

## Machining

*Precise material removal to bring a part to specified size*

- Automotive machining examples
  - Boring cylinders
  - Honing cylinders
  - Grinding cranks and cams
  - Grinding or milling heads and blocks
  - Grinding flywheels
  - Drilling and reaming for valve guides

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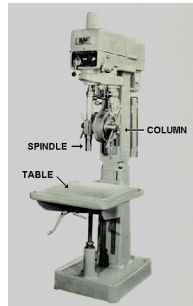
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## Machining

### Drilling

- End cutting
- Used for roughing holes to size
- Reamers finish holes to size and surface finish



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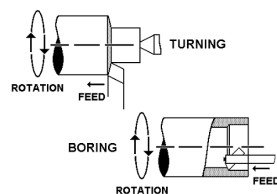
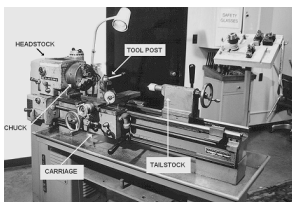
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## Machining

### Turning & boring

- Turning – outside diameter with single pointed tools on a lathe
- Boring – inside diameter with single pointed tools on a lathe



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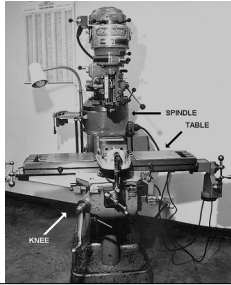
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## Machining

### Milling

- Vertical spindle
- Used to remove material from a flat surface



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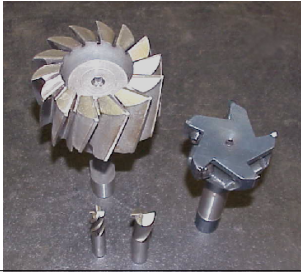
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## Machining

### Milling

- Typical milling cutters  
HSS & carbide



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## Machining

### Grinding

- Abrasive machining using millions abrasive grains
- Minimal stock removal
- High surface finish quality

### Vertical spindle surfacing

- Used to grind flywheels, blocks, and cylinder heads



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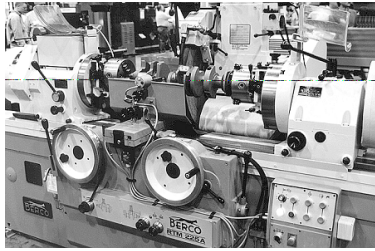
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## Machining

### Horizontal spindle grinders

- Used for valve grinders, crankshaft grinders, and camshaft grinders



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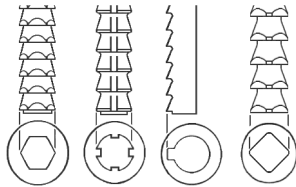
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## Machining

### Broaching

- Chip removal is done with progressively larger cutting teeth
- Keyways in sprockets and gears
- Not done in auto machine shops



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## Machining

### Tool materials

#### HSS (High speed steel)

- Drills, reamers, and milling cutters
- Tungsten, vanadium, and cobalt added for hardness

#### Tungsten carbide

- Boring bars and cutter of a face mill
- Attached to a tool holder
- Heat resistant and operate at high speeds (up to 3 times HSS)
- Cobalt increased for shock resistance

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## Machining

Tool materials

Tungsten Carbide (cont.)

- As cobalt % increases, resistance to shock increases, & resistance to heat decreases

Aluminum Oxide grinding wheel

- Used for steel & nodular iron (cranks & cams)

Silicon Carbide grinding wheel

- Used for iron (heads & blocks)

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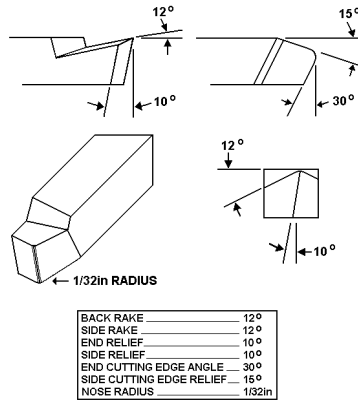
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## Machining

Lathe tool



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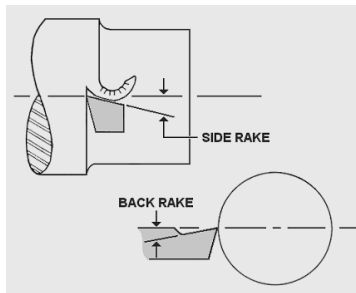
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## Machining

- Rake angles form the surface that the chips pass over
- Back rake angle angles are greater for boring



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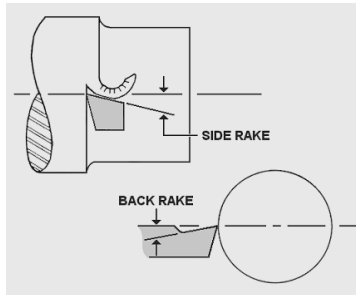
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## Machining

- Relief angles prevent the cutting tool from bumping into the work



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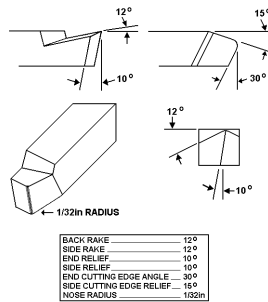
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## Machining

- Nose radius affects surface finish
- Large radius increases power required and tool chatter



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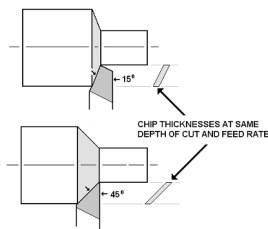
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## Machining

### Side cutting angle

- The greater the angle, the more tool deflection
- The smaller the angle, the bigger the chip and more the tool will wear



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## Machining

### Cutting oils

- Extend tool life
- Cool cutting tool
- Cast iron can be machined without cutting oil
- Aluminum requires cutting oil
- All threading operations require cutting oil

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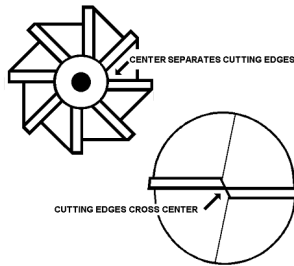
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## Machining

### End mills

- Used to remove chips from the end or the side of tool
- ‘Two flute’ cutters cut from the end
- Cutters with more than two flutes are used for cutting on the side



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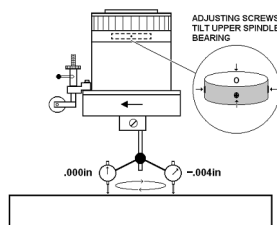
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## Machining

### Spindle tilt

- The spindles of automotive surfacing machines are tilted about  $.004''$
- This produces a ‘hollow cut’ of less than  $.0005''$



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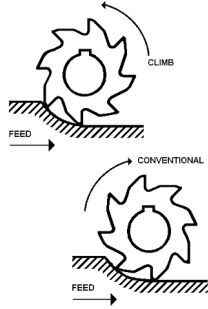
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## Machining

### Conventional vs. climb milling

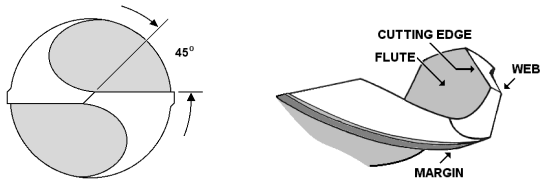
- Conventional – Cutter rotates opposite direction of feed
- Climb – Cutter rotates same direction as feed



## Machining

### Drill bits

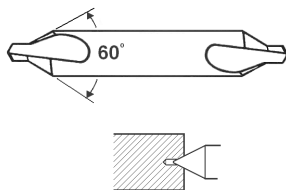
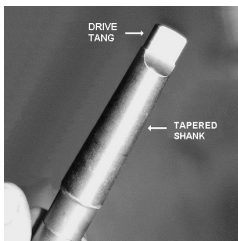
- Available in fraction, letter, or number sizes
- End cutting
- Helical flutes for chip removal
- Length & angle of cutting edges should be equal



## Machining

### Drill bits (cont.)

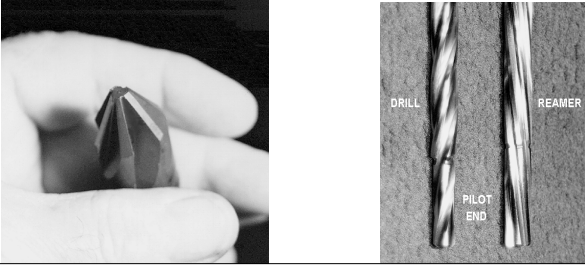
- Morse taper (5/8" per foot), drift needed for removal
- Center drill (60°), for pilots and machining centers



## Machining

Core drills and countersinks

- Core drills enlarge holes only, will not cut in center
- Countersinks chamfer bolt holes (82°)



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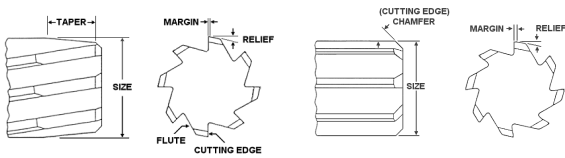
## Machining

Hand reamers

- Cut material for a distance on the end (1/16" per foot)
- Cut only .003" to .005"

Machine reamers

- Cut material on a short 45° angle
- Cut only 5% material



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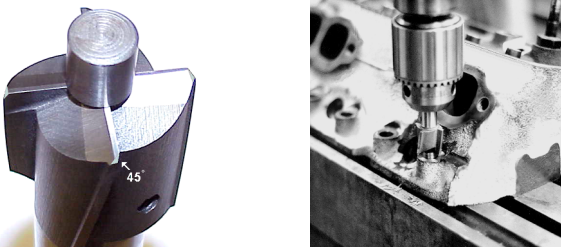
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## Machining

Counter bores

- Spot-facing head bolt holes



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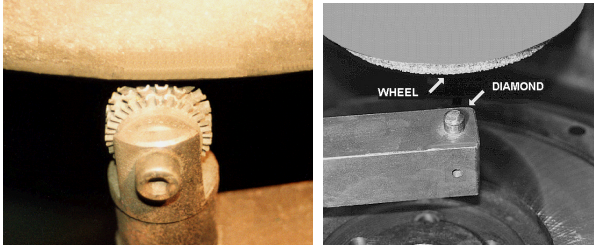
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## Machining

### Grinding

- Diamond dresser (trues wheels)
- Star wheel dresser (does not true wheel)



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## Machining

### Hard grinding action

- No wheel breakdown
- Little material removal
- Burnt work
- Wheel needs dressing

### Soft grinding action

- Too much wheel breakdown
- Stone material gets caught between wheel and work
- Rough surface finish

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## Machining

### Honing

- Slower speed than grinding
- Honing stones must also break down
- Honing oils cool the work and flush away the grit

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