CUTTING FLUIDS AND SURFACE ROUGHNESS, METAL FINISHING PROCESSES, SURFACE PREPARATION.

CUTTING FLUIDS

Cutting fluid (coolant) is any liquid or gas that is applied to the chip and/or cutting tool to improve cutting performance. A very few cutting operations are performed without the application of cutting fluids. Generally, it is essential that cutting that cutting fluids be applied to all machining operations.

Cutting fluids serve three basic functions:

i. To remove heat in cutting: The effective cooling action of the cutting fluid depends on the method of application, type of the cutting fluid, the fluid flow rate and pressure. The most effective cooling is provided by mist application combined with flooding. Application of fluids to the tool flank, especially under pressure, ensures better cooling that typical application to the chip but is less convenient.
ii. To lubricate the chip-tool interface: Cutting fluids penetrate the tool-chip interface improving lubrication between the chip and tool and reducing the friction forces and temperatures.
iii. To wash away chips: This action is applicable to small, discontinuous chips only. Special devices are subsequently needed to separate chips from cutting fluids.

METHOD OF APPLICATION

1. **Manual application**: Application of a fluid from a can manually by the operator.
2. **Flooding**: A steady stream of fluid is directed at the chip or tool-workpiece interface. Most machine tools are equipped with a recirculating system that incorporates filters for cleaning of cutting fluids. Cutting fluids are applied to the chip although better cooling is obtained by applying it to the flank face under pressure.
3. **Coolant-fed tooling**: Some tools especially drills for deep drilling are provided with axial holes through the body of the tool so that the cutting fluid can be pumped directly to the tool cutting edge.
4. **Mist applications**: Fluid droplets suspended in air provide effective cooling by evaporation of the fluid. Mist application in general is not as effective as flooding but can deliver cutting fluid to inaccessible areas that cannot be reached by conventional flooding.

TYPES OF CUTTING FLUID

1. **Cutting oils**: They are cutting fluids based on mineral or fatty oil mixtures. Chemical additives like sulphur improve oil lubricant capabilities. Areas of application depend on the properties of the particular oil but commonly cutting oils are used for heavy cutting operations on tough steels.
2. **Soluble oils**: The most common, cheap and effective form of cutting fluids consisting of oil droplets suspended in water in a typical ratio of water to oil (30:1). Emulsifying agents are also

added to promote stability of emulsion. For heavy duty work, extreme pressure additives are used. Oil emulsions are typically used for aluminium and copper alloys.

3. **Chemical fluids**: These cutting fluids consist of chemical diluted in water. They possess good flushing and cooling abilities. Tend to form more stable emulsions but may have harmful effects to the skin.

Environmental issues

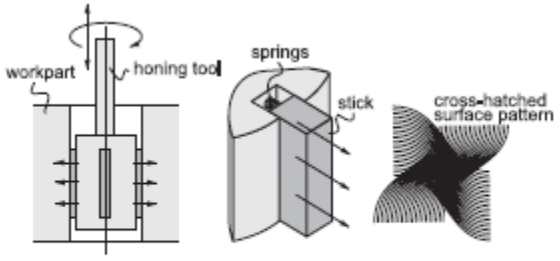
Cutting fluids become contaminated with garbage, small chips, bacteria, etc, over time. Alternative ways of dealing with the problem of contamination are:

i. Replace the cutting fluid at least twice per month.
ii. Machine without cutting fluids (dry cutting)
iii. Use a filtration system to continuously clean the cutting fluid.

FINISHING OPERATIONS

The objective is to achieve superior surface finish up to mirror-like finishing and very close dimensional precision. Some of the finishing operations are discussed below:

i. **Honing**: is a finishing process performed by honing tool which contains a set of three to dozen and more bonded abrasive sticks. The sticks are equally spaced about the periphery of the honing tool. They are held against the work surface with controlled light pressure, usually exercised by small springs. The honing tool is given a complex rotational and oscillatory axial motion, which combine to produce a crosshatched lay pattern of very low surface roughness. Honing produces a characteristic crosshatched surface surface that tends to retain lubrication during operation of the component, thus contributing to its function and service life. A cutting fluid must be used in honing to cool and lubricate the tool and to help remove the chips. A common application of honing is to finish the holes. Typical examples include bores of internal combustion engines, bearings, hydraulic cylinders and gun barrels.

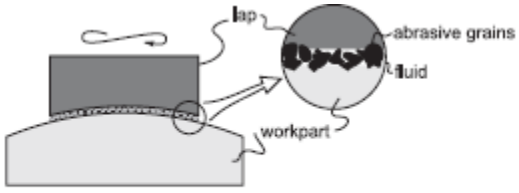


Schematics of honing process showing the honing tool, how the abrasive sticks are pressed against the work surface by springs, and the resulting surface pattern.

ii. **Lapping**: In this, oil-based fluid suspension of very small free abrasive grains (aluminium oxide and silicon carbide, with typical grit sizes between 300 and 600) and lapping compound is applied between the workpiece and the lapping tool. The lapping tool is called a lap which is made of soft materials like copper, lead or wood. The lap has the reverse of the desired shape of the work part. To accomplish the process, the lap is pressed against the work and moved

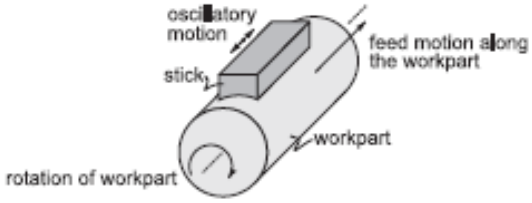
back and forth over the surface in a figure-eight or other motion pattern, subjecting all portions of the surface to the same action. Lapping is sometimes performed by hand, but lapping machines accomplish the process with greater consistency and efficiency.

The cutting mechanism in lapping is that the abrasives become embedded in the lap surface and the cutting action is very similar to grinding but a concurrent cutting action of the free abrasive particles in the fluid cannot be excluded. Lapping is used to produce optical lenses, metallic bearing surfaces, gages, and other parts requiring very good finishes and extreme accuracy.



Schematics of lapping process showing the lap and the cutting action of suspended abrasive particles.

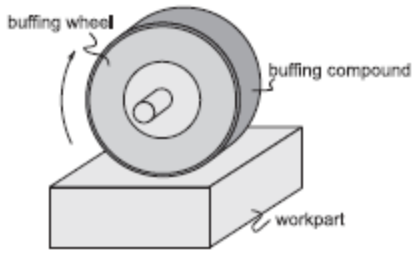
iii. **Super-finishing**: It is a finishing operation similar to honing but it involves the use of a single abrasive stick. The reciprocating motion of the stick is performed at higher frequency and smaller amplitudes. The grit size and pressures applied on the abrasive stick are smaller. A cutting fluid is used to cool the work surface and wash away chips. The cutting action terminates itself when a lubricant film is built up between the tool and work surface. Thus super-finishing is capable only of improving the surface finish but not dimensional accuracy. The result of these operating conditions is mirror like finishes with surface roughness values around 0.01 μm. It can be used to finish flat and external cylindrical surfaces.



Schematics of the superfinishig process.

iv. **Polishing**: It is a finishing operation to improve the surface finish by means of a polishing wheel made of fabrics or leather and rotating at high speed. The abrasive grains are glued to the outside periphery of the polishing wheel. Polishing operations are often accomplished manually. It is used to remove scratches and burrs and to smooth rough surfaces.

v. **Buffing**: It is a finishing operation similar to polishing in which abrasive grains are not glued to the wheel but are contained in a buffing compound that is pressed into the outside surface of the buffing wheel while it rotates. Buffing is usually done manually, although machines have been designed to perform the process automatically. It is used to provide attractive surfaces with high luster.



Schematics of the buffing operation.

Review questions

1. What are cutting fluids?
2. List the methods of application of cutting fluids
3. Discuss the cutting fluid types
4. Explain the following finishing operations: Honing, buffing, lapping, polishing and super-finishing