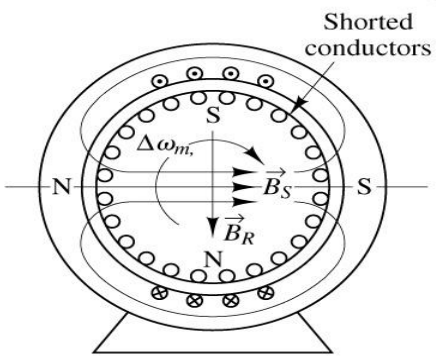
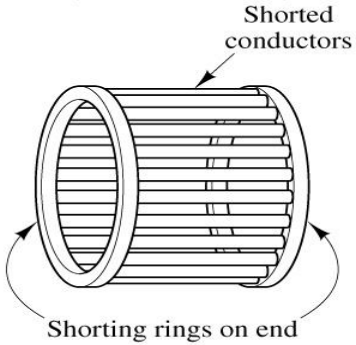
Squirrel Cage Rotor Design

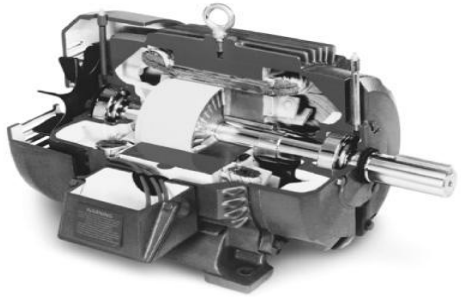
Squirrel cage induction motor; (b) conductors in rotor; (c) photograph of squirrel cage induction motor; (d) views of Smokin' Buckey motor: rotor, stator, and cross section of stator



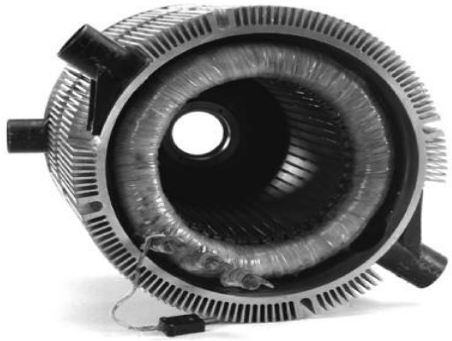
(a)



(b)



(c)



(d)

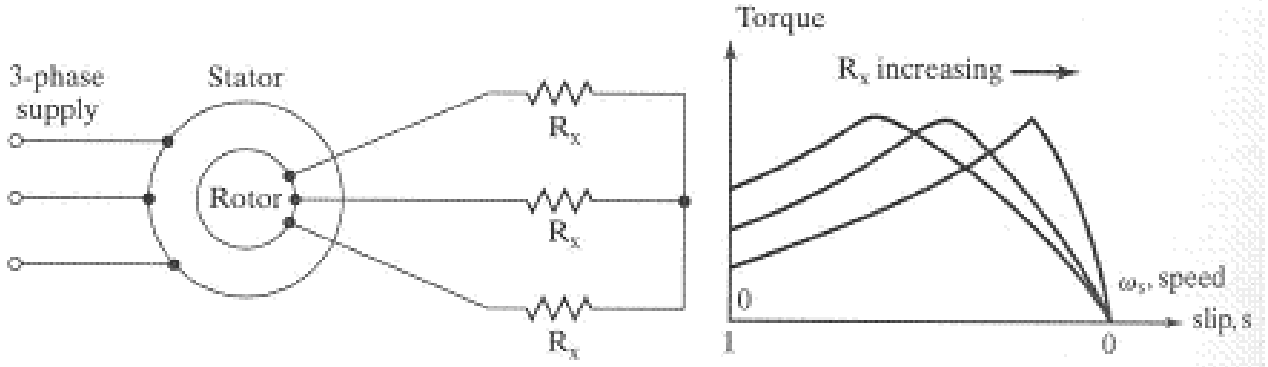
Speed Control of Induction Motors

Induction Motor Drives: Stator Voltage Control

- The stator voltage can be varied by three-phase
  - ac voltage controllers,
  - voltage-fed variable de-link inverters, or
  - pulse-width modulation (PWM) inverters.
- However, due to limited speed range requirements, the ac voltage controllers are normally used to provide the voltage control.
- The ac voltage controllers are very simple.
- However, the harmonic contents are high and the input PF of the controllers is low.
- They are used mainly in low-power applications, such as fans, blowers, and centrifugal pumps, where the starting torque is low.
- They are also used for starting high-power induction motors to limit the in-rush current.

Induction Motor Drives: Rotor Voltage Control

- In a wound-rotor motor, an external three-phase resistor may be connected to its slip rings, as shown in Figure 16.5a.
- The developed torque may be varied by varying the resistance R_x. If R_x is referred to the stator winding and added to R_r, Eq. (16.18) may be applied to determine the developed torque.
- The typical torque-speed characteristics for variations in rotor resistance are shown in Figure 16.5b.



(a) Rotor resistance

(b) Increasing R_x

FIGURE 16.5

Speed control by motor resistance.

Induction Motor Drives: Rotor Voltage Control

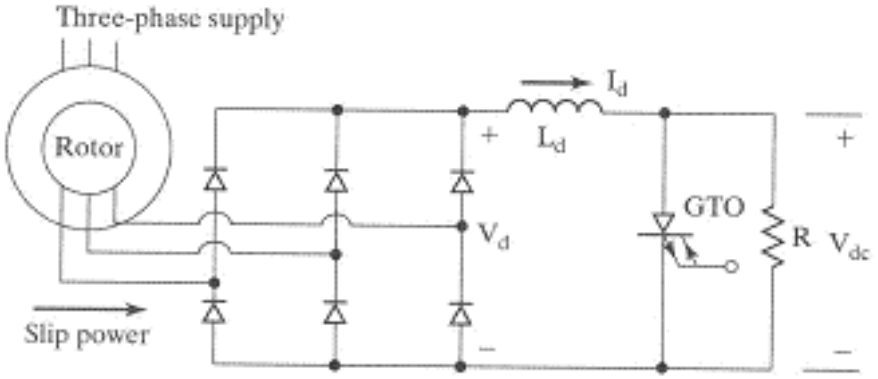
- This method increases the starting torque while limiting the starting current.
- However, this is an inefficient method and there would be imbalances in voltages and currents if the resistances in the rotor circuit are not equal.
- A wound-rotor induction motor is designed to have a low-rotor resistance so that the running efficiency is high and the full-load slip is low.
- The increase in the rotor resistance does not affect the value of maximum torque but increases the slip at maximum torque.
- The wound-rotor motors are widely used in applications requiring frequent starting and braking with large motor torques (e.g., crane hoists).
- Because of the availability of rotor windings for changing the rotor resistance, the wound rotor offers greater flexibility for control.
- However, it increases the cost and needs maintenance due to slip rings and brushes.
- The wound-rotor motor is less widely used as compared with the squirrel-case motor.

Induction Motor Drives: Rotor Voltage Control

- The three-phase resistor may be replaced by a three-phase diode rectifier and a dc converter, as shown in Figure 16.6a, where the gate-turn-off thyristor (GTO) or an insulated-gate bipolar transistor (IGBT) operates as a dc converter switch.
- The inductor L_d acts as a current source I_d and the dc converter varies the effective resistance, which can be found from Eq. (15.45):

$$R_e = R\,(1 - k) \qquad (16.41)$$

- where k is the duty cycle of the dc converter and the motor speed can be controlled by varying the duty cycle.
- The portion of the air-gap power, which is not converted into mechanical power, is called slip power. The slip power is dissipated in R.



(a) Slip control by dc converter

Induction Motor Drives: Frequency Control

- The torque and speed of induction motors can be controlled by changing the supply frequency.
- We can notice from Eq. (16.31) that at the rated voltage and rated frequency, the flux is the rated value.
- If the voltage is maintained fixed at its rated value while the frequency is reduced below its rated value, the flux increases.
- This would cause saturation of the air-gap flux, and the motor parameters would not be valid in determining the torque-speed characteristics.
- At low frequency, the reactances decrease and the motor current may be too high. This type of frequency control is not normally used.