Chip-Type Machining Processes

Basic Mechanics of Metal Cutting

- **Metal** ahead of the **cutting tool** is **compressed** and this results in the **deformation** or **elongation** of the **crystal structure** resulting in a **shearing** of the metal.
- As the **process continues**, the metal above the cutting edge is forced along the "chip-tool" interference zone and is moved away form the work.

Basic Mechanics of Metal Cutting

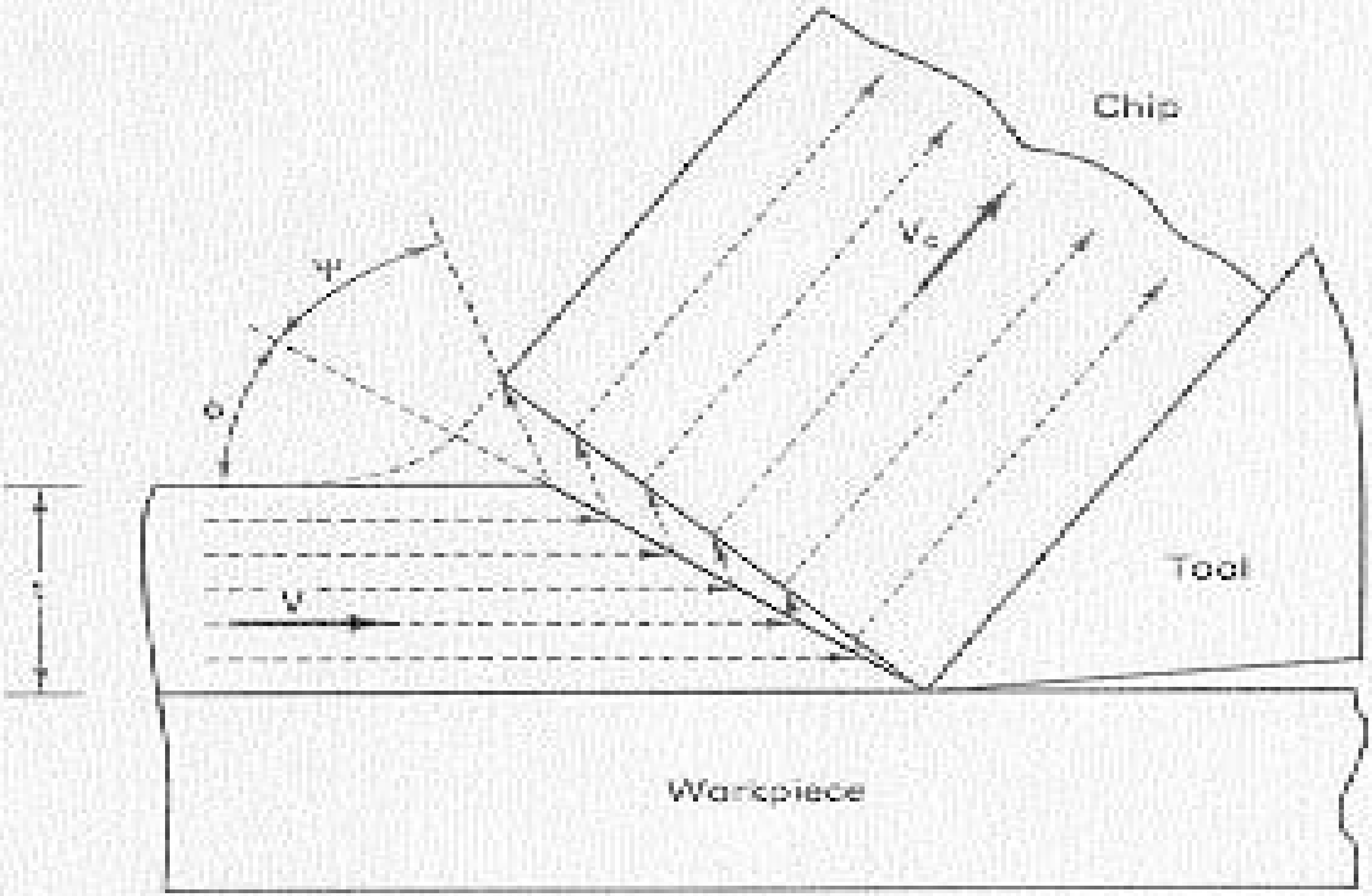


FIGURE 21-13 Schematic representation of the material flow, i.e., the chip forming shear process.

Chip Formations

- During this process three basic types of chips are formed namely:
  - Discontinuous
  - Continuous
  - Continuous with a Built-Up Edge (BUE)

Discontinuous

- Typically associated with **brittle metals** like Cast Iron
- As **tool contacts work**, some **compression takes place**
- As the **chip starts up** the chip-tool interference zone, **increased stress occurs** until the metal reaches a **saturation point and fractures** off the work piece.

Discontinuous

- Conditions which favor this type of chip
  - Brittle work material
  - Small rake angles on cutting tools
  - Coarse machining feeds
  - Low cutting speeds
  - Major disadvantage—could result in poor surface finish

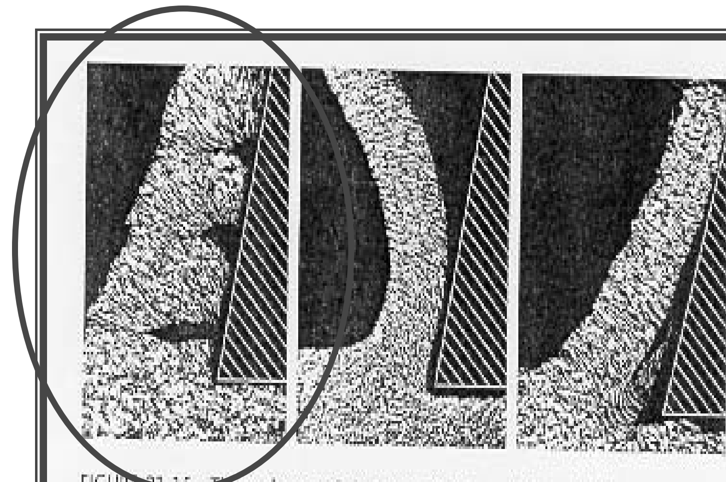


FIGURE 21.15 Three characteristic types of chips. (Left to right) discontinuous, continuous, and continuous with built-up edge. Chip samples produced by quick-stop techniques. *(Courtesy of Cincinnati Milacron, Inc.)*

Continuous

- Continuous "ribbon" of metal that flows up the chip/tool zone.
- Usually considered the ideal condition for efficient cutting action.

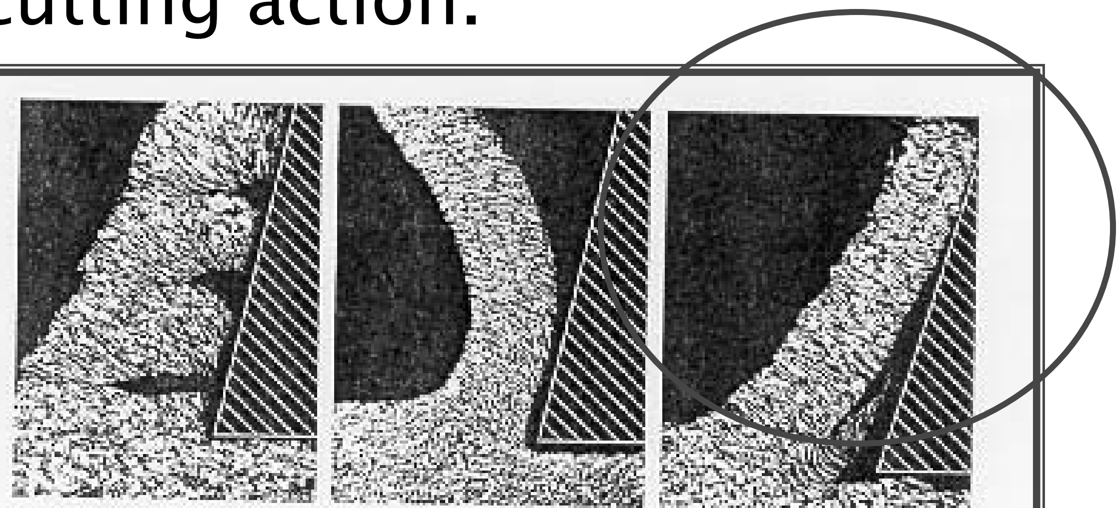


FIGURE 21-15 Three characteristic types of chips. (Left to right) discontinuous, continuous, and continuous with built-up edge. Chip samples produced by quick-stop techniques. *(Courtesy of Cincinnati Milacron, Inc.)*

Continuous

- Conditions which favor this type of chip:
  - Ductile work
  - Fine feeds
  - Sharp cutting tools
  - Larger rake angles
  - High cutting speeds
  - Proper coolants

Continuous with a Built-up Eedge(BUE)

- Same process as continuous, but **as the metal begins to flow up** the chip-tool zone, small particles of the **metal begin to adhere or weld themselves to the edge** of the cutting tool.
- As the particles continue to weld to the tool it affects the cutting action of the tool.

Continuous with a built-up edge(BUE)

- This type of chip is common in softer non-ferrous metals and low carbon steels.
- Problems
  - Welded edges break off and can become embedded in workpiece
  - Decreases tool life
  - Can result in poor surface finishes

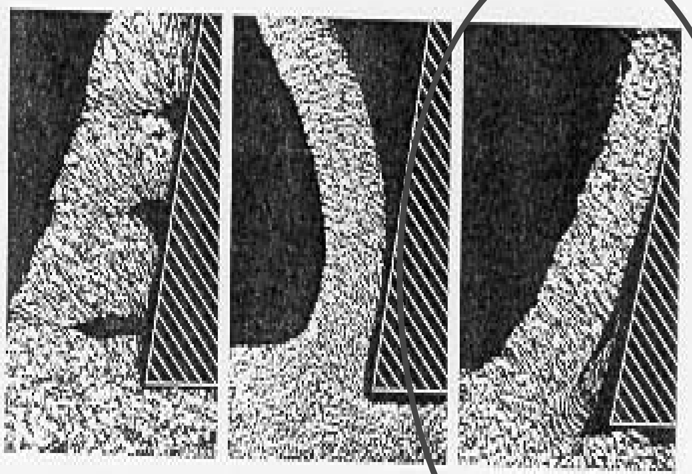


FIGURE 21-15 Three characteristic types of chips. (Left to right) discontinuous, continuous, and continuous with built-up edge. Chip samples produced by quick-stop techniques. (*Courtesy of Cincinnati Milacron, Inc.*)

Heat & Temperature in Machining

- In **metal cutting** the **power input** into the process in largely **converted to heat.**
- This elevates the temperature of the chips, work-piece and tool.
- These elements along with the coolant act as heat sinks.
- So lets look at coolants…

Coolants/Cutting fluids

- Cutting fluids are used extensively in metal removal processes and they
  - Act as a **coolant**, **lubricant**, and assist in **removal of chips**.
  - Primary **mission of cutting fluids** is to **extend tool life** by **keeping keep temperatures down.**
  - Most **effective coolant is water**…
  - However, it is hardly ever used by itself.
  - Typically **mixed with a water soluble oil** to add **corrosion resistance** and **add lubrication capabilities**.

Issues Associated With Coolants

- Environmental Concerns
- Machine systems and Maintenance
- Operators Safety

Machining Operations

- Machining Operations can be classified into two major categories:
  - Single point = Turning on a Lathe
  - Multiple tooth cutters = pocket milling on a vertical milling machine

Tool Selection Factors

- Inputs
- Work material
- Type of Cut
- Part Geometry and Size
- Lot size
- Machinability data
- Quality needed
- Past experience of the decision maker

Constraints

- Manufacturing Practice
- Machine Condition
- Finish part Requirements
- Work holding devices/Gigs
- Required Process Time

Outputs

- Selected Tools
- Cutting parameters

Tool Selection Process

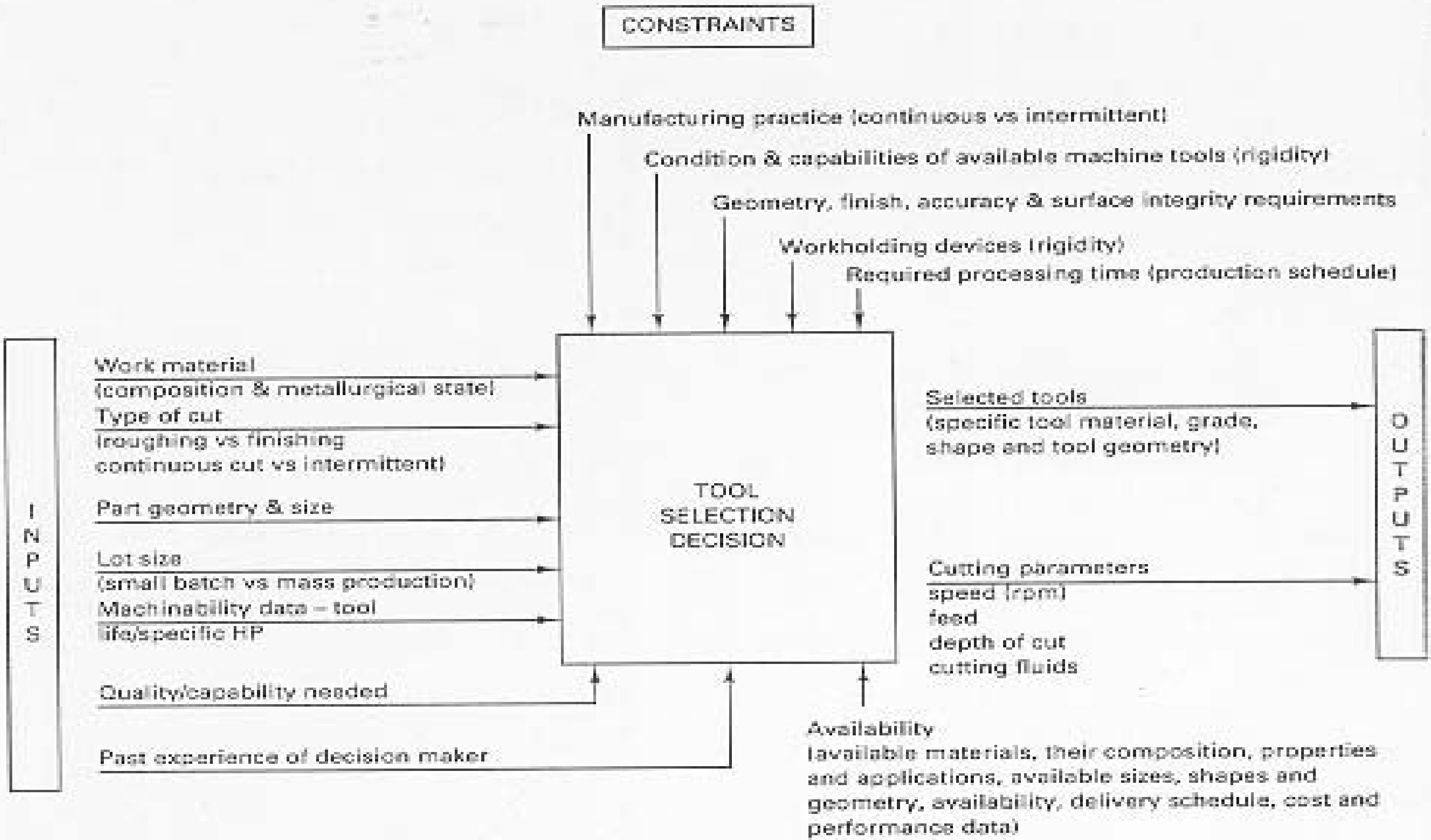


FIGURE 22-2 The selection of the cutting tool material and geometry and the cutting conditions for a given application depends on many variables.

Elements of an Effective Tool

- High Hardness
- Resistance to Abrasion and Wear
- Strength to resist bulk deformation
- Adequate thermal properties
- Consistent Tool life
- Correct Geometry

Tool Materials

- Wide variety of materials and compositions are available to choose from when selecting a cutting tool
- We covered these in the previous chapter

Tool Geometry

- The geometry of a cutting tool is determined by three factors:
  - Properties of the Tool material
  - Properties of the Work piece
  - Type of Cut

Tool Geometry

- The most important geometry's to consider on a cutting tool are
  - Back Rake Angles
  - End Relief Angles
  - Side Relief Angles

Standard Terminology for Tool Geometry

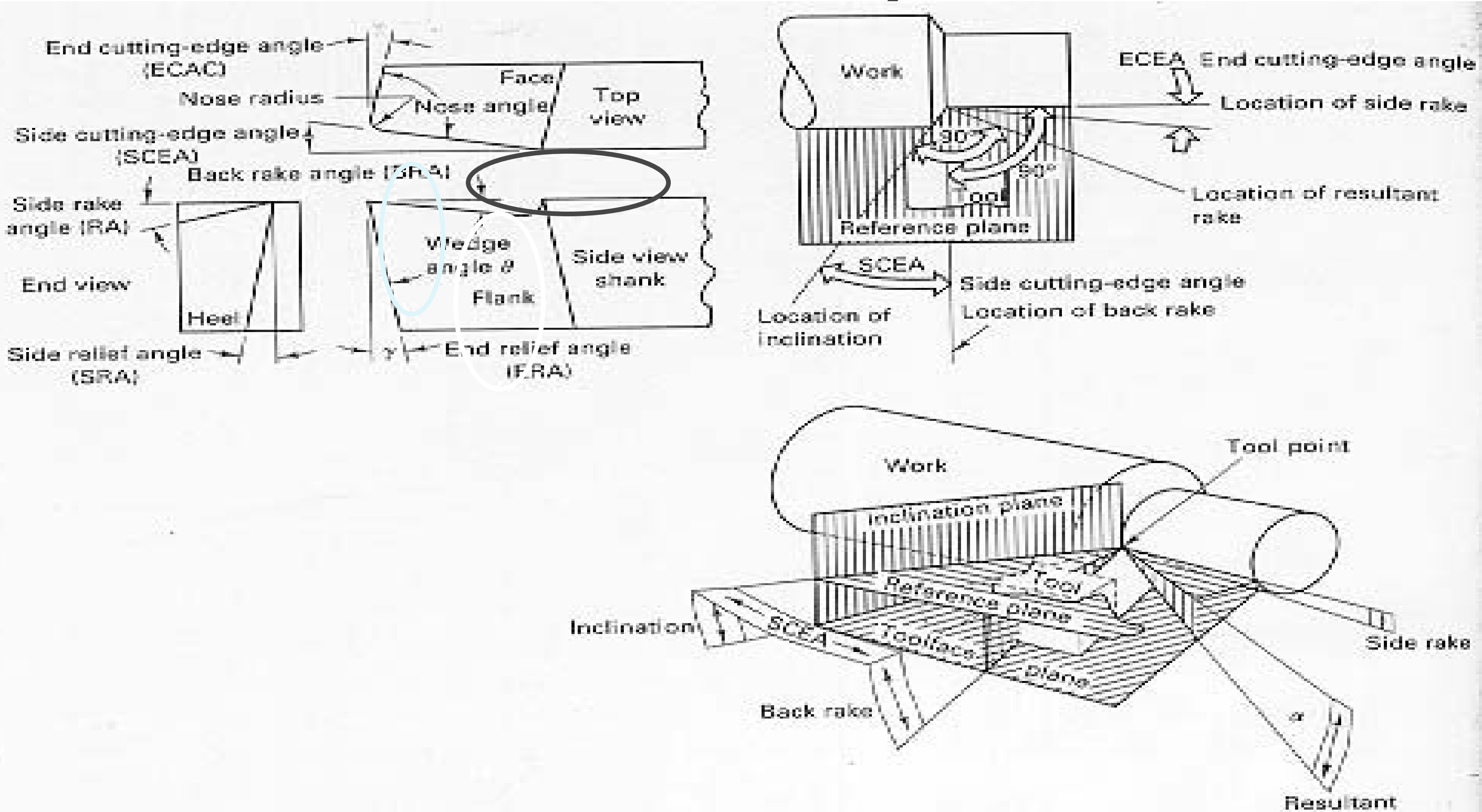


FIGURE 22-11 Standard terminology to describe the geometry of single-point tools.

Rake Angles

- Back-Allows the tool to shear the work and form the chip.
- It can be positive or negative
  - Positive = reduced cutting forces, limited deflection of work, tool holder and machine
  - Negative = typically used to machine harder metals-heavy cuts
- The side and back rake angle combine to from the “true rake angle”

Rake Angles

- Small to medium rake angles cause:
  - high compression
  - high tool forces
  - high friction
  - result = Thick—highly deformed—hot chips

Rake Angles

- Larger positive rake angles
  - Reduce compression and less chance of a discontinuous chip
  - Reduce forces
  - Reduce friction
  - Result = A thinner, less deformed, and cooler chip.

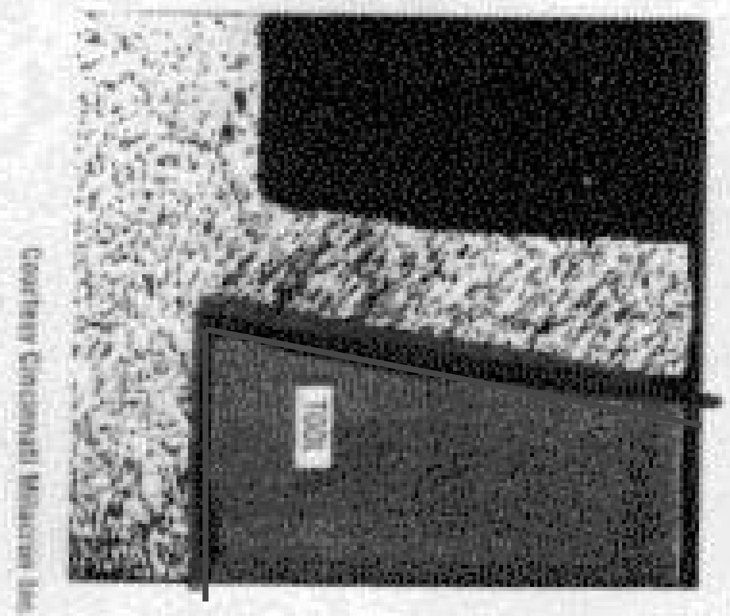


Fig. 6-14A Large rake angle ground on a cutting tool

Rake Angles

- Problems….as we increase the angle:
  - Reduce strength of tool
  - Reduce the capacity of the tool to conduct heat away from the cutting edge.
  - To increase the strength of the tool and allow it to conduct heat better, in some tools, zero to negative rake angles are used.

Negative Rake Tools

- Typical tool materials which utilize negative rakes are:
  - Carbide
  - Diamonds
  - Ceramics
- These materials tend to be much more brittle than HSS but they hold superior hardness at high temperatures.
- The negative rake angles transfer the cutting forces to the tool which help to provide added support to the cutting edge.

Negative Rake Tools

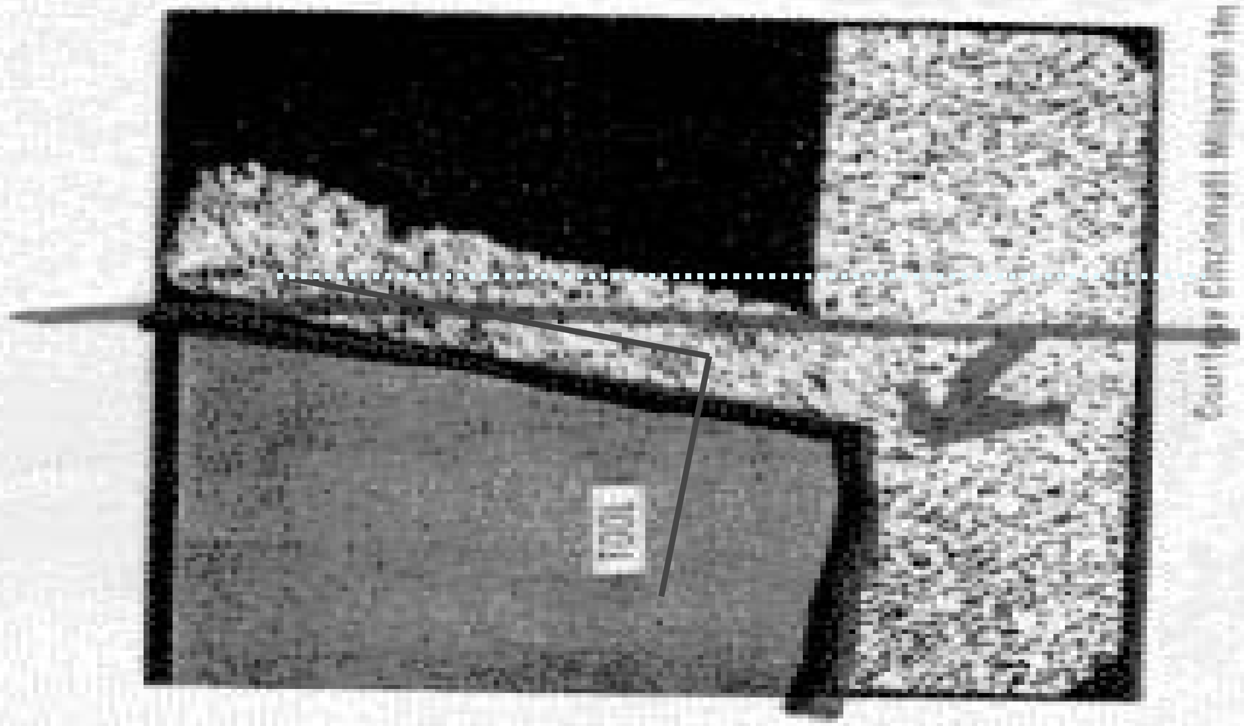


Fig. 6-148 Small or negative rake angle ground on a cutting tool

Summary Positive vs. Negative Rake Angles

- Positive rake angles
  - Reduced cutting forces
  - Smaller deflection of work, tool holder, and machine
  - Considered by some to be the most efficient way to cut metal
  - Creates large shear angle, reduced friction and heat
  - Allows chip to move freely up the chip-tool zone
  - Generally used for continuous cuts on ductile materials which are not to hard or brittle

Summary Positive vs. Negative Rake Angles

- Negative rake angles
  - Initial shock of work to tool is on the face of the tool and not on the point or edge. This prolongs the life of the tool.
  - Higher cutting speeds/feeds can be employed

Tool Angle Application

- Factors to consider for tool angles
  - The hardness of the metal
  - Type of cutting operation
  - Material and shape of the cutting tool
  - The strength of the cutting edge

Carbide Inset Selection

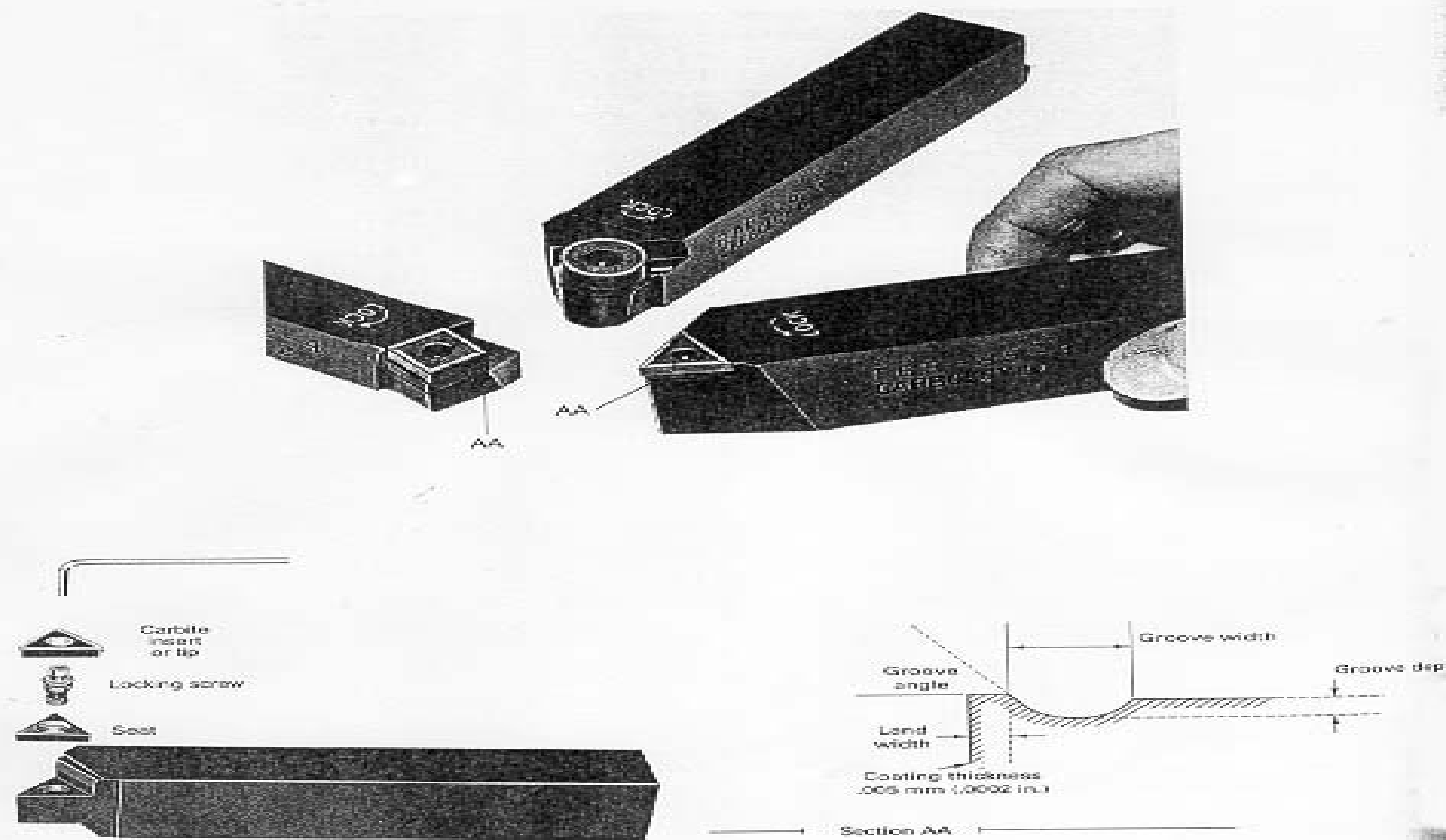
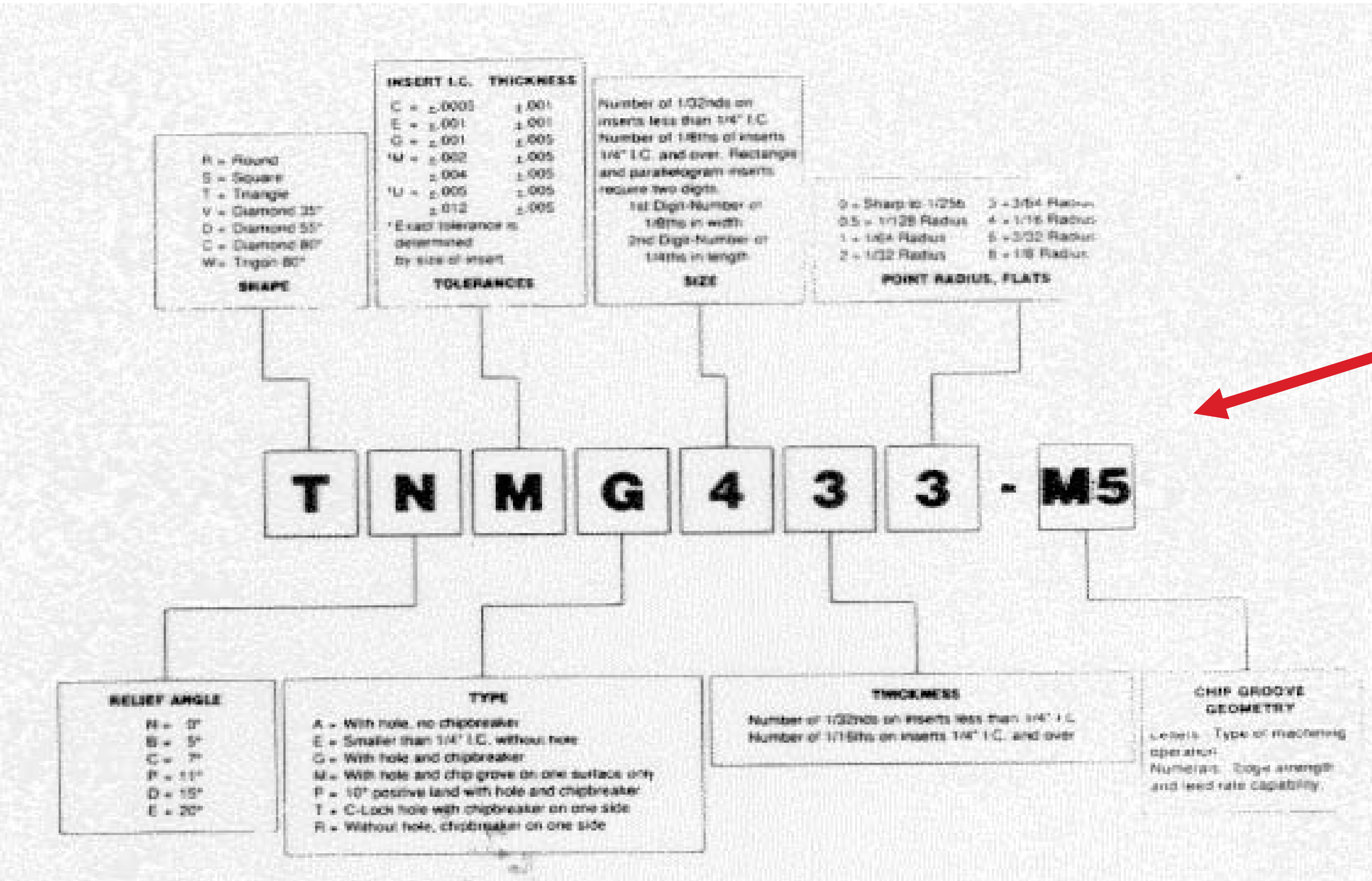


FIGURE 22-5 (Top) Examples of throwaway carbide cutting tool tip with chipbreaker grooves on rake face; (Left) components of a typical mounting holder; (Section AA) groove design on coated tool to reduce forces and breakup chips. *(Courtesy of General Electric.)*

Carbide Inset Selection



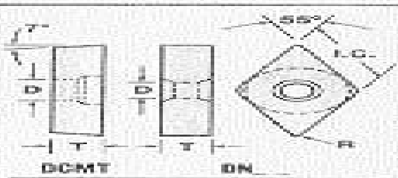
M1-Fine
M2-Medium
M3-S.S
M4-Cast iron
M5-General Purpose

A.N.S.I. Insert Identification System

ANSI - B212.4-1986

Carbide Inset Selection

Turning Inserts



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1/4	3/32	1/128	.114	DCMT 21.50.5-F2			•	•		•		•			☆					•			•		DCMT 070202
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SPECIFICATIONS					COATED											PVD		UNCOATED					CRMT		