effects among the people and in environment.

Riverbed mining causes various types of transient effects such as noise, dust and smoke pollution and it can adversely impact on human health and as a whole it increases the external cost [37, 38]. During survey of the site, the impact on human health was observed. Respondents reported that the eye diseases, throat pain and skin diseases have appeared with the people who were living on the banks along the Tinau River River. But the details of these diseases lack the proofs and it needs further investigation.

The people who are living on the floodplain area of Tinau River are from the poor economic background and less sensitive to health issues and education. It was found that most of the people on the floodplains are living from 10 years back. Most of the people living by capturing the floodplain of Tinau River are illegally settled. It was known by the respondents that the major determining vote banks are with the people of floodplain area for local and central election. Furthermore, local and central level leaders are behind with them. As a result, the district and local administrative bodies could not replace them from the floodplains. Therefore, Tinau River floodplain, the pasture land of both FMIS has been occupied and the livestock farming has decreased along with the dairy co-operatives associated with it.

From time to time Government of Nepal has made different types of Acts, regulations, policies and plans to reform and provide irrigation facilities to the farmers. The major Acts, Regulations and Policies related to irrigation development are: Civil Code 1910, Irrigation Act 1961, Water Tax Act 1966, Irrigation and Electricity Act 1967, Canal Rules and Regulations 1974, Irrigation Regulation 1988, Irrigation Policy 1992, Water Resource Act 1992, Environmental Protection Act 1996, Nepal Drinking Water Policy 1998, Local Self-Governance Act 1999, Irrigation Policy 2003, and so on [**39**]. These Acts, Policies and Regulations have provided the rights to use water resources for the communities to the extent of their capacity to increase the production and productivity. But the Government agencies are not paying attention to the proper implementation of the above stated laws, Acts, Regulations and policies in a proper manner.

Extraction of riverbed materials has increased the income of LABs but it has not made up the external cost [35]. The strategies of the sustainable development should include empowering the locals, bottom-up approach, putting people first and fully people's participation in the developmental activities [39]. But these principles are not always in practice. The term "People's Participation" is very wide and can cover many things in sustainable development, however, it is rhetoric only in many cases. Especially, while making plans and selecting new schemes many bureaucrats use the concept of people's participation. During implementation of the project people's participation is not fully practiced in our context [12, 40]. Hence, the development of any project including irrigation must include local community people at all stages of development for the sustainability of the project so that it could reduce probable water disputes [14]. The projects which can affect the people and create the external cost must be planned in a participatory approach [36]. The riverbed materials must be extracted in environment friendly way. The extraction should be controlled and guided by a technical manual. A river warden should be appointed and all resources should be studied in a scientific way [8, 35].



The study showed that the riverbed extraction has resulted cost externalization in *Sorha Chhattis Mauja* and *Chaar Tapaha* FMIS. The dust and smoke pollution has increased. Some diseases like respiratory, throat pain and skin diseases are found in the people living in the floodplains and command area of Chaar Tapaha and Sorha-Chhatis Maujs FMISs though the sufficient proofs associated with it are lacking. Labor costs for canal repair and maintenance has increased by many folds. Production and productivity of the farmers has decreased. There were some wetlands and local *Gholas* in the command area of *Sorha–Chhattis Mauja* and *Chaar Tapaha* FMIS, which became completely dry. The government has started to protect the river. The protection works cost millions of rupees, which is the external cost. The industrialists have not internalized this cost in their projects and ultimately this is borne either by the community people themselves, or by local administrative bodies or by the central government. The environmental degradation is high due to over extraction of riverbed materials. But the cost of environmental cost and it has not been recovered by the revenue collected from the riverbed materials of the same river.

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AUTOMATED TEST EQUIPMENT (ATE) FOR CHARACTERIZATION OF WIDE BAND ACTIVE PHASED ARRAY (APA) USED FOR EW APPLICATIONS

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Solid State Trans/Receive (TR) module based Active Phased Arrays are widely used in modern Electronic Warfare (EW) systems to achieve high Effective Radiated Power (ERP). The Active Array based Transmitter plays a very significant role in acquiring the threats in dense EW environment. The specialty of this technology lies in its reliability, fidelity and high degree of accuracy. It is therefore imperative to fully characterize these transmitters independently in the laboratory condition prior to integration in the actual system for field evaluation and its prolonged use. Characterization of the Active Array Transmitter is an involved process since each TR module needs to be characterized separately for amplitude, phase and spectral purity over wide frequency range of operation. Developing an automated environment for testing of these parameters is a challenging task and needs concerted efforts to integrate specialized hardware and test equipment with customized software. This technical paper is an attempt towards design and development of an automated test setup in the laboratory condition consisting of a Test Jig with suitable Digital IO Boards for discrete line communication with Active Phased Array (APA), high speed interface converters for serial communication with APA and Ethernet interface for communication with Radio Frequency test instruments. A LabVIEWTM based Automated Test Software has been developed to carry out tests as per users requirements. This test setup generates test data such as amplitude, frequency, phase, time and analyses its parametric changes for evaluation and report generation.

Keywords: Active Phased Array (APA), TR Modules, Automated Test Equipment

I. INTRODUCTION

Active Phased Array (APA) based Transmitters are being increasingly used in modern EW systems [1] [2] due to their inherent advantages such as high ERP with low power consumption, size and weight advantages over TWTs and operational capabilities such as Fine Direction measurement, dynamic ERP control, longer shelf and operational life.

The array uses a certain number of Active TR modules each connected to its corresponding antenna element. The number of TR modules used depends on the ERP requirement and also on the size and weight constraints. The broad architecture of the TR module [1] is shown in Figure 1 and that of the APA Transmitter is shown in Figure 2.



Figure 1: Architecture of the TR Module

On the transmit path is a high power amplifier the output of which is connected to a circulator. On the receive path is a Low Noise Amplifier (LNA). The TR module employs a common phase shifter for both transmit and receive paths for beam forming applications. The outputs of the TR modules are power combined and passed through a Beam Forming Network (BFN) that generates the mono-pulse sum and difference channels outputs that are used for fine Direction Finding (DF) applications. The Delta1 and Detla2 outputs are the mono-pulse difference outputs that are used for DF. The sum channel is also used for feeding the signal for transmission into a directional beam by the Beam Forming Network. A reciprocal amplifier is used in this path to provide the necessary transmit and receive gains to compensate for the losses of the Beam Forming Network and that of the power division.

A digital controller board, also called the Array Controller provides a communication interface with which to control the APA. A high level interface protocol is implemented within the controller in order to provide handshaking so that an external system can interface with it and perform tasks such as setting beams, fine calibration etc.

2. APA TESTING

A complex system such as the APA with multiple transmit and receive paths needs to be completely characterized and tested in the laboratory prior to system integration. It is imperative to know the amplitude and phase imbalances that arise between the multiple RF Channels since they need to be compensated for accurate beam forming. Since each TR module employs a digital phase shifter and an attenuator, the phase and amplitude imbalances and inaccuracies in phase/attenuation setting in each of the phase shifters/attenuators also need to be characterized. Further in the receive path, since there is a Low Noise Amplifier (LNA) in each TR module, the gain variation between multiple TR modules also need to be characterized.

The achieved beam ERP depends upon the power output of the power amplifiers employed in each of the individual transmit modules. Hence power output measurements need to carried out independently in each of the TR modules and only then as estimate of the transmit ERP achievable can be made. The harmonics/spurious levels and output noise levels of each of the TR modules also need to be measured. It is also required to test the interfaces of the APA in order to see that the interface messages and handshaking protocols work as defined in the ICD.

Hence extensive tests need to be carried out for the APA in a standalone mode in order to fully characterize and valid its performance.

3. AUTOMATED TEST EQUIPMENT (ATE) FOR APA

Due to broad frequency range of operation and the extensive number of RF channels that have to be tested in both transmit and receive mode, an Automated Test Equipment (ATE) has been built in order to fully automate testing and characterization of the APA. The ATE environment incorporates both hardware interfaces such as Digital IOs and

customized software developed using LabVIEW_{TM} [3]. The ATE setup for the testing the APA in the transmit and receive modes is illustrated in the figures 3 and 4.



Figure 2: Typical Architecture of a linear Active Phased Array (APA) Transmitter



Figure 3: ATE setup for transmit mode testing of APA



Figure 4: ATE setup for receive mode testing of APA

APA Communication Interfaces The APA has a high speed serial communication interface and implements a handshaking protocol with multiple message formats for various control functions. Further, there are a set of discrete differential lines for high speed control. An Ethernet interface with sniffer capability is also provided for debug requirements though not commonly used as part of operational requirements.

Hardware Specialties The ATE environment uses a high speed FPGA based control board in order to control the discrete lines of the APA. The control board provides high speed TTL output lines that are passed through a single ended to differential converter since the APA has differential discrete lines. The use of FPGA based control board enable high speed control of the APA via the discrete lines.

Software Platform/Architecture The ATE uses comprehensive automated test software developed in LabVIEW Graphical programming environment. The software communicates with the APA over a high speed USB to RS-422 converter and with the controller board through the RS422 link. The automated test software implements the high level communication protocol as defined in the Interface Control Document of the APA. All parameters of the APA such as the direction of beam setting, transmit ERP, receive attenuation, no of TR modules enabled/disabled etc can be controlled via messages sent over the serial link. Also in order to enable high speed switching between preset beam forming settings, multiple modes /directions can be set for every frequency setting via the interface messages. The software handles handshaking in terms of requests and acknowledgements. The use of LabVIEW graphical programming language makes the automated test software modular and easy to debug while providing it with an intuitive user GUI for test settings configuration and report generation.

4. TESTS CONDUCTED AND REPORTS

The following important tests were automated.

- Output power test
- Receive Path Gain
- Phase Shifter Accuracy Tes
- Attenuator Accuracy Test
- Amplitude and Phase Matching tests

Output power test Measurement of the maximum output power available from each TR module is carried out in this test.

The output of each TR module is connected to the power meter while the ATE software loops through the frequency of the input while ensuring that power level corresponding to the saturated power input is fed to each TR module. A screenshot of the output power test is shown in Figure 5.

Receive Path Gain Measurement of individual receive path gain is carried out by feeding known power to each TR module input and measuring the signal power received in the Delta1 and Delta2 ports. The test is repeated for the entire band of frequencies. A screenshot of the receive path gain test is shown in Figure 6.

Phase Shifter Accuracy tests The test involves measuring the phase setting accuracy for difference phase steps of the phase shifter in each of the TR module. The ATE software selects the TR module under test while disabling other TR modules and then loops through each phase step while calculating the error between the actual phase shift set and that which is measured. The absolute phase is then plotted as a measure of each phase step. A screenshot of the phase shifter accuracy test is shown in Figure 7.

Attenuator Accuracy Test The test involves measuring the Attenuator setting accuracy for difference attenuation steps of the Digitally Controlled Attenuator (DCA) in each of the TR module. The ATE software selects the TR module under test while disabling other TR modules and then loops through each attenuation step while calculating the error between the actual attenuation set and that which is measured. The error is then plotted as a measure of each attenuation step. A screenshot of the attenuator accuracy test is shown in Figure 8.

Amplitude and Phase matching measurement tests These tests involve measuring the amplitude and phase matching between the Delta ports of the APA. Here test signal is fed through an adaptor that couples the signal to each TR module. The test is carried out by setting the Attenuator and phase shifter to 0 dB and 0 Deg respectively and then sweeping the input frequency from 6 GHz to 18 GHz in steps of 100 MHz. The amplitude and phase of the signal received in Delta1 port is compared to the amplitude and phase of the signal received in Delta2 port. The difference is plotted to indicate the phase and amplitude imbalances between the two ports. A screenshot of the Attenuator accuracy test is shown in Figure 9.



Figure 5: T/R Module Output Power Measurement Test



Figure 6: T/R Module Receive Path Gain Measurement Test



Figure 7: T/R Module Phase Shifter Accuracy Test



Figure 8: T/R Module Rx Attenuator Test



Figure 9: Phase and Amplitude Mismatch/Imbalance Test



The automated test setup for characterization of Wideband Active Phased Array enables quick measurements of all the critical parameters required to characterize the various modules of the array. The automated test setup is realized with standard test equipment and standard RF components without any major customization. High speed APA interfaces providing discrete lines were developed as part of the ATE. The setup helps generate quick measurement reports and enables quick troubleshooting in case of failures.

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ECG SIGNAL ANALYSIS USING ADAPTIVE WAVELET NEURAL NETWORK

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Electrocardiogram (ECG) signal analysis is an important area in intensive care unit (ICU) and coronary care unit (CCU) for diagnosis of cardiac abnormalities. Accurate detection of QRS complex forms the basis of extraction of other features and parameters from the ECG signal. A new method, the Adaptive Wavelet Neural Network (AWNN), developed initially for natural and engineering non-linear and non-stationary signal analysis, has now been applied in physiological signal analysis. This paper proposes a method for QRS complex detection in electrocardiogram (ECG) signal based on the AWNN. A commonly used Mexican hat wavelet has been chosen as the activation function for hidden-layer neurons of feed -forward neural network (FFNN). By applying AWNN on the ECG data, taken from MIT- BIH Arrhythmia database, it is found that QRS detection rate is 99.860 % with Sensitivity 99.945% and Positive Predictivity 99.915% which is better than the result obtained using other existing methods such as wavelet, multi-layer perceptron (MLP) and radial basis function (RBF) neural networks as well as recently proposed fuzzy neural network (FNN).

Keywords—Electrocardiogram (ECG) signal, Wavelet Transform (WT), Adaptive Wavelet Neural Network (AWNN), QRS detection rate, Sensitivity, Positive Predictivity, MIT- BIH Arrhythmia database, Back-Propagation Algorithm (BPA).

1. INTRODUCTION

Electrocardiogram (ECG) is one of the most important physiological parameter, which is being extensively used for knowing the state of the cardiac patients. It enables a rapid observation of the behaviour of the heart activity in terms of heart rhythm, conduction intervals, morphological aspects of the waves (P, Q, R, S, T) associated to depolarisation and repolarisation of the auricles and ventricles. Feature extraction of ECG is most essential task in the manual and automated ECG analysis for use in instruments like ECG monitors, Holter tape recorders and scanners, ambulatory ECG recorders and analysers. Reliable detection of the QRS complex in either a normal or an abnormal ECG and its analysis is the first and foremost task in almost every ECG signal analysis system aimed at the diagnostic interpretation of ECG. As the wavelet transform (WT) has promising feature to characterize the local regularity of signals by decomposing the signal into elementary building blocks that are well localized both in time and frequency, and thereby, their robustness to noise make it appropriate choice for QRS complex detection. The feature of characterizing the local regularity of the signal is used to distinguish QRS complex from spurious noise, artifacts, baseline drift and high P and T waves. The performance of temporal and multiscale methods to align the QRS complexes in a single recording channel of different simulated high

resolution ECG and Holter records have been analysed ^[1]. Martinez et al have presented and validated a wavelet-based ECG delineation system which performs QRS detection and provides the locations of the peak(s) of P,Q,R,S and T waves, and the P, QRS, and T wave boundaries using a single analysis stage: the dyadic wavelet transform of the ECG signal^[2]. An effective simulation technique for ECG signal has been developed for the enhancement of the ECG identification algorithm design and testing by Adam Josko et al in year 2005 ^[3]. Po-Ching Chen et al presented a new algorithm which automatically categorized T-wave morphologies and improved the precision of T -wave delineation by WT using multiscale differential operator^[4]. Automatic beat-segmentation and classification system based on a Markovian approach is proposed where ECG signal is analysed in two layers. At layer 0, the ECG signal is segmented in terms of the beat waveforms and at layer 1; the system identifies premature ventricular contraction beats^[5]. Phillippe Ravier et al have redefined classical performance evaluation tools in entire QRS complex classification systems and to evaluate the effects induced by QRS detection errors on the performance of heartbeat classification processing (normal versus abnormal)^[6]. An automated patient- specific ECG heartbeat classifier based on an efficient formation of morphological and temporal features from the ECG data and evolutionary neural network (NN) processing of the input patterns is proposed. The wavelet- based morphology features are extracted from the ECG data and are further reduced to a lower dimensional feature vector using principal component analysis (PCA) technique ^[7]. Rute Almeida et al proposed a novel multilead (ML) based automatic strategy for delineation of ECG boundaries and evaluated with respect to the QRS and T-wave boundaries [8]. A wavebased Bayesian framework is used for PVC beat detection that is capable of running on a single ECG lead ^[9]. A Kalman filter with adaptive noise-covariance estimation has been implemented for enhancing the SNR of the ECG signals, while at the same time preserving clinically relevant morphological variations in the ECG^[10].

A wavelet neural network (WNN) was first proposed by Zhang *et al.* ^[11] as an alternative to the classical feedforward neural network (FFNN) for approximating arbitrary nonlinear functions, inspired by both the FFNN and wavelet theory. Due to the local properties of wavelets and the concept of adapting the wavelet shape according to training data set instead of adapting the parameters of the fixed shape basis function, WNNs are having better generalization property in contrast to the classical FFNNs and hence, these are more appropriate for the modelling of high frequency signals. The WNNs have been successfully applied in the field of function learning ^[12], nonlinear system identification ^[13] and time series predictions ^[14].

The concept of Adaptive Wavelet Neural Network (AWNN) is inspired by both the technologies of wavelet decomposition and neural networks. In standard neural networks, the input output mapping is approximated by the superposition of sigmoid functions; while in AWNN, this relationship is approximated by the superposition of a series of wavelet functions. AWNN combines the multi-resolution nature of wavelets and the adaptive learning ability of neural networks, and has found many applications in time series prediction, function approximation and physiological signal analysis.

2. ADAPTIVE WAVELET NEURAL NETWORK

The wavelet analysis procedure is implemented with dilated and translated versions of a mother wavelet. Since signals of interest can usually be expressed using wavelet decompositions, signal processing algorithms can be performed by adjusting only the corresponding wavelet coefficients. In theory, the dilation (scale) parameter of a wavelet can be any positive real value and the translation (shift) can be an arbitrary real number. This is referred to as the continuous wavelet transform. In practice, however, in order to improve computation efficiency, the values of the shift and scale parameters are often limited to some discrete lattices. This is then referred to as the discrete wavelet transform. Both continuous and discrete wavelet transforms have been introduced to implement neural networks. Some basic concepts about wavelet transform and adaptive neural network are discussed here.

2.1.CONTINUOUS WAVELET TRANSFORM Historically the continuous wavelet transform was the first studied wavelet transform. The continuous wavelet transform W(a, b) of function f(t) with respect to a mother wavelet $\phi(t) \in L^2(\Re)$ is given by

$$W(a,b) = \frac{1}{\sqrt{C_{\phi}}} \int_{-\infty}^{\infty} f(t)\phi_{a,b}^{*}(t)dt$$
(1)

 $\phi_{a,b}(t) = \frac{1}{\sqrt{a}} \phi\left(\frac{t-b}{a}\right), t \in \Re, a, b \in \Re, a > 0$

Where

The dilation (scale) parameter *a* controls the spread of the wavelet and translation (shift) parameter *b* determines its central position and (*) denotes the complex conjugate. A set of basis function $\phi_{a,b}(t)$ is derived from scaling and shifting the mother wavelet. The basis function of the transform is called the daughter wavelet. The mother wavelet has to satisfy the following admissibility condition:

(2)

$$C_{\phi} = 2\pi \int_{-\infty}^{\infty} \frac{\left| \overline{\phi} (w)^{2} \right|}{w} dw < \infty$$
(3)

Where $\phi(w)$ the Fourier transforms of $\phi(t)$ is given by

1

$$\bar{\phi}(w) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \phi(t) e^{-jwt} dt.$$
(4)

Practically $\phi(w)$ will have sufficient decay, so that the admissibility condition reduces to

$$\int_{-\infty}^{\infty} \phi(t)dt = \phi(0) = 0$$
(5)

The WT transforms the function from original domain (*time*) in to wavelet domain (a, b domain). A function f(t)having both smooth global variations and sharp local variations can be effectively represented in wavelet domain by corresponding wavelet function W(a, b). The original function f(t) can be recovered from the wavelet function by using an inverse wavelet transform, defined as

$$f(t) = \frac{1}{\sqrt{C_{\phi}}} \int_{-\infty}^{\infty} \int_{0}^{\infty} W(a,b) \frac{1}{\sqrt{a}} \phi\left(\frac{t-b}{a}\right) \frac{da.db}{a^{2}}$$
(6)

2.2. DISCRETE WAVELET TRANSFORM IN DWT, it is convenient that the parameters a and b corresponding to wavelets are sampled on so called "dyadic" grid and can be defined as functions of level and position. The common definition of such discreet wavelet is

$$\phi_{j,k}(t) = 2^{-\frac{j}{2}} \phi(2^{-j}t - k); \qquad j,k \in \mathbb{Z}$$
(7)

The discreet wavelet transform can be also defined by

$$W(j,k) = \frac{1}{\sqrt{C_{\phi}}} \int_{-\infty}^{\infty} f(t)\phi_{j,k}^{*}(t)dt$$
(8)

where level j determines how many wavelets are needed to cover the mother wavelet, and the number kdetermines the position of the wavelet and gives the indication of time. For practical implementation ϕ and computational efficiency, the inverse wavelet transform (6) is often discretized and can be expressed as

$$f(t) = \sum_{i} W_{i} \frac{1}{\sqrt{a_{i}}} \phi\left(\frac{t - b_{i}}{a_{i}}\right)$$
(9)

Where (a_i, b_i) represent discrete points in wavelet domain, and W_i is the coefficient representing the wavelet transform evaluated at (a_i, b_i) . Based on (9), a three layer feed-forward neural network (FFNN) with as the activation function of the hidden neurons and with a linear neuron in the output layer can be constructed and it can be referred as wavelet neural network (WNN).

2.3. WAVELET NEURAL NETWORK (WNN): Normally, both continuous and discrete wavelet transforms have been used to implement wavelet neural networks. Existing WNNs can, therefore, be categorized into the following two types.

Fixed Grid Wavelet Neural Networks (FGWNN), where the activation functions stem from the discrete wavelet transforms and unlike in adaptive neural networks, the unknown inner parameters of the networks vary on some fixed discrete lattices. In such a WN, the positions and dilations of the wavelets are fixed (predetermined) and only the weights have to be optimized by training the network. In general, gradient type algorithms are not needed to train such a network. An alternative solution for training this kind of network is to convert the networks into a linear-in-the-parameters problem, which can then be solved using least squares type algorithms.

Adaptive Wavelet Neural Networks(AWNN), where wavelets as activation functions stem from the continuous wavelet transform and the unknown parameters of the networks $x = [x_1, x_2, ..., x_n]$ include the weighting coefficients (the outer parameters of the network) and the dilation and translation factors of the wavelets (the inner parameters of the network). These parameters can be viewed as coefficients varying continuously as in conventional neural networks and can be learned by gradient type algorithms.

3. ARCHITECTURE OF AWNN

A typical Adaptive Wavelet Neural Network (AWNN) contains an input layer, a wavelet layer, a product layer and an output layer. The structure of an AWNN model is shown in Figure 1. Similar to FFNN, it comprises of an input layer, a hidden (or wavelet) layer and a linear output layer. The input data in input layer of the network are directly transmitted into the wavelet layer. As the hidden layer neurons make use of wavelets as activation functions, these neurons are usually referred as "wavelons".

The wavelet family can be generated by translating and dilating the mother wavelet and it can be expressed as follows:

$$\psi_{a,b}(x_i) = \left(1 - \left(\frac{x_i - b}{a}\right)^2\right) c^{-0.5\left(\frac{x_i - b}{a}\right)^2}, i \in n$$
(10)

The n-dimensional wavelet basis function can be calculated by the tensor product of 1-D wavelets. Therefore, the output of all hidden layer neurons (wavelons) will be the same and can be written as



Figure 1. General structure of an AWNN Model

In order to map linear input-output relation, it is customary to have additional direct connection from input layer to output layer, since there is no point in using wavelets for reconstructing linear term. The output of the AWNN can be computed as

$$y = \sum_{j=1}^{m} w_{j} z_{j} + \sum_{i=1}^{n} v_{i} x_{i} + g$$
(12)

Where is the layer weight between th wavelon and output node, is the input weight between th input node and output node, and is the bias of output node.

4. LEARNING ALGORITHM AND TRAINING OF AWNN

This study adopts a three-layer neural network trained by back-propagation algorithm (BPA) to analyze physiological signals. Since pattern recognition of ECG waveforms resembles human learning, the use of supervised learning applying gradient descent algorithm is examined. The BPA is a supervised learning algorithm, in which a sum of square error function is defined. The learning process aims to minimize overall system error. Figure 2 depicts the back-propagation algorithm used for network training with moderate values of learning rate and momentum. The algorithm is described as follows:

Step1: Normalize the training patterns and initialize weight values and threshold values.

Step2: Train the BP AWNN to calculate errors between output and target values.

Step3: If the error satisfies the stop criterion, terminate the training. Otherwise, return to step 2.

Step4: Normalize the test patterns and apply them to the AWNN to estimate the predicted value.



5. RESULTS AND DISCUSSIONS

Simulations for several different cases are carried out applying aforesaid algorithm to evaluate the performance of the proposed AWNN based method in MATLAB. In the following examples, all the ECG signals are from the MIT–BIH arrhythmia database. Every file in the database consists of lead II recordings sampled at 360 Hz with 11 bits per sample of resolution. Figure 3 shows an arrhythmic signal, designated as 100 in MIT-BIH database, having 3600 samples for 10 seconds duration with sampling frequency 360 Hz.



Figure 3. An arrhythmic signal designated as 100



Figure 4. Analysed arrhythmic signal





Analysed arrythmic signal for signal designate 100 is shown in figure 4.Figure 5 is the training result of thr network which gives performance as 9.04074e-005 with a goal of 0.0001 and regression analysis is shown in figure 6. The result of QRS detection obtained after analysis is shown in Table 1.For Record No. 100, total no of beats detected is 2141 whithout any failed detection.Failed Detection is the summation of False Positive (FP) and False Negative (FN).Sensitivity, Positive Predictivity, and QRS Detection Rate is calculated as follows:

Sensitivity;
$$=\frac{TP \times 100}{TP + FN}$$
 Positive Predictivity $=\frac{TP \times 100}{TP + FP}$
QRS $=\frac{(TotalBeat - (FP + FN) \times 100}{TotalBeat}$ Detection Rate

where FP denotes the number of false positives and corresponds to a detector error of detecting a QRS complex where there is none and FN denotes the number of false negatives (FN's) and corresponds to a detector error of not detecting a QRS where there is one, respectively and TP is difference between detected QRS beat and FP.

Table 1. Result of QRS detection using Adaptive Wavelet Neural Network (AWNN) for MIT-BIH database.

Record No.	Total No. of Beats	Detected QRS	ТР	FP	F N	Failed Detection (FP+FN)	Sensitivity (%)	Positive Predictivity (%)	QRS Detection Rate (%)	
100	2141	2141	2141	0	0	0	100 100		100	
101	1735	1734	1734	0	1	1	99.942	100	99.942	
102	2069	2069	2069	0	0	0	100	100	100	
103	1952	1951	1951	0	1	1	99.948	100	99.948	
104	2113	2112	2112	0	1	1	99.952	100	99.952	
105	2428	2427	2424	3	4	7	99.834	99.876	99.711	
200	2431	2426	2426	0	5	5	99.794	100	99.794	
201	1949	1958	1949	9	0	9	100	99.540	99.538	
202	2024	2031	2024	7	0	7	100	99.655	99.654	
203	2871	2869	2869	0	2	2	99.930	100	99.930	
205	2526	2526	2526	0	0	0	100	100	100	
Total	24239	24244	2422 5	19	14	33	99.945	99.915	99.860	

Rate of QRS detection in ECG signal is obtained as 99.860% with a *Sensitivity* of 99.945 % and *Positive Productivity* of 99.915 % as mentioned in above table which is superior to the detection rate obtained using other existing methods.



The paper examines the effectiveness of Adaptive Wavelet Neural Network (AWNN) for QRS Complex detection in ECG signal which is basis of diagnosis of so many heart related diseases. In this paper, an AWNN, which combines the localization property of wavelet and learning capability of the FFNN, has been examined to analyse ECG signal and to find *QRS detection rate, Sensitivity* and *Positive Predictivity* for MIT –BIH arrhythmia data base. The test results obtained have been presented and compared with existing analysis method such as wavelet, MLP, RBF, and fuzzy neural networks. It is observed that an AWNN converges with higher detection rate and outperformed because of its favorable property for modeling the non-stationary and high frequency signals such as ECG signal. In all the test signals it is found thatAWNN has least number of FN detection which indicates that this method does not miss as many QRS complex as other algorithm does i.e. QRS complex corresponds to a modulus maxima pair of the AWNN.



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SINGLE PHASE FIVE LEVEL INVERTER BY USING MULTI CARRIER PWM TECHNOLOGY

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This paper proposes a single phase five level cascaded inverter which is based on the investigation and analyses of multicarrier PWM methods. These types of converter are suitable for high voltage and high power application. Due to their ability to synthesize wave forms with better harmonic spectrum. Carrier disposition method is mainly discussed in this paper. Multicarrier phase disposition method for single phase five level cascaded inverter is discussed in this paper. By the use of carrier-based modulation scheme, harmonics is reduced and efficiency increases. A five level cascaded inverter with peak voltage 200 V and power 2 kW is simulated using MATLAB simulink environment and total harmonic distortion (THD) are measured.

Keywords—Total harmonic distortion (THD), PWM (pulse width modulation) and EMC (electromagnetic compatibility)



The inverter is a device that produce an output voltage or current with two levels either 0 or $\pm V_{DC}$. They are known as 2 level inverter. To improve the output voltage or a current waveform with a minimum amount of ripple content, a high switching device is required, with PWM topology. With two levels inverter has suffer from many disadvantages like switching losses and more harmonic.

To increase the voltage inverters are connected in series, in order to increase the current inverter are connected in parallel. The multilevel inverters are particular advantages for operating at high power and high voltage application. The multilevel inverter has several advantages over the basic 2 level inverter. The smaller voltage steps lead to the production of higher power quality waveform and also reduce stress on the load and reduce the electromagnetic compatibility (EMC) and also reduce the electromagnetic interferences [5]. One more and most important feature of multilevel inverter is that semiconductors are connected in series, which allows operation at higher voltages [1]-[10].

As the number of voltages levels increases, the harmonic content of the voltage waveform decreases [1]. In the recent years, inverters become very necessary for motor controlling and power system. In AC drives multilevel inverter shows much promises in reduction in harmonic and supplying high power. Multilevel inverters are mainly used for medium

and high renewable sources such as fuel cell, photovoltaic cell etc.

FEATURES OF MULTILEVEL INVERTERS: A multilevel inverter can eliminate the need for the step-up transformer and reduce the harmonic produced by the inverter. Medium design complexity and power sharing is controlled. MOSFET are used in this multi inverter in order to achieve high efficiency and to reduce the cost of inverter [4]. As the number of voltage level increases n, the number of switches increases by the formula 2 * (n - 1) [4]. In this paper multicarrier PD method is discuss ,in this method all the carrier signals are in same phase [3], [2] and [5].

2. OPERATION PRINCIPLE

Single phase five level inverter consist of two H-bridge is shown in fig 1 [3] and [2]. Each H-bridge consist of four switches, here MOSFETs are used. Each H-bridge is connected to separate DC source. Thus for the 1 phase 5 level inverter all together consist of 2 H-bridges. The connection diagram of single phase 5-level inverter is shown below. It consists of eight switches. The switching strategy of 5-level cascaded inverter is shown in table 1.



Fig 1. The circuit diagram single phase 5-level cascaded inverter

VOLT-AGE	\mathbf{S}_1	S_2	S_3	S_4	S ₅	S_6	S_7	S_8	D ₂	D_7	D_8
0	1	0	0	0	0	0	0	1	1	1	0
V _{dc}	1	0	0	1	0	0	0	1	0	1	0
2V _{dc}	1	0	0	1	1	0	0	1	0	0	0
- V _{dc}	0	1	1	0	0	0	1	0	0	0	1
-2 V _{dc}	0	1	1	0	0	1	1	0	0	0	0

Table 1. The switching table for single phase five level cascaded inverter

According to this switching arrangement we get the wave form of single phase five level cascaded inverter as shown below.



Fig 2 Complete wave form of single phase 5-level cascaded inverter during one switching cycle

3. DIFFERENT METHOD OF MULTICARRIER PWM SCHEME

a) The amplitude modulation index: It is the ratio of amplitude of the reference signal (A_0) to the peak to peak value of the carrier signal (A_{cpp}) [3] and [2].

$$M_{a} = \frac{A_{o}}{A_{cpp}}$$
 for phase shift

 $M_{a} = \frac{A_{o}}{4.A_{cpp}}$ for CD and hybrid

b) The frequency modulation index: It is the ratio of carrier signal (f_c) to the frequency of the reference signal.

$$M_{f} = \frac{f_c}{f_o}$$

4. SIMULATION OF CASCADED 5-LEVEL INVERTER

Using MATLAB simulink software along with its SIMULINK and SIMPOWERSYSTEM toolboxes, this 5-level cascaded inverter is simulated. Fig. 3 shows the Schematic diagram for simulation of 5-level cascaded inverter. It consists of two subsystems 1) PWM signal generator 2) 5-level inverter.

A subsystem of PWM signal generator is shown in figure 4. Here multi carrier signal is used to generate the PWM signals for various switches used in 5-level cascaded inverter. For 5-level inverter 4 carrier signals are used. The PWM switching generated signal for different switches of inverter are shown on figure 6.



Fig. 3 Complete Schematic diagram for simulation of 5-level cascaded inverter using MATLAB Simulink



Fig. 4 Schematic diagram for simulation of subsystem PWM generator of 5-level cascaded inverter



Fig. 5 Schematic diagram for subsystem of 5-level cascaded inverter



Fig. 6 PWM generating signals for 5-level cascaded inverter


Fig. 7 shows the output voltage and current waveforms for 5-level inverter



Fig. 8 shows the THD content in current waveform of 5-level inverter.



Fig. 9 shows the THD content in voltage waveform of 5-level inverter.

5. RESULTS AND CONCLUSION

In this paper single phase five level inverter using PWM techniques for VSI inverter has been represented. The modulation techniques has been analysed and the conclusion is that, the harmonics are reduced by using PWM techniques and eliminate the use of filter. The PWM method is the internal control of inverter is employed to reduce harmonic content in the current up to 1.53 %. However step by step we have to determine the methods, which should be employed in order to find the exact solution. We also find that where reduce harmonic content, high voltage and high power are required multilevel inverters are employed. Multilevel inverters are mainly used for medium and high renewable sources applications where such as fuel cell or photovoltaic cells are employed.

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GREEN BUSINESS PRACTICES: STUDY OF TOP INDIAN COMPANIES FROM DIVERSE SECTORS

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Past researches have shown that consumers appreciate and at times base their purchases in favour those firms that make charitable donations, protect environment and behave ethically. All this makes for the evidence that social concerns have entered into consumer decision making process. Hence, a company cannot afford to risk its reputation by being irresponsible towards environment. Starting a green business or making an existing one greener is a daunting task. A green business strives to have a positive impact on the environment and community. It develops and practices business strategies that go beyond regulation and demonstrate commitment to a healthy and sustainable future. Companies have strengthened their commitment to sustainability as the benefits become more apparent and the alternatives more untenable. Just as natural resources are becoming scarce and costly; customers, employees and investors are increasingly environmentally-conscious. Championing sustainability allows businesses to align deeply with their missions and engage customers on a more meaningful level. This paper studies the emerging Green practices adopted by top four companies from different industries; namely ITC from Hospitality sector, TCS from IT sector, Maruti Suzuki India from the automobile sector and Hindustan Unilever from FMCG sector. It analyses the impact of new conventional approaches, leaving the traditional method of going green far behind. Learning from this model can be emulated by other large and medium scale industries. They can also draw the benefits of greater environmental compliance and responsiveness.

Key words: Carbon Footprint; End of Life of Vehicle (ELV); Green Business Practice; LEED Green Building; Zero Discharge Site

1. INTRODUCTION

Marketing is ultimately dependent on the use of scarce resources to fulfill human needs. In order to protect the environment and to improve the quality of life; companies are concerned with issues that include conservation of natural resources, reducing environmental pollution, protecting endangered species, and control of land use. The three R's of environmentalism: Reduce, Reuse, and Recycle is finding favor with boardrooms because consumers are willing to pay more for a green product.

Traditionally, companies employed practices like saving paper by printing only what is essential, keeping electrical gadgets switched off when not in use and so on. But no longer are these measures sufficient enough to meet the futuristic needs which have forced the corporate think-tanks to innovate and evolve on a continuous basis. Many technological breakthroughs are being adopted worldwide. In this paper, we are focussing on the ones employed by industry majors like ITC, Maruti Suzuki India, Tata Consultancy Services and Hindustan Unilever.

Some of them are:

1.1 Green Infrastructure: As a testimony to its low carbon philosophy, ITC continues to provide inspiration to the 'green buildings' movement in India. Each of the chain's hotels pays architectural tribute to the ancient dynasties which ruled India from time to time. The design concept and themes of these dynasties play an important part in their respective style and décor. All ITC premium luxury hotels have been accorded the Leadership in Energy and Environmental Design (LEED) Platinum certification.¹ This achievement makes ITC Hotels the 'greenest luxury hotel chain' in the world, positioning ITC, at the forefront of global environmental stewardship. These iconic green buildings have set benchmarks in energy efficiency, water conservation and solid waste recycling. At 170,000 sq feet, ITC Green Centre is the world's largest 0% water discharge, non-commercial Green building, and compared to similar buildings, ITC Green Centre has a 30% smaller carbon footprint. For example, the L-shaped architecture of the building serves more than one function in more than one area of the immediate environment. The central atrium allows a column of glare-free natural light to form in the heart

of the building, thereby reducing the use of artificial light. It also ensures that one part of the façade is always in the shade, preventing too much heat from entering the structure, and the cooling effect is supported moreover by the discreet bodies of water placed in front of the building. Significantly, the atrium also connects the various parts of the building to each other, both horizontally and vertically. Not only does it provide a sense of space, but by its very design it encourages interaction between the various parts, and more, it promotes a sense of community. It is the hub of the building in every sense of the word.

1.2 Manufacturing Overhaul: Maruti Suzuki follows "One Gram One Component"² programme that aims at reducing material consumption through re-engineering and design modification of existing vehicles.

OBD II Implementation: OBD is a tool to diagnose the health of a car with respect to its emissions. In the event of a malfunction of the emission control system, the OBD system lights up the engine check lamp on the speedometer. This helps in speedy identification and rectification of emission-related faults in the system. In 2011-12, Maruti Suzuki became the first company in India to introduce OBD II compliance models with the launch of the new Swift and DZire. The Company is in the process of making all its models OBD - II compliant.

1.3 Greenhouse gas emissions:

a) Factory level : By 2012, Hindustan Unilever (HUL) succeeded in reducing CO2 emissions per tonne of production by 41.8% against the 2004 baseline and 22% compared to their 2008 baseline.³ This was achieved through various initiatives such as biomass boilers, thermal fluid heaters and hot air generators at factory sites. These projects helped increase the share of renewable energy to 19% in year 2012.

The major source of greenhouse gas (GHG) emission at Maruti Suzuki2⁴ is the combustion of fuel for power generation and process requirements, accounting for over 90% of the Company's total GHG emissions. Hence, special fluidised bed type incinerator installed for cleaning of paint booth gratings instead of a direct burning type incinerator is used.

b) Zero HFC Refrigerants: In 2007, HUL stopped purchasing Hydro fluorocarbons (HFC) refrigerant cabinets for its Kwality Walls brand (Ice Cream Division) and replaced them with new cabinets that use climate-friendly Hydrocarbon (HC) refrigerants⁵. These freezers have brought about a significant reduction in carbon footprint. So far, 30,000 cabinet refrigerators have been commissioned and likely to reach 8, 50,000 units by 2015.

Maruti fills environment friendly refrigerant gas R134a in the vehicles it produces⁶. The refrigerant gas is filled into the vehicles with advanced dispensing machines having automatic selection of vehicle type and filling quantity, to avoid any leakage at the time of filling.

1.4 Energy Conservation: In keeping with its commitment to utilize an increasing component of renewable energy, ITC has set up a 14 MW wind energy unit in Chennai. It has also recently commissioned a 21 MW plant in Karnataka and a 2.5 MW plant in Rajasthan. ITC's strategies for climate change adaptation and sustainable livelihood creation are aligned to the Indian Government's National Action Plan on Climate Change. The architecture of ITC Green Centre allows enough natural light to penetrate throughout the building during daytime, and business is concluded by sundown, so that very little energy to light the building at night. And this particular stratagem goes further to prevent any kind of light pollution produced by the building. The high roof coating reduces the amount of heat absorbed by reflecting over 90% of visible and infra red radiations away from the building. This reduces the roof surface temperature by 30 degrees and brings down the use of energy for air conditioning in the top floor by 10-15%. Moreover, the 250mm thickness of the building's walls, the double glazed windows and high performance glass reduce the amount of solar heat entering the building by more than 65%. For example, water heated by solar thermal technology saved approximately 30,000 kilowatts per hour in 2008-09⁷.

Hotel directs the hotel staff to keep the curtains drawn apart if the conference hall has access to daylight and also if formal suits and ties can be dispensed with, raise the air-conditioning to about 25 or 26 deg C.

HUL took up several environment-friendly initiatives such as setting up a cogeneration power unit, use of sky light pipes which allow natural sunlight for illumination on the shop-floor and the use of LED lights and energy efficient motors. The pilot project of using CFL bulb at its Bangalore depot resulted in reduction in power consumption by a whopping 50 percent.

Maruti introduced a new generation electro-deposition (ED) paint coating that operates at low voltage and consumes less energy in paint operations at its Gurgaon plant. In addition, Aerodynamic energy-efficient fibre reinforced plastic (FRP) blades replaced the standard blades at the cooling towers for lower energy consumption. The voltage in the shops was optimised for lighting and motor loads. Desiccant-type air dryers were introduced to reduce energy consumption. Only LED lights were installed at Manesar plant, making it the first car manufacturing plant in India to use LED technology entirely.

1.5 Water Conservation

a) Unique Product: HUL devised a unique way of saving water used for laundry purposes. Studies show that rinsing clothes accounts for the bulk of water consumption in the laundry process. On an average, three to four buckets of water are used for rinsing per wash. Rinsing alone accounts for 80% of water consumption in laundry for many households that rely on washing clothes by hand. They developed two products: Magic and Comfort 1 Fabric Conditioner which make rinsing, a less water consuming activity as just a capful in the very first bucket of rinse helps remove all the lather and soap and thereby help save up to three buckets of water per wash.

b) Re-model Manufacturing process: With a view to lessen the water abstraction rate, HUL deployed Rainwater harvesting in 22 sites out of a total of 38 sites. Sites for Home Care products at Goa, Mangalore, Puducherry, Dapada, Sumerpur, Tatapuram and Chiplun saved up to 13,500 kilolitres of water per annum cumulatively by implementing roof rainwater harvesting. Other Initiatives include recycling of treated effluent water through Reverse Osmosis technology, optimising process operations etc. The recycled water is used for the cooling tower for air-conditioning, landscaping and flushing. The site, therefore, is a zero discharge site. Thus, 30 of 38 manufacturing sites are zero-discharge sites.

c) Waterless facilities: ITC Hotels started water management in 1990 and since then has reduced more than 40% water use by innovative design expression and are constantly raising the water productivity in their chain of hotels. All ITC hotels are working towards being zero discharge hotels, by treating and recycling water within their hotels and providing the surplus to their nearest neighbour or the municipality for use in horticulture.

Hotel	Water Saved*
ITC Windsor	15
Sheraton Chola	05
ITC Kakatiya	07
ITC Maurya	30
Welcome Hotel New Delhi	30
Total	87

Table A Zero Discharge Hotels

Source: http://www.itchotels.in

* All figures are in kiloliters per day

In addition, rain water harvesting is also adopted by the organization in its other industries and conglomerate activities and for building social infrastructure. The amount of rainwater harvested regularly exceeds the total amount of water consumed by the company's units. An intelligent approach to landscaping is adopted by hosting indigenous plants from the region which require very little water to thrive. The waterless urinals in the building are used, where biological blocks containing particular bacteria are used that reduce odour problems and blockages in the urinals. Incidentally, all waterless urinals annually save approximately 300,000 litres of drinkable water collectively⁸.

1.6 Air Quality The low levels of Volatile Organic Compounds in the materials used in the construction of ITC Green Centre, in adhesives, sealants used for carpets, composite woods and paints ensures that there aren't any known harmful substances in the air that might affect inhabitants of the building, and the comfortable distance between floor and ceiling allows natural ventilation. They also have designated smoking zones in convenient locations with their own exhaust fans. Moreover, 90% of all regularly occupied areas have access to open-able windows, and when the temperature outside is low; an external air-economizer draws in 100% of the air from outside, inviting fresh air into the building. And this works especially well when working in conjunction with the fan-based night-purge system that flushes out heat when the building is vacant, making sure that the environment is pleasant when people return in the morning to work. And during work hours, the CO2 monitoring system maintains carbon dioxide levels based on the number of occupants within the building and the conditions outdoors.

1.7 Waste Management through

a) Reduce / Reuse / Recycle Packaging: ITC has made significant efforts in solid waste recycling and nearly 100% of wastes generated by its Units are recycled. Over and above that, ITC have pioneered a special initiative - 'Wealth out of Waste' (WOW)⁹ which aims to raise awareness among the public on the benefits of the reduce-reuse-recycle process and inculcate the habit of source segregation, thereby protecting the environment, conserving scarce natural resources and improving civic amenities, public health and hygiene. This not only caters to the fibre requirements of ITC's Paperboards business but also creates large scale urban employment besides preserving natural resources.

HUL introduced Re-fill packs in several products such as Lifebuoy, Vim Liquid & Kissan Ketchup to encourage re -use of Primary package.

To tackle the menace of sachet waste, the technology options being worked on include pyrolysis, cement coprocessing and mechanical recycling. Pyrolysis offers a closed loop system which involves catalytic depolymerisation of plastics into fuel. The fuel can be used in factories as furnace oil or can be used for similar industrial applications at viable cost. HUL factory in Puducherry has successfully used the fuel to power its boiler to check feasibility of this approach.

b) Conversion of Waste into energy alternative: At HUL emphasis on recycling has led to more than 98% of total waste being recycled in environmentally-friendly ways which also include sludge-digesters installed in the Nasik and Amli (Silvassa) factories. In Nasik, the gas generated would be used in the canteen for cooking. Another example of the 'energy from waste' model at work is the Effluent Treatment Plant sludge of the Hosur factory. It is co-processed through the plants of ACC Limited (a cement major) which uses the sludge as fuel in its cement kiln. This has eliminated the need for incineration and land filling. The saleable solid wastes such as metal scrap and glass waste are sold to recyclers. All inprocess and vehicle related e-waste is disposed off through authorised recyclers only.

c) End of Life of Vehicle (ELV) Compliance: Both Swift and Dzire manufactured by Maruti Suzuki are ELV compliant i.e. they do not contain hazardous substances such as mercury, hexavalent chromium and cadmium. ELV is an European norm. By 2013, all models comply with this norm except M800, Omni and Gypsy

1.8 Green Supply Chain ITC Hotels pursues a policy sustainable development and has aligned it with its supply chain. It ensures that its supply partners upholds similar ecological beliefs and they are to submit the filled questionnaire regarding their water use, air, noise levels, energy consumption, fire protection, mechanical and civil standards along with hygiene, waste management and lightening conditions.

Maruti Suzuki has a supplier base of 267 suppliers, including 20 joint venture companies. Most of its suppliers and joint venture companies, contributing to 86% (by value) of the components sourced by the Company, are located within a radius of 100 km. The Company is working with all its tier 1 suppliers to implement Environment Management System at their facilities. As on 31st March, 2012, 66.3% of the Company's suppliers were ISO 14001 compliant¹⁰. The Company has set a target for its entire tier I suppliers to get ISO 14001 certification in a time-bound manner.

1.9 Green IT The sheer scale and complexity of the automobile industry makes it heavily dependent on IT. With the increase in business operations, the role of IT has become critical. While there are enormous benefits of using IT systems, the environmental impact of such systems during use and at the time of disposal at the end of their usable life cannot be overlooked. Maruti Suzuki uses the best-in-class IT equipments that consume less energy, replaces existing equipment with more energy efficient ones and has a buy-back arrangement with IT equipment suppliers. A user-wise accounting system tracks and reduces the amount of paper used in printing. Users are educated about the need to conserve resources such as paper, electricity and ink. The IT Data Centre of the Company has been designed to consume less energy. The temperature of the servers is maintained continuously through ducts at floor level.

1.10 E-waste Management The E-waste generated at the various TCS facilities includes defunct computers, monitors, servers, etc. and specified electronic and electrical items. Management of E-waste is as per TCS' E-waste Management policy which complies with the WEEE directive and the Government of India's E-waste (Management and Handling) Rules, 2011. In FY 2012, 7650 numbers of equipment were disposed of through government authorized handlers / recyclers. In addition, computers which were deemed obsolete for TCS's purposes but are in working condition, are donated to charitable institutions which have use for such equipment. Recipients of such donations are advised to return the hardware to TCS once it reaches end-of-life for proper disposal through government authorized E-waste vendors.

1.11 Hazardous Waste Management At TCS, hazardous waste is disposed of as per the Ministry of Environment and Forests' (MoEF) Hazardous Waste Handling and Management Rules, only through MoEF-authorized agencies. This is overseen in some states by the local pollution control boards. Additionally, all the used printer cartridges and photocopier toner bottles are sent back to the manufacturer under product take back arrangement to ensure proper disposal.

Та	ble	B
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Hazardous Waste Treatment

Hazardous wastes Disposed	FY 2012
Lube oil from DG sets (litres)	16,596
Used batteries from UPS systems (nos.)	7147

Source: www.tcs.com

2. CONCLUSION

The above example of Indian organizations shows that how different companies are contributing towards social responsibility. Nowadays, consumers are not only interested in knowing more about the products they buy, but they wish to know more about the companies behind the products. Social investors do not just look at companies, which make money but also focus on issues such as a corporation's impact on society. The development of CSR can be seen in the growing expectations of the community and stakeholders of the developing role of companies in society and the response of companies to growing environmental, social and economic pressures. Successful businesses should promote the interests of not only their shareholders, but also assume a position with social responsibility programs that aims to serve the society. More importantly, in this age of widespread communication customers of any product or service are unlikely to feel satisfied in buying from a company that is seen to violate the expectations of ethical and socially responsible behavior.



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IMPACT OF ECONOMIC SLOWDOWN IN ASIA: A COMPARATIVE IN-DEPTH STUDY

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The economic slowdown of American economic has a domino effect on all most all the countries of the world. In some of the counties the effect was severe but in Asian countries, the impact was not so severe. The paper critically evaluates the economic indicators of different Asian countries i.e., pre and post recession period. In this paper FDI, inflation rate, the bank rates and other variables have been taken as independent variable, and GDP has been taken as dependent variable. The effect has been calculated through various descriptive statistics parameters. The correlation has been made with American growth trend and the countries of Asia. A comparative study has been made between Indian and Chinese economy for a better understanding of the Asian countries. In recession Indian economy is guided by strict and stringent RBI policy as because the lending guidelines were not lenient in India, the impact of recession on India was quite mild.

Keywords: FDI, GDP, Inflation, Economic Meltdown

1. INTRODUCTION TO INDIAN AND CHINESE ECONOMY

China's economy during the past 30 years has changed from a centrally planned system that was largely closed to international trade to a more market-oriented economy that has a rapidly growing private sector and is a major player in the global economy. Reforms started in the late 1970s with the phasing out of collectivized agriculture, and expanded to include the gradual liberalization of prices, fiscal decentralization, increased autonomy for state enterprises, the foundation of a diversified banking system, the development of stock markets¹, the rapid growth of the non-state sector, and the opening to foreign trade and investment. Annual inflows of foreign direct investment rose to nearly \$108 billion in 2008.

India is developing into an open-market economy, yet traces of its past autarkic policies remain. Economic liberalization, including reduced controls on foreign trade and investment, began in the early 1990s and has served to accelerate the country's growth, which has averaged more than 7% per year since 1997. India's diverse economy encompasses traditional village farming, modern agriculture, handicrafts, a wide range of modern industries, and a multitude of services. Slightly more than half of the work force is in agriculture, but services are the major source of economic growth, accounting for more than half of India's output, with only one-third of its labor force. India has capitalized on its large educated English-speaking population to become a major exporter of information technology services and software workers. An industrial slowdown early in 2008, followed by the global financial crisis, led annual GDP growth to slow to 6.5% in 2009, still the second highest growth in the world among major economies. India escaped the brunt of the global financial crisis because of cautious banking policies and a relatively low dependence on exports for growth. Domestic demand, driven by purchases of consumer durables and automobiles, has re-emerged as a key driver of growth, as exports have fallen since the global crisis started. India's fiscal deficit increased substantially in 2008 due to fuel and fertilizer subsidies, a debt waiver program for farmers, a job guarantee program for rural workers, and stimulus expenditures. The government abandoned its deficit target and allowed the deficit to reach 6.8% of GDP in FY10. Nevertheless, as shares of GDP, both government spending and taxation are among the lowest in the world. The government has expressed a commitment to fiscal stimulus in FY10, and to deficit reduction the following two years. It has increased the pace of privatization of government-owned companies, partly to offset the deficit. India's long term challenges include widespread poverty, inadequate physical and social infrastructure, limited employment opportunities, and insufficient access to basic and higher education. Over the long-term, a growing population and changing demographics will only exacerbate social, economic, and environmental problems.

2. INDIA VS. CHINA ECONOMY

Making an in depth study and analysis of India vs. China economy² seems to be a very hard task. Both India and China rank among the front runners of global economy and are among the world's most diverse nations. Both the countries were among the most ancient civilizations and their economies are influenced by a number of social, political, economic and other factors. However, if we try to properly understand the various economic and market trends and features of the countries, we can make a comparison between Indian and Chinese economy. Going by the basic facts, the economy of China is more developed than that of India³. While India is the 12th largest economy in terms of the exchange rates, China occupies the third position. Compared to the estimated \$1.209 trillion GDP of India, China has an average GDP of around \$7.8 trillion. In case of per capital GDP, India lags far behind China with just \$1016 compared to \$6,100 of the latter. To make a basic comparison of India and China Economy, one needs to have an idea of the economic facts of the countries.

Making an in depth study and analysis of India vs. China economy seems to be a very hard task. Both India and China rank among the front runners of global economy and are among the world's most diverse nations. Both the countries were among the most ancient civilizations and their economies are influenced by a number of social, political, economic and other factors. However, if we try to properly understand the various economy. Going by the basic facts, the economy of China is more developed than that of India. While India is the 11th largest economy in terms of the exchange rates, China occupies the second position surpassing Japan. Compared to the estimated \$1.3123 trillion GDP of India, China has an average GDP of around \$4909.28 billion. In case of per capital GDP, India lags far behind China with just \$1124 compared to \$7,518 of the latter. To make a basic comparison of India and China Economy, we need to have an idea of the economic facts of the countries.

Facts	India	China
GDP	around \$1.3123 trillion	around 4909.28 billion
GDP growth	8.90%	9.60%
Per capital GDP	\$1124	\$7,518
Inflation	7.48 %	5.1%
Labor Force	467 million	813.5 million
Unemployment	9.4 %	4.20 %
Fiscal Deficit	5.5%	21.5%
Foreign Direct Investment	\$12.40	\$9.7 billion
Gold Reserves	15%	11%
Foreign Exchange Reserves	\$2.41 billion	\$2.65 trillion
World Prosperity Index	88Th Position	58th Position
Mobile Users	842 million	687.71 million
Internet Users	123.16 million	81 million.

Table-1: Comparison of different index of India and China

If one makes the analysis of the India vs. China economy⁴, can see that there are a number of factors that has made China a better economy than India⁵. First things first, India was under the colonial rule of the British for around 190 years. This drained the country's resources to a great extent and led to huge economic loss. On the other hand, there was no such instance of colonization in China. As such, from the very beginning, the country enjoyed a planned economic model which made it stronger.

Agriculture: Agriculture is another factor of economic comparison of India and China⁶. It forms a major economic sector in both the countries. However, the agricultural sector of China is more developed than that of India. Unlike India, where farmers still use the traditional and old methods of cultivation, the agricultural techniques used in China are very much developed. This leads to better quality and high yield of crops which can be exported.

IT/BPO: One of the sectors where India enjoys an upper hand over China is the IT/BPO industry. India's earnings from the BPO sector alone in 2010 is \$49.7 billion while China earned \$35.76 billion. Seven Indian cites are ranked as the world's top ten BPO's while only one city from China features on the list.

Liberalization of the market: In spite of being a Socialist country, China started towards the liberalization of its market economy much before India. This strengthened the economy to a great extent. On the other hand, India was a little slow in embracing globalization and open market economies⁷. While India's liberalization policies started in the 1990s, China welcomed foreign direct investment and private investment in the mid 1980s. This made a significant change in its economy and the GDP increased considerably.

Difference in infrastructure and other aspects of economic growth: Compared to India, China has a much well developed infrastructure. Some of the important factors that have created a stark difference between the economies of the two countries are manpower and labor development, water management, health care facilities and services, communication, civic amenities and so on. All these aspects are well developed in China which has put a positive impact in its economy to make it one of the best in the world. Although India has become much developed than before, it is still plagued by problems such as poverty, unemployment, lack of civic amenities and so on. In fact unlike India⁸, China is still investing in huge amounts towards manpower development and strengthening of infrastructure.

Company Development: Tax incentives are one area where China is lagging behind India. The Chinese capital market lags behind the Indian capital market in terms of predictability and transparency. The Indian capital or stock market⁹ is both transparent and predictable. India has Asia's oldest stock exchange which is the BSE or the Bombay Stock Exchange. Whereas China is home to two stock exchanges, namely the Shenzhen and Shanghai stock exchange. As far as capitalization is concerned the Shanghai Stock Exchange is larger than the BSE since the SSE has US\$1.7 trillion with 849 listed companies and the BSE has US\$1 trillion with 4,833 listed companies. But more than the size what makes both these stock exchanges different is that the BSE is run on the principles of international guidelines and is more stable due to the quality of the listed companies. In addition to this the Chinese government¹⁰ is the major stake holder of most of its State-owned organizations hence the listed firms have to run according to the rules and regulations laid down by the government. Hence India is ahead of China¹¹ in matters of financial transparency.

Company Management Capabilities: It is said that Indians have great managerial skills. India also leaves China behind as far as management abilities are concerned. As compared to China India has better managed companies. One of the major reasons for this is that management reform training in China began 30 years ago and sadly the subject has still not picked up as a matter of interest by the citizens of the country. Another important factor behind China not doing well in the business forefront is that most of the countries came to China and manufactured their goods. It was not Chinas exports that drove the economy instead it was the export products of outsiders. Even in the case of mergers and acquisitions China still has not managed to do too well. On the other hand Indian companies¹² are rapidly expanding mergers and acquisitions. Some of the recent examples include; Tata Steel's \$13.6 Billion Acquisition of Corus, Tata Tea's purchase of a controlling stake in Britain's Tetley for US\$407 million, Indian Pharmaceutical giant Ranbaxy's acquisition of Romania's Terapia etc.

China's Import & Export (2010/11): As far as exports of both the countries are concerned both the countries managed to do pretty well in 2010. China's total imports and exports¹³ stood at US \$2677.28 billion at the end of November 2010. India's exports grew¹⁴ by 26.8% and imports increased by 11.2%. Below is presented details about China's import and exports for the year 2010.

	Absolute Value for	Year-on-year growth	Absolute Value for	Year-on-year growth % for
	November	% for November	first 11 months	first 11 months
Export Value	1533.3	34.9	14238.4	33.0
Import Value	1304.4	37.7	12534.3	40.3
Total Import and Export Value	2837.6	36.2	26772.8	36.3
Import and Export Balance	228.9	20.7	1704.1	-3.9

Table-2: China's Import and Exports for the Year 2010



Fig-1: Top Five Export items of China

OBJECTIVES: This study has the following objectives:

- To discover the major trend in economic and social indicators.
- To find out the impact of economic slowdown on the two competitive giants of Asia i.e., India and China
- To assess the effect of different economic variables on the Gross Domestic Product of the two economies
- To discover the approaches of the two economies in view of recessional crisis management.

METHODOLOGY The study is based on descriptive research design. To find out the impact of the recession on the economy, the Real GDP has been taken as the dependant variable whereas the other economic and social variable has been taken as independent variable. In this study regression and ANOVA has been applied to assess the impact. The study is based on the data from 2003 to 2009. The data which are relevant has been taken from authenticated sources.

HYPOTHESIS: For this study, three null hypotheses have been taken and those are as follows:

- Unemployment does not have any impact on GDP
- Inflation does not have any impact on GDP
- The Combination of rate of inflation and unemployment does not have any impact on GDP.

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LITERATURE REVIEW N.Sivasankaran & Dr. M.Kannadhasan, BIM, Trichy in their paper titled "Lessons Learnt from the Global Recession in the Indian context" has emphasized on the challenges caused by the economic meltdown originated by the sub-prime crisis. In their study they took 10 respondent companies operating in India using an interview schedule. The companies responded to the survey belong to both manufacturing and services sector. The collected data were subjected to analysis by applying Mann -Whitney U Test and Kruskal- Wallis One –Way ANOVA and thereby interpretations and conclusion were drawn. The study concludes that cost leadership, building relationships with customers and focus on business efficiency are the top three lessons learnt by the surveyed companies. Most of the respondents opine that their industry have already recovered from the recession and have reached the pre-recession scenario. Further, there exist differences between the services and manufacturing sector in their ability to manage the recession, however respondents belonging to small, medium, and large industries do not exhibit differences in their ability to manage the impact of recession.

Dr. Sumanjeet Singh, in his paper titled "Global Financial Crisis and Indian Economy: Impact Assessment, Policy Responses and Recovery" makes an attempt to assess the impact of global financial crisis on the Indian economy and discuss the various policy measures taken by government of India to reduce the intensity of impacts. The paper also highlighted recovery of Indian economy from crisis and in the end of paper concluding remarks are given towards.

3. THE ECONOMIC AND SOCIAL INDEX OF INDIA AND CHINA- A COMPARATIVE STUDY

CHINA

Year	GDP - real growth rate	Percent Change
2003	8.00 %	
2004	9.10 %	13.75 %
2005	9.10 %	0.00 %
2006	10.20 %	12.09 %
2007	10.70 %	4.90 %
2008	11.90 %	11.21 %
2009	9.00 %	-24.37 %
2010	9.10 %	1.11 %

INDIA

Year	GDP - real growth rate	Percent Change
2003	4.30 %	
2004	8.30 %	93.02 %
2005	6.20 %	-25.30 %
2006	8.40 %	35.48 %
2007	9.20 %	9.52 %
2008	9.00 %	-2.17 %
2009	7.40 %	-17.78 %
2010	7.40 %	0.00 %

Table-3 clearly shows the trend of GDP of India and China from the year of 2003 to 2010. The Chinese GDP was at 8.00% in 2003 and steadily it has gone up to 11.90% in 2008, and due to impact of crisis the GDP fall to 9.00% i.e., decline of 24.37%. While in case of India, the double digit GDP was not met. The GDP of India was at 4.30% in 2003, whereas, by 2007, it reached 9.20%. But due to economic slowdown, it has further slipped down to 7.40%. Table-4: LABOR FORCE

CHINA

INDIA

Year	Labor force	Percent Change
2003	744,000,000	
2004	778,100,000	4.58 %
2005	760,800,000	-2.22 %
2006	791,400,000	4.02 %
2007	798,000,000	0.83 %
2008	800,700,000	0.34 %
2009	807,300,000	0.82 %
2010	813,500,000	0.77 %

Labor force	Percent Change
406,000,000	
472,000,000	16.26 %
482,200,000	2.16 %
496,400,000	2.94 %
509,300,000	2.60 %
516,400,000	1.39 %
523,500,000	1.37 %
467,000,000	-10.79 %
	Labor force 406,000,000 472,000,000 482,200,000 496,400,000 509,300,000 516,400,000 523,500,000 467,000,000

In 2003, the labor force of china was 74.4 Mn whereas that of India was 40.6 Mn. In 2008, China was having a labor force of 80.07 Mn whereas India at that time was having 51.64 Mn labor force. By 2010, the total labor force of China is 81.35 Mn whereas India's labor force is 46.70 Mn. From 2009 to 2010, there is 10.79% of decline in labor force. This indicates that labor turnover (retrenchment) in India is more in recession compare to China.



INDIA



Fig-2: COMPOSITION OF SECTOR

In case of China, agriculture contributes 10.3% of GDP while in case of India agriculture contributes 17.1% of GDP. But industry contributes 46.3% of GDP in China, while it is only 28% in India. On the other hand services contributes 43.4% of GDP in China whereas 54% in India.



Fig-3: UNEMPLOYMENT

Unemployment rate of China in 2003 was 10.10% whereas by the end of 2010 it has decreased to 4.30%. This is a trend which shows that Chinese are learning global languages basically English and French to accommodate in the job market. Whereas the unemployment rate in India was 8.80% in 2003 and by the year 2010, it has increased up to 10.70%. As because of crisis, the services sector has suffered. The retrenchment has been seen in IT sector. The Chinese economy is dominated by manufacturing industry whereas Indian economy is service dominated. That is why the recession is having impact on unemployment rate in India.

CHINA

INDIA



Fig-4: INFLATION RATE

It can be analyzed that the inflation rate of China is most of the time revolving between 2% to 5%. Whereas the inflation rate (consumer price index) varies from 6% to 10% in these years.

4. THE IMPACT OF UNEMPLOYMENT AND INFLATION ON INDIAN ECONOMY

The relationship of GDP with Unemployment in India:

Table-5: Regression

Model R R Square		R Square	Adjusted R Square	Std. Error of the Estimate	
1	.268(a)	.072	083	1.69326	

In this section the unemployment rate has been taken as independent variable and GDP is taken as dependent variable. The value of R-Square i.e., 0.072 suggests that the unemployment rate has not any impact on the GDP as because the null hypothesis is true.

Table-6: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.332	1	1.332	.465	.521(a)
	Residual	17.203	6	2.867		
	Total	18.535	7			

The ANOVA shows the significance of 0.521, and as because this value is above the value of 0.05, it will lie on the right side of the normal distribution. So the null hypothesis is true i.e., The significance of t-statistics also give the same conclusion.

Tabl	le-7:	t-Sta	tistics

Model		Unstandardized Coefficients S		Standardized Coefficients		
		B Std. Error E		Beta	Т	Sig.
1	(Constant)	10.450	4.333		2.412	.052
	Unemployment	340	.498	268	682	.521

Table-8: Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.268(a)	.072	299	1.85468

The R-square value of 0.072 shows that null hypothesis-2, i.e., inflation does not have any impact on GDP. The significance level 0.829 of F-statistic also draws the same conclusion.

Table-9: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.336	2	.668	.194	.829(a)
	Residual	17.199	5	3.440		
	Total	18.535	7			

Table-10: t-Statistics

Model		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	Т	Sig.
1	(Constant)	10.411	4.903		2.123	.087
	Inflation	.009	.289	.014	.032	.976
	unemployment	342	.549	270	622	.561

Relationship of GDP with Inflation and Unemployment in India

Table-11: Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.268(a)	.072	299	1.85468

If on aggregate basis, the inflation rate and unemployment are taken as independent variable and GDP is treated as dependent variable, then the value of R-Square is 0.072, the significance is 0.829 as per F-statistics.

Table-12: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.336	2	.668	.194	.829(a)
	Residual	17.199	5	3.440		
	Total	18.535	7			

Table-13: t-Statistics

Model		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	t	Sig.
1	(Constant)	10.411	4.903		2.123	.087
	Inflation	.009	.289	.014	.032	.976
	Unemployment	342	.549	270	622	.561

5. THE IMPACT OF UNEMPLOYMENT AND INFLATION ON CHINESE ECONOMY

GDP and Inflation CHINA

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.185(a)	.034	159	1.20000

The value of R-square is 0.034 shows that the inflation rate of china does not have any impact on the GDP. The significance of 0.692 in F-statistics also narrates that the null hypothesis is true.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.254	1	.254	.177	.692(a)
	Residual	7.200	5	1.440		
	Total	7.454	6			

t-Statistics

Model		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	t	Sig.
1	(Constant)	9.637	.719		13.402	.000
	inflation	.088	.210	.185	.420	.692

GDP and Unemployment in China

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.383(a)	.147	024	1.12766

The significance of 0.396 shows that the null hypothesis is accepted. The value of t-statistics also concludes the same. This states that unemployment does not have any impact on GDP.

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.096	1	1.096	.862	.396(a)
	Residual	6.358	5	1.272		
	Total	7.454	6			

Model		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	t	Sig.
1	(Constant)	10.807	1.094		9.881	.000
	Unemployment	144	.155	383	928	.396

GDP and Inflation and Unemployment

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.405(a)	.164	254	1.24816

The significance of 0.699 narrates that null hypothesis is accepted. Unemployment and inflation rate combine does not have any impact on GDP.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.223	2	.611	.392	.699(a)
	Residual	6.232	4	1.558		
	Total	7.454	6			

Model		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	Т	Sig.
1	(Constant)	10.593	1.424		7.436	.002
	Unemployment	137	.174	364	788	.475
	Inflation	.063	.221	.132	.285	.790

6. CONCLUSION

Now China¹⁵ is facing the consequences of its largesse. Fears are rising that Beijing's easy-money policies have fueled a potential property-price bubble. According to government data, average real estate prices in Chinese cities jumped 7.8% in December from a year earlier — the fastest increase in 18 months. The credit boom has also sparked worries about the nation's banking system. Many economists expect the large surge in credit to lead to a growing number of nonperforming loans (NPLs). In a November report, UBS economist Wang Tao calculates that if 20% of all new lending in 2009 and 10% of the amount in 2010 goes bad over the next three to five years, the total amount of NPLs from China's stimulus program would reach \$400 billion, or roughly 8% of GDP. Though Wang notes that the total is small compared with the level of NPLs that Chinese banks carried in the past, she still calls the sum "staggering." Policymakers in Beijing are clearly concerned. Since December, they have introduced a series of steps to cool down the housing market and restrict access to credit by, for example, reintroducing taxes on certain property transactions and raising the required level of cash that banks have to keep on hand in an effort to reduce new lending.

India, meanwhile, isn't experiencing nearly the same degree of fallout from its recession-fighting methods. The government used the same tools as every other to support growth when the financial crisis hit – cutting interest rates, offering tax breaks and increasing fiscal spending – but the scale was smaller than in China¹⁶. Goldman Sachs estimates that India's government stimulus will total \$36 billion this fiscal year, or only 3% of GDP. By comparison, China's two-year, \$585 billion package is roughly twice as large, at about 6% of GDP per year. Most important, India managed to achieve its substantial growth without putting its banking sector at risk. In fact, India's banks have remained quite conservative through the downturn, especially compared with Chinese lenders. Growth of credit, for example, was actually lower in 2009 than in 2008. As a result, economists see continued strength in India's banks. India maintained robust growth without Beijing's hefty stimulus in part because it is less exposed to the international economy. China's exports represented 35% of GDP compared with only 24% for India in 2008. Thus India was afforded more protection from the worst effects of the financial crisis in the West, while China's government¹⁷ needed to be much more active to replace lost exports to the U.S. More significantly, though, India's domestic economy provides greater cushion from external shocks than China's. Private domestic consumption accounts for 57% of GDP in India compared with only 35% in China. India's confident consumer didn't let the economy down¹⁸.

The Indian economy is not immune to risks¹⁹. The government has to contend with a yawning budget deficit, and last year's weak monsoon rains will likely undercut agricultural production and soften rural consumer spending. But rapid growth is expected to continue. The World Bank forecasts India's economy will surge 7.6% in 2010 and 8% in 2011, not far behind the 9% rate it predicts for China for each of those years.



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