Cutting Fluids—Types and Applications

Presented by-

SANDEEP PATEL

M.Tech (Manufacturing)
NIT Warangal, India

Cutting Fluids

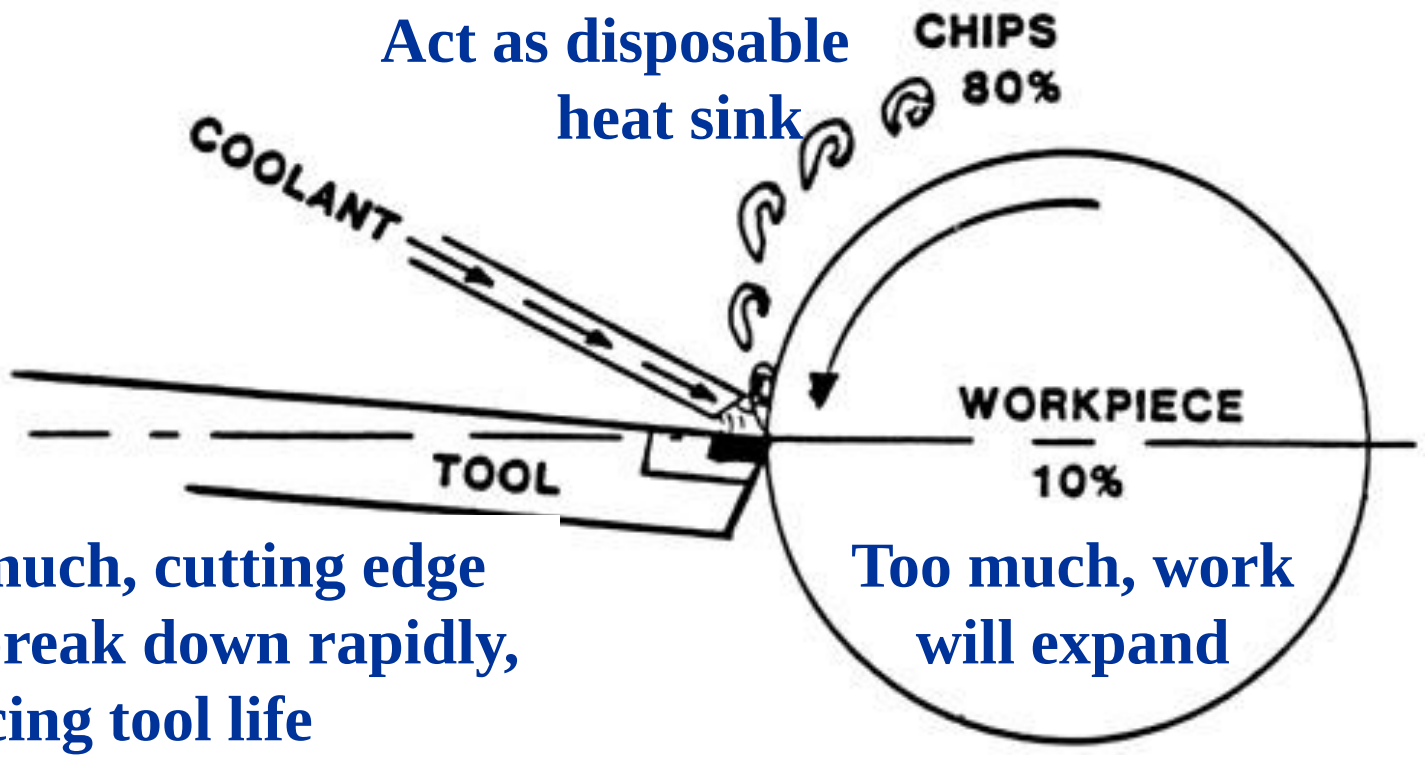
- Essential in metal-cutting operations to reduce heat and friction
- Centuries ago, water used on grindstones
- 100 years ago, tallow used (did not cool)
- Lard oils came later but turned rancid
- Early 20th century saw soap added to water
- Soluble oils came in 1936
- Chemical cutting fluids introduced in 1944

Economic Advantages to Using Cutting Fluids

- Reduction of tool costs
  - Reduce tool wear, tools last longer
- Increased speed of production
  - Reduce heat and friction so higher cutting speeds
- Reduction of labor costs
  - Tools last longer and require less regrinding, less downtime, reducing cost per part
- Reduction of power costs
  - Friction reduced so less power required by machining

Heat Generated During Machining

- Heat finds its way into one of three places
  - Workpiece, tool and chips



Heat Dissipation

- Ideally most heat taken off in chips
- Indicated by change in chip color as heat causes chips to oxidize
- Cutting fluids assist taking away heat
  - Can dissipate at least 50% of heat created during machining

Characteristics of a Good Cutting Fluid

1. Good cooling capacity
2. Good lubricating qualities
3. Resistance to rancidity
4. Relatively low viscosity
5. Stability (long life)
6. Rust resistance
7. Nontoxic
8. Transparent
9. Nonflammable
10. Anti-welding

Types of Cutting Fluids

- Most commonly used cutting fluids
  - Either aqueous based solutions or cutting oils
- Fall into three categories
  - Cutting oils
  - Emulsifiable oils
  - Chemical (synthetic) cutting fluids

Cutting Oils

- Two classifications
  - Active
  - Inactive
- Terms relate to oil's chemical activity or ability to react with metal surface
  - Elevated temperatures
  - Improve cutting action
  - Protect surface

Active Cutting Oils

- Those that will darken copper strip immersed for 3 hours at temperature of 212°F
- Dark or transparent
- Better for heavy-duty jobs
- Three categories
  - Sulfurized mineral oils
  - Sulfochlorinated mineral oils
  - Sulfochlorinated fatty oil blends

Inactive Cutting Oils

- Oils will not darken copper strip immersed in them for 3 hours at 212°F
- Contained sulfur is natural
  - Termed inactive because sulfur so firmly attached to oil – very little released
- Four general categories
  - Straight mineral oils, fatty oils, fatty and mineral oil blends, sulfurized fatty-mineral oil blend

Emulsifiable (Water Soluble) Oils

- Mineral oils containing soaplike material that makes them soluble in water and causes them to adhere to workpiece
- Emulsifiers break oil into minute particles and keep them separated in water
  - Supplied in concentrated form (1-5 /100 water)
- Good cooling and lubricating qualities
- Used at high cutting speeds, low cutting pressures

Chemical Cutting Fluids

- Also called synthetic fluids
- Introduced about 1945
- Stable, preformed emulsions
  - Contain very little oil and mix easily with water
- Extreme-pressure (EP) lubricants added
  - React with freshly machined metal under heat and pressure of a cut to form solid lubricant
- Reduce heat of friction and heat caused by plastic deformation of metal

Advantages of Synthetic Fluids

1. Good rust control
2. **Resistance to rancidity for long periods of time**
3. Reduction of amount of heat generated during cutting
4. Excellent cooling qualities

5. Longer durability than cutting or soluble oils
6. Nonflammable - nonsmoking
7. Nontoxic??????
8. Easy separation from work and chips
9. Quick settling of grit and fine chips so they are not recirculated in cooling system
10. No clogging of machine cooling system due to detergent action of fluid
11. Can leave a residue on parts and tools.

Caution

Chemical cutting fluids widely accepted and generally used on ferrous metals. They are not recommended for use on alloys of magnesium, zinc, cadmium, or lead. They can mar machine's appearance and dissolve paint on the surface.

Functions of a Cutting Fluid

- Prime functions
  - Provide cooling at relatively high cutting speed.
  - Provide lubrication at relatively low cutting speed.
- Other functions
  - Prolong cutting-tool life
  - Provide rust control
  - Chip disposal.
  - Prevent corrosion.

Functions of a Cutting Fluid: Cooling

- Heat has definite bearing on cutting-tool wear
  - Small reduction will greatly extend tool life
- Two sources of heat during cutting action
  - Plastic deformation of metal
    - Occurs immediately ahead of cutting tool
    - Accounts for 2/3 to 3/4 of heat
  - Friction from chip sliding along cutting-tool face

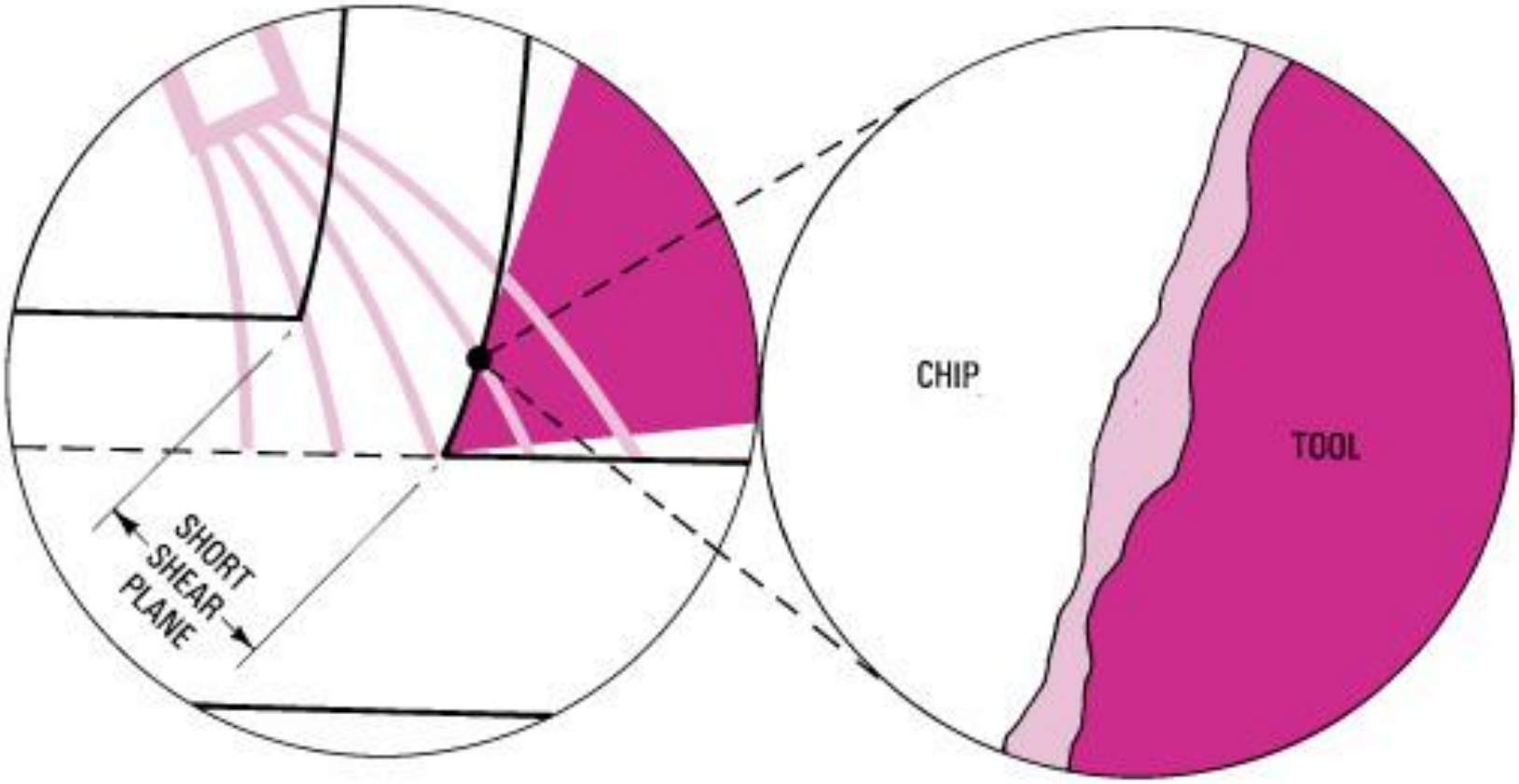
Functions of a Cutting Fluid: Cooling

- Water most effective for reducing heat by will promote oxidation (rust)
- Decrease the temperature at the chip-tool interface by 50 degrees F, and it retains the hardness of cutting tool thereby increase tool life by up to 5 times.
- In addition removal of heat from the cutting zone reduces thermal distortion of work.

Functions of a Cutting Fluid: Lubrication

- Reduces friction between chip and tool face
  - Shear plane becomes shorter
  - Area where plastic deformation occurs correspondingly smaller
- Extreme-pressure lubricants reduce amount of heat-producing friction
- EP chemicals of synthetic fluids combine chemically with sheared metal of chip to form solid compounds (allow chip to slide)

Cutting fluid reduces friction and produces a shorter shear plane.



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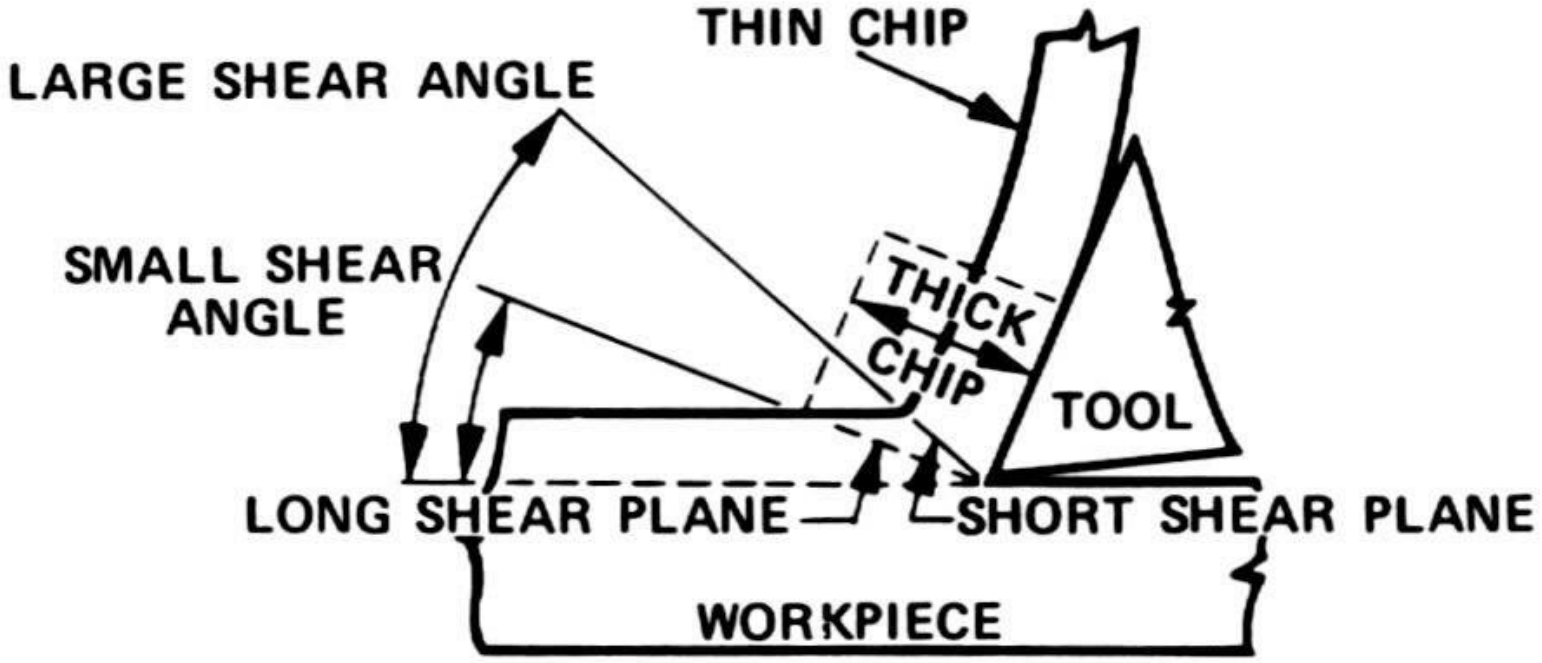


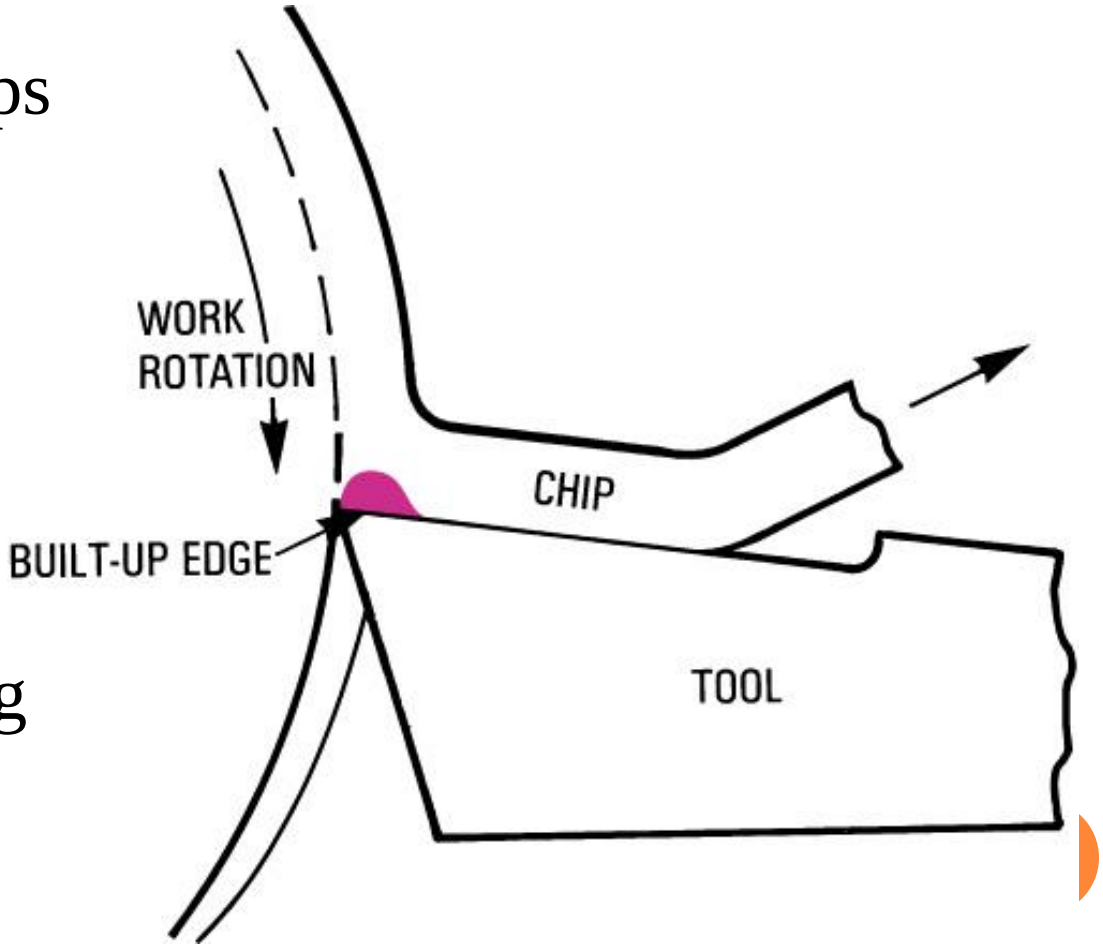
Cutting-Tool Life

- Heat and friction prime causes of cutting-tool breakdown
- Reduce temperature by as little as 50°F, life of cutting tool increases fivefold
- Built-up edge
  - Pieces of metal weld themselves to tool face
  - Becomes large and flat along tool face, effective rake angle of cutting tool decreased

Built-up Edge

Built-up edge keeps breaking off and re-forming

Result is poor surface finish, excessive flank wear, and cratering of tool face



Cutting Fluid's Effect on Cutting Tool Action

1. Lowers heat created by plastic deformation of metal
2. Friction at chip-tool interface decreased
3. Less power is required for machining because of reduced friction
4. Prevents built-up edge from forming
5. Surface finish of work greatly improved

Rust Control

- Water best and most economical coolant
  - Causes parts to rust
- Rust is oxidized iron
- Chemical cutting fluids contain rust inhibitors
  - Polar film
  - Passivating film

Rancidity Control

- Rancidity caused by bacteria and other microscopic organisms, growing and eventually causing bad odors to form
- Most cutting fluids contain bactericides that control growth of bacteria and make fluids more resistant to rancidity

Application of Cutting Fluids

- Cutting-tool life and machining operations influenced by way cutting fluid applied
- Copious stream under low pressure so work and tool well covered
  - Inside diameter of supply nozzle ¾ width of cutting tool
  - Applied to where chip being formed

Refrigerated Air System

- Another way to cool chip-tool interface
- Effective, inexpensive and readily available
- Used where dry machining is necessary
- Uses compressed air that enters vortex generation chamber
  - Cooled 100°F below incoming air
- Air directed to interface and blow chips away