Metalcutting Fluids

Training Objective

After watching the program and reviewing this printed material, the viewer will understand the importance and application methods of metalcutting fluids in machining operations.

- Factors in the selection of the proper fluid are shown.
- Types of fluids and methods of application are demonstrated.
- Fluid maintenance issues are discussed.
- Operator health issues are addressed.

Cutting Fluids/Coolants

These fluids, often referred to as coolants, are an integral part of most machining or chip making processes. Usually mixed with water, they perform several functions including:

- Cooling work and tool surfaces
- Removal of chips from the cutting area
- Contributing to longer tool life
- Promoting part surface integrity
- Aiding in corrosion control

The primary factor in the selection of a fluid is the nature of the machine process and the non-cutting function of the fluid itself. In some cases, as with cast iron, no fluid or coolant is used.
Additionally, the method of fluid/coolant application can directly affect chip formation, chip removal, cutting tool life, and surface integrity.

Surface Integrity

This refers to the quality of the part's surface finish after machining. Surface quality is very much dependant on how well the fluid reduces tool-to-part friction and its ability to dissipate heat. Without a cooling fluid the part may be affected physically, electrically, and magnetically.

Non-Cutting Functions

The selection of a fluid/coolant must also consider its impact, not only on the part being machined or ground, but upon the local environment of the operation. These considerations would include the:

- Addition of rust inhibitors to control corrosion
- Stink (odor) resistance to prevent the formation of noxious fumes
- Gum resistance to prevent the accumulation of residue on the part surface
- Operator health and comfort
- Disposability which, depending on chemical content, may come under certain environmental restraints

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Fluid Lubrication and Cooling

In machining operations fluids will provide lubrication both to the equipment and the actual cutting zone. Lubrication fluid will absorb and dissipate frictional heat by carrying it away from cutting zone. In situations where tools run very fast, or if there is extreme hardness in the part, cooling becomes more important than lubrication. In contrast with slower tool speeds and softer material, lubrication needs are more critical.
In respect to lubricity, special fluid properties influence their operative characteristics. They are:

- Extreme Pressure Additives – These contain high levels of chlorine, sulfur, or phosphorus which react to the newly machined surface to prevent edge build-up and chip welding in the work zone.
- Boundary Lubrication – Having highly polar molecules which attach themselves to the metallic surfaces involved and repel each other reducing friction.
- Hydrodynamic Lubrication or 'Full Fluid' Lubrication – Where the fluid becomes a barrier between two surfaces resulting in no metal-to-metal contact.

Types of Fluids

There are several groups of metal cutting fluids, including:

- Straight or Cutting Oils – May be synthetic, vegetable, animal, or mineral oils. They are not usually mixed with water and may contain certain chemicals. Their major advantage is their lubricity between work piece and the tool. They are not suitable for high speed machining.
- Soluble Oils, also called Chemical Emulsions – They are mixed with water and typically contain other additives to aid in maintaining work surface integrity. The quality of the water used is critical to optimum performance. Being mixed with water, the soluble oils have less lubrication qualities but are a more efficient in their cooling ability.
- Semi-Synthetic or Semi-Chemical Fluids – These will contain small amounts of oil and other additives to enhance lubrication while providing maximum cooling. As such, they are useful in more difficult machining and grinding operations. Disadvantages include lower lubrication ability, possible skin irritants, and less corrosion protection.
- Synthetic or Chemical Fluids – These are blended coolants but contain no oils. They provide high cooling capability, low surface tension, and quick wetting ability. They produce no smoke, reject tramp oils and remain cleaner. However, they have less lubricity, are high in chemical oxygen needs, and have narrow concentration ranges. Their primary use is in high speed turning of harder materials and in surface and cylindrical grinding.

Fluid Application Systems

Delivery of the fluid/coolants to the cutting zone is accomplished by several methods including:

- Flooding – Most common delivery methods. Utilizes a low pressure pump and a nozzle directed at the work.
- High Pressure-High Volume (HPHV) – Most effective in cooling the work and chip removal. System must be totally enclosed to maintain system pressure.
- Spray Mist – Coolant is combined with a stream of high pressure air. The resulting mist is directed at the work with most of it evaporating upon contact.
- Minimum Quantity Lubrication (MQL) – Lubricant is sprayed onto the face of the cutting tool. This method is used where flooding may cause thermal cracking and enclosed high pressure systems are not possible.
- Dry Machining – Used with porous materials like cast iron and is the least costly in overall machining. Also has the advantage of maintaining a clean atmosphere and few health problems. However, dry machining requires slower process speed and results in shorter tool life.

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Cutting Fluid Maintenance

Maintenance and monitoring of the fluids is necessary for useful fluid life. Part of this is in the care and cleanliness of the machine tools themselves. Monitoring includes concentration checks using the appropriate test, including:

- Refractometers, which are used to determine the total amount of solubles in a solution.
- Titration Kits, which are used to analyze fluid concentration in metalcutting fluids contaminated with tramp oils.
- Tests for PH levels and alkalinity (acid splits) are also useful.

Additionally, the use of the various metalcutting fluids involves health and safety issues for operators and other personnel. The fluid manufacturer's product data sheets should always be consulted and rigidly followed.

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Review Questions

1. No type of fluid or coolant is used when machining:
   a. stainless material
   b. aluminum stock
   c. cast iron
   d. sulphur bearing steels

2. Part surface integrity is very dependant upon:
   a. low fluid acid content
   b. slower machining speeds
   c. reduced part-to-tool part friction
   d. post cleaning operations

3. Part cooling during machining is critical with:
   a. cast materials
   b. softer materials
   c. harder materials
   d. composites

4. A typical 'Extreme Pressure Additive' is:
   a. chlorine
   b. silicone
   c. mercury
   d. aluminum oxide

5. Where fluid molecules are polar and repel each other is called:
   a. flooding
   b. boundary lubrication
   c. chemical lubrication
   d. lubricity

6. A type of cutting fluid which offers the least corrosion resistance is:
   a. semi-synthetic
   b. straight oils
   c. soluble oils
   d. chemical emulsions

7. High pressure-high volume fluid delivery systems require:
   a. large fluid reservoirs
   b. multiple spray nozzles
   c. enclosed machining stations
   d. faster recovery speeds

8. The amount of solubles in a cutting solution is determined by:
   a. specific gravity tests
   b. weight vs. volume tests
   c. viscosity tests
   d. refractometer tests

9. Titration tests measure:
   a. Ph levels
   b. alkalinity levels
   c. tramp oil contamination
   d. moisture amounts

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Answer Key

1. c
2. c
3. c
4. a
5. b
6. a
7. c
8. d
9. c