

CHAPTER III. Processes for obtaining parts by material removal

III.1. Introduction

Machining by material removal consists of gradually reducing the dimensions of the workpiece by removing metal cold and without deformation using a tool. The amount of material removed is called chips and the instrument with which the material is removed is called a cutting tool. The operator uses machines called machine tools to machine a workpiece.

Machining encompasses all techniques used to manufacture mechanical parts. Starting with a raw or semi-finished part, material is removed using a machine tool to obtain the desired shape. The advantage of this process over most manufacturing processes is that it allows for high precision in terms of the geometry obtained. The tool follows a trajectory relative to the workpiece. These movements are performed by the components of the machine tool.

To achieve satisfactory results (good condition of the machined surface, fast machining speed, moderate tool wear, etc.), the cutting parameters must be defined according to the type of machining to be performed. There are several criteria for defining cutting parameters, including:

- a. The type of machine (turning, milling, drilling, etc.);
- b. The power of the machine;
- c. The material being machined (steel, aluminum, etc.);
- d. The tool material (HSS, carbide, etc.);
- e. The type of operation (drilling, turning, surfacing, etc.).

The ultimate goal is to obtain a machined part in good condition. To do this, certain specific parameters must be determined:

1. Cutting speed: V_c ;
2. Feed rate: F ;
3. Depth of cut: a .

III.2. Turning

Turning is a machining process that involves removing chips to produce cylindrical and/or conical parts using cutting tools on machines called lathes. The workpiece is secured in a clamp, chuck, or between centers. It is also possible to drill on a lathe, even if this is not its primary function.

The workpiece is moved in a uniform circular motion, known as the cutting motion M_c . The tool is moved in a parallel or oblique translation relative to the axis of rotation, known as the feed motion M_a . In its movement, the tip of the tool describes a line called the generatrix, which transforms the workpiece into a solid of revolution. By varying the displacement of the tool (radial movement), it is possible to obtain all solids of revolution such as cylinders, cones, spheres, etc.

Turning also allows internal shapes to be formed by drilling, boring, and tapping. In turning, the cutting motion is achieved by rotating the workpiece clamped between the jaws of a chuck or in a special clamp, while the feed motion is achieved by moving the cutting tool. The combination of these two motions allows material to be removed in the form of chips.

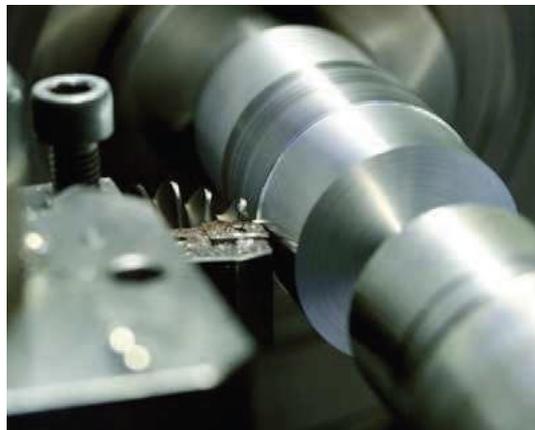


Figure 1. Turning

On a conventional parallel lathe, two main types of operations can be performed:

1. External machining, including face turning, turning, external threading, grooving, chamfering, cutting, etc.
2. Internal machining, including drilling, boring, internal turning, internal threading, countersinking, etc.

In general, each turning operation is associated with a specific tool.

Operations related to Turning

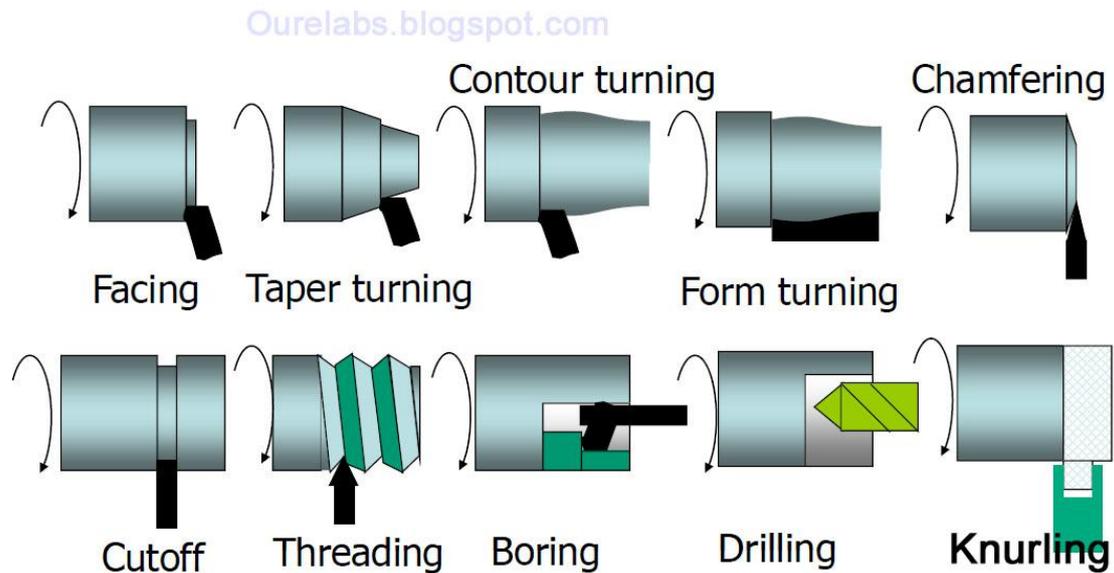


Figure 2. Turning operations

III.3. Milling

Milling is a machining process that removes material. It involves the use of a machine tool called a milling machine and a special cutting tool (with multiple edges) called a milling cutter. The milling machine is particularly suitable for machining flat surfaces and, if the machine is equipped with numerical control, can also be used to produce all types of shapes, even complex ones. Milling cuts are usually made with teeth placed on the periphery and/or on the end of a disc or cylinder.

A milling cutter is a multi-edged tool:

- The milling cutter rotates: this is the rotational movement (M.R.)
- The workpiece moves horizontally: feed movement (M.A.)
- The “cutting movement” results from the combination of the rotational movement and the feed movement.
- The “pass depth” is adjusted by moving the workpiece (W.P.).

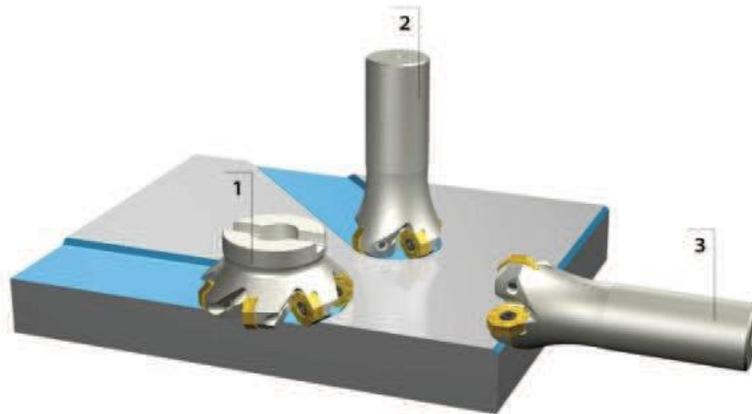


Figure 3. Milling

III.4 Drilling

Drilling is a machining operation that involves making a hole in a workpiece. This hole may pass through the workpiece from one side to the other, in which case it is called a through hole, or it may not pass through, in which case it is called a blind hole.

The most commonly used machine tool for drilling is the drill. Drills can be classified into several types:

- Sensitive or bench drills
- Column drills
- Radial drills
- Portable compressed air or electric machines.



Figure 4. Drilling

The cutting tool is called a drill bit. To drill a hole with a drill, two relative movements are required:

1. A cutting movement (Mc): Rotation of the drill bit;
2. A feed movement (Mf): Straight movement parallel to the tool axis.

III.5. Grinding

Grinding is a machining process that removes chips. It is performed using a rotating tool with multiple cutting edges called a grinding wheel (abrasive belt) consisting of cutting particles bonded together by a binder, each particle removing a small chip when one of its edges comes into contact with the workpiece. The aim is to grind the surface to a perfect shape (usually flat, cylindrical, or conical). This operation is generally performed at high speed, with very small chips. The surface finish is improved by using increasingly fine abrasives. Grinding is performed on a machine called a grinding machine.

A grinding machine is a machine tool used to perform finishing operations. Grinding is often characterized by high structural rigidity. As its name suggests, a grinding machine performs grinding operations using tools called grinding wheels, which are characterized by a fine grain and extreme hardness.

The grinding operation performed with the grinding machine is necessary to obtain a perfectly finished part after it has been machined by another type of machine tool such as a milling machine, lathe, or machining center.

Depending on the type of operation or surface to be treated, there are different types of grinding machines, all available on the second-hand market:

- Grinding machines for flat surfaces;
- Grinding machines for cylindrical and conical surfaces (internal & external);
- Centerless grinding machines;
- Special grinding machines for screws and gear wheels.

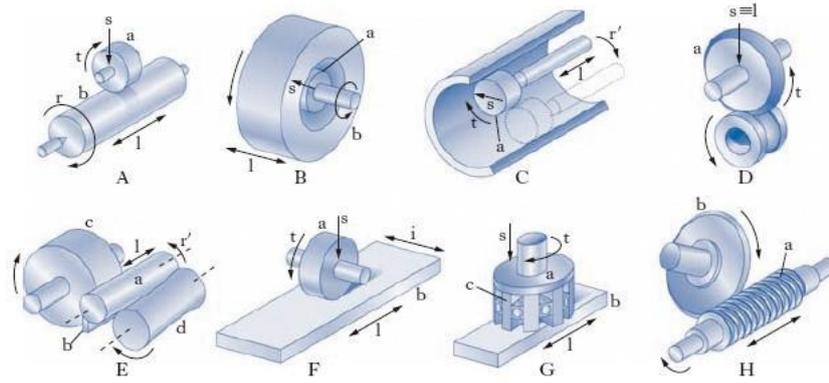


Figure 5. Grinding operations

III.6. Broaching (on a broaching machine)

Broaching is a machining process that uses a tool with multiple cutting edge called a “broach.”

The broach tool has teeth that gradually increase in height, so that each one cuts deeper into the workpiece than the one before it.

Internal broaching (shapes a, b, c, d opposite) requires the broach to be able to pass through the workpiece. It is therefore necessary to make a through hole beforehand.

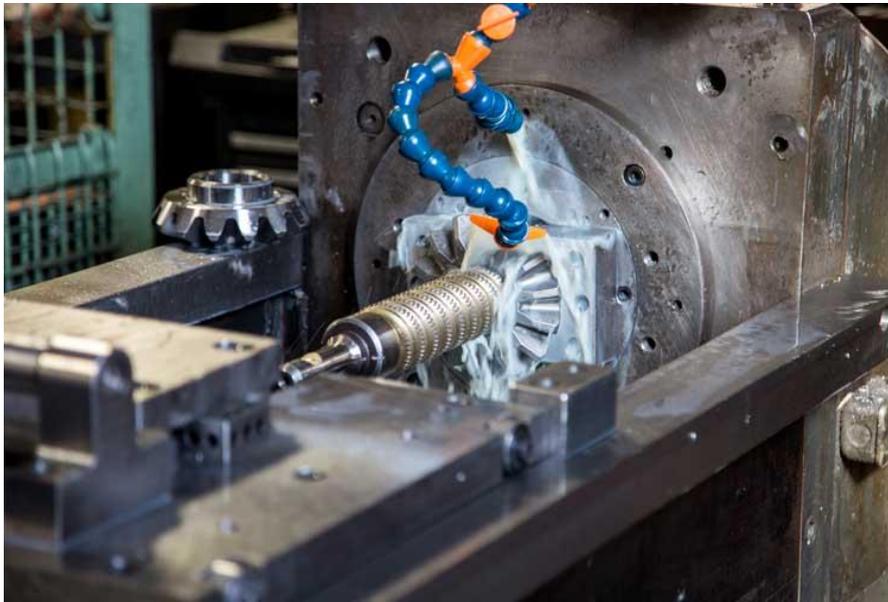


Figure 6. Broaching

Grinding, lapping, superfinishing (on a grinding wheel or abrasive belts)

These three techniques are used to finish parts by abrasion (or grinding) until a mirror-like surface is achieved.

III.7. Electrical discharge machining

Material removal is achieved by electrical discharges between a workpiece electrode and a tool electrode.

Advantages:

- Machining of hardened and tough materials, which cannot be machined using chip removal processes;
- Machining of three-dimensional shapes that can be “demolded” (the tool penetrates the workpiece and leaves its complementary shape behind) and helical shapes (by giving the tool a rotational movement combined with its translational movement);
- Good surface finishes ($R_a \approx 2 \mu\text{m}$) and precision ($\approx 20 \mu\text{m}$).

Disadvantages:

- This process can only be used on electrically conductive materials;
- Cost of equipment (specific to each shape of part to be produced) and wear on the electrode tool.

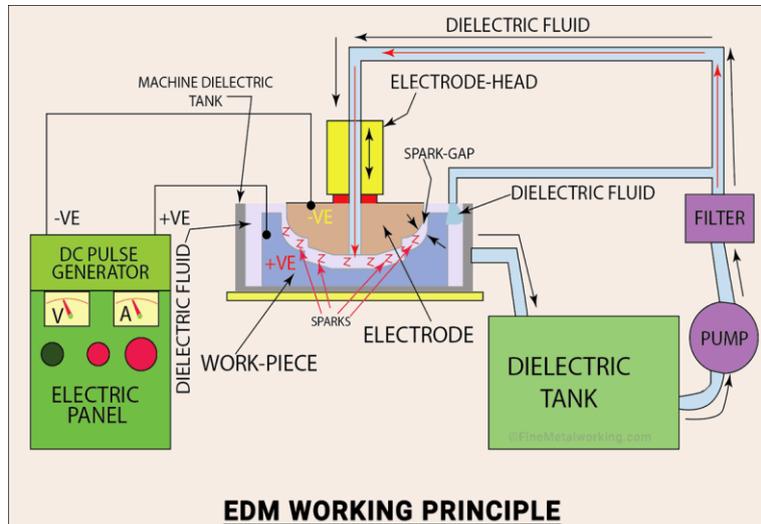
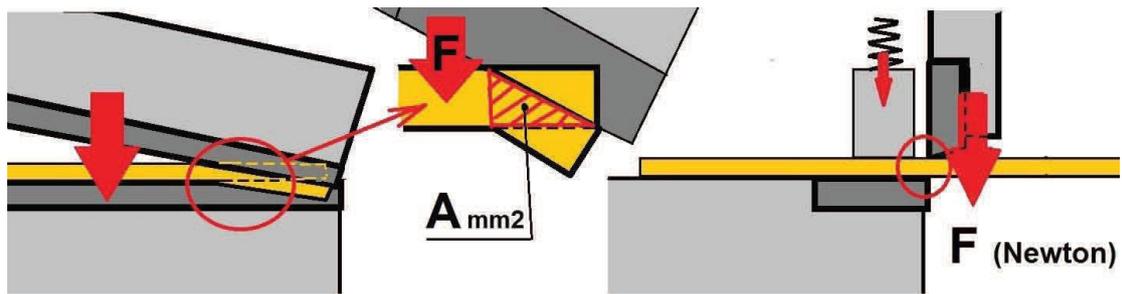


Figure 7. Electrical discharge machining

III.8. Cutting, punching, shearing

Cutting involves shearing sheet metal along a closed contour.

- ❖ **Shearing:** Involves cutting (shearing) sections of profile or sheet metal.



- ❖ **Punching:** Cutting is performed by a punch shaped like the opening (hole) to be cut.

There are several cutting techniques:

- **Conventional cutting** (mechanical, using a closed-profile cutting tool moved by a press);
- **Oxy-cutting** (jet of pure oxygen on metal that has been locally heated to its combustion temperature);
- Laser cutting;
- **Water jet cutting** (the water jet must be fine enough, fast enough, and pressurized enough to cut most metals without wetting them);
- **Plasma cutting** (similar to TIG welding, but with different gas mixtures—an electric arc generates a plasma jet that causes local melting across the entire thickness of the material to be cut).