AUTOMOTIVE MANUFACTURING
Powertrain technologies

POWERTRAIN ASSEMBLY
The technologies

Introduction to assembly

1. Assembly is a reversible process
2. Normally sequential, manual or automatic
3. The involved technologies **other that loading, handling and assembly**, are:
   - **Tightening**
   - **Insertion with pression**

- Feeding and sideline are essential part of the process definition

1. Online testing is a modern approach to the quality control
2. Final test through firing is nor reduced to % and replaced by cold testing

Assembly technologies: Tightening (1)

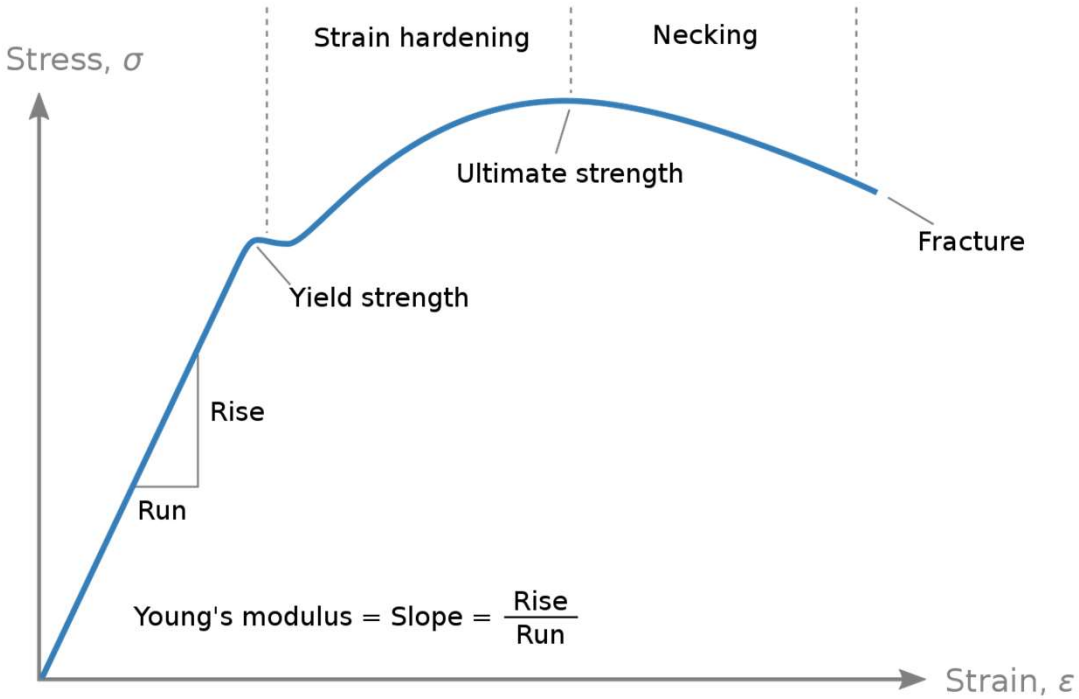
The base for the tightening technology is the Stress/strain diagram (steel), σ=Y(ε)

There is a first track of elasticity, then a curve of stability and after the fracture.

In a perfect world, when the head of the bolt reach the contact and the two parts are packed, every further turn should involve a strain.

To be precise the Torque applied to the bolt should end in a defined stress, with a ray relation:

σ=k* T/r where k is related to geometry



Assembly technologies: Tightening (2)

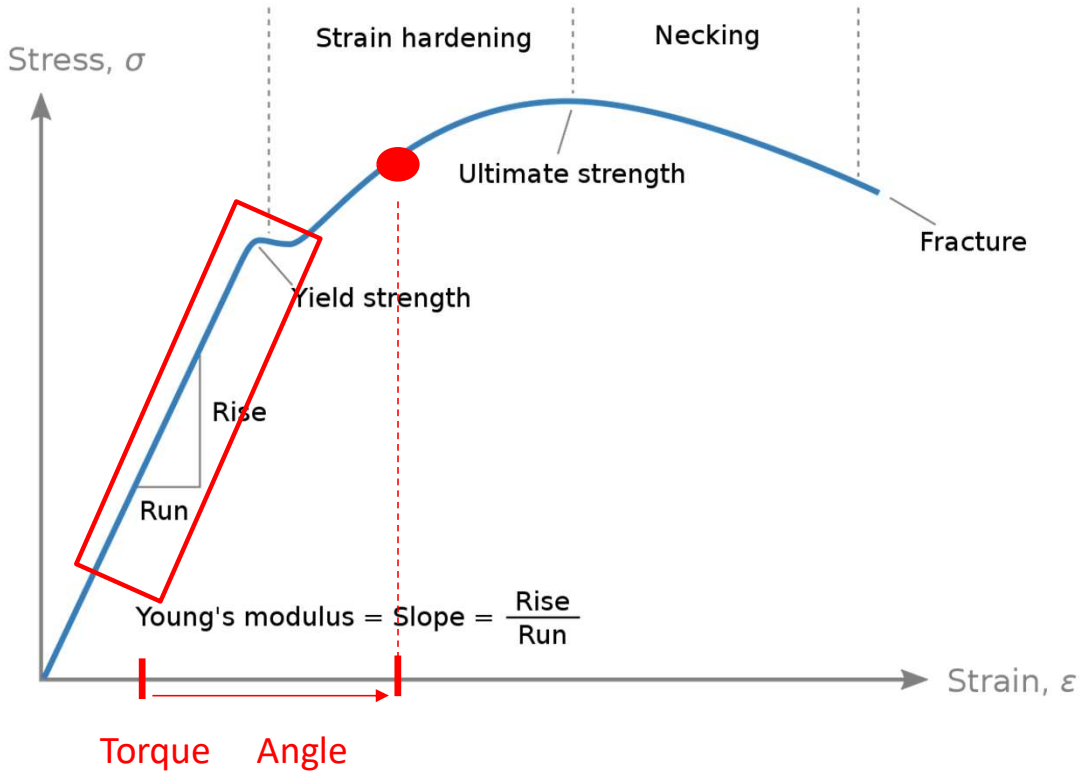
Unfortunately, the world seems not perfect because of unknown attritions.

The stress that keep together the part is

σ= k*(T measured – T attritions) /r

Since in the elastic behavior, the Torque is extremely instable in function of the strain, that is influenced by the package, we cannot use the formula: S= Y(N*a) where N is number of turns and a is the advance of a turn. So, we try to minimize attrition and work in elasticity area.

But for the most critical tightening we do a preload with a defined Torque and then and angle to ensure to go over the yield strength but not over the ultimate strength.



Auxiliary equipment

Assembly is not only a sequence of positioning and fixing operation.

Great importance must be given to the quality of the process that has to be controlled online.

During the process there are several test:

- Mechanical tests (e.g. in engine free rotation, shim definition)
- Leak test (e.g crank seals leakages) with air, pression or depression, or gas
- Electric tests

At the end there are two main inspection system:

- Cold test
- Hot test (with or without braking system)

Engine Leak Test example

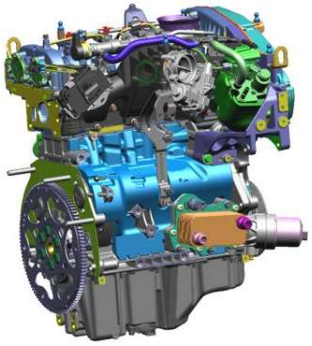
- **Leak test** is defined as a **static pneumatic test** performed on an engine by introducing dried compressed air into the **engine cooling and lubrication circuits**. In so doing, after measuring the air pressure drop, it is possible to detect any not-sealing condition through the analysis of data acquired by means of specific instruments.

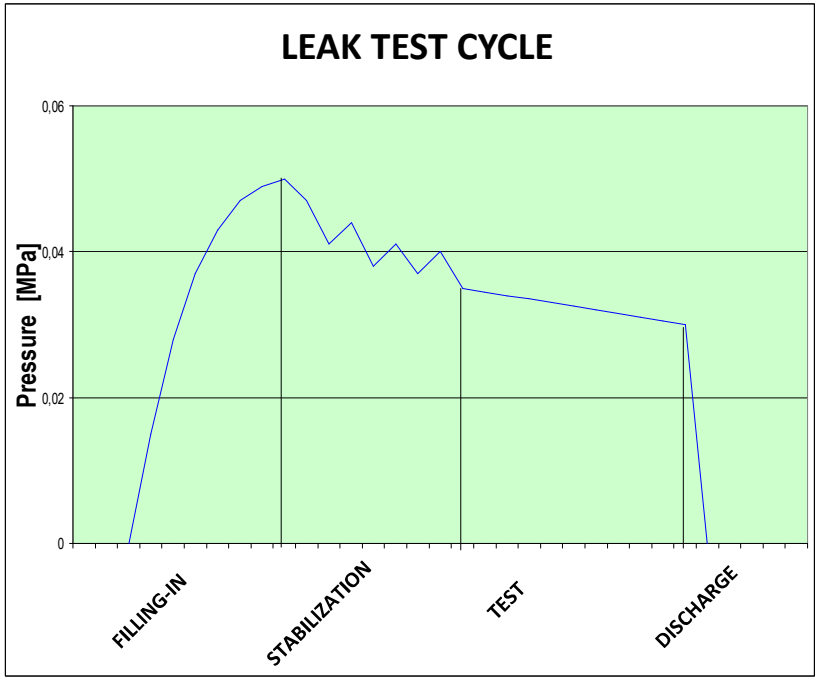
- To carry out the test, the external cavities of the engine circuits are insulated through specific **plugging units** integrated in the system which insufflates air into the engine.

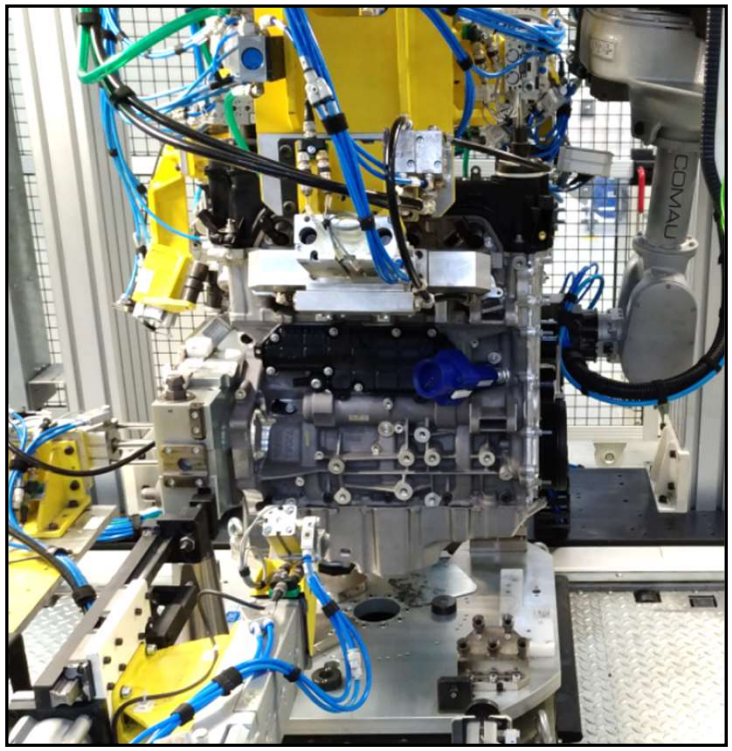
- The whole leak test cycle time is approximately one minute, a part of which is dedicated to the pressure drop measurement.

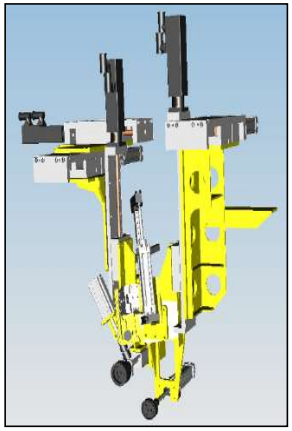
- Leak test can be run in fully automatic or in semi-automatic way, depending on factors such as production capacity, capex expenditure investment, manpower hourly rate.

Leak test is run on engines partially dressed, that enables to quickly fill-in cavities and circuits and detect all real leakages only.









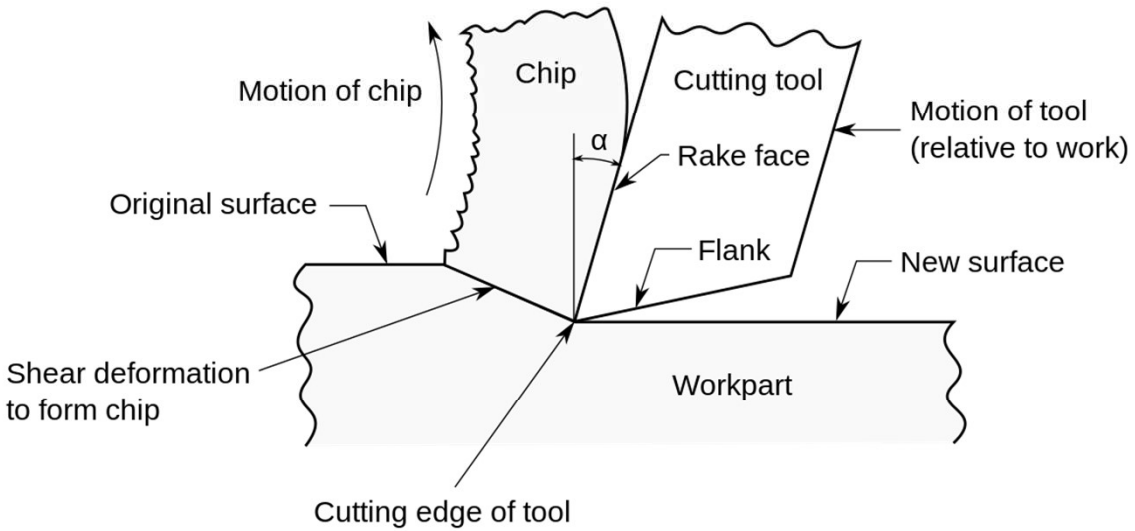
Insulation of engine cooling and lubrication circuits is got by manual expansion plugs and automatic plugging actuators.

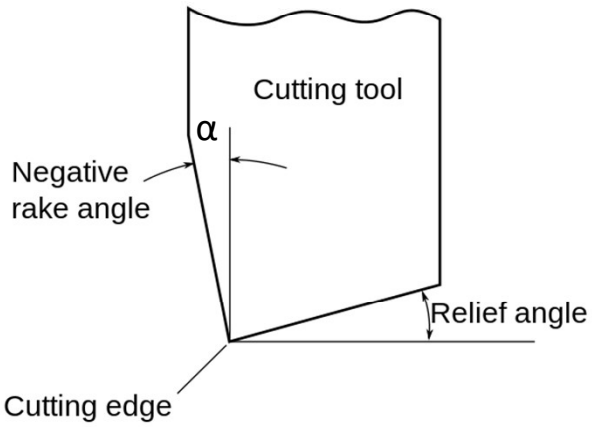
POWERTRAIN MACHINING
The technologies

Introduction

1. Metal cutting or Machining is a process in which metallic parts are cut in order to reach a final precise shape starting from a raw component (casted or forged)
2. There are two main classes of metal cutting: prismatic and rotational:
   - In the first the part is fixed inside a fixture and the tool is rotating. The tool is mounted onto a spindle
   - In the second the part is rotating and the tool, mounted on a tower, is just moving slowly to advance and reach the right quote
3. The part of the machine that is in contact with the part is called (cutting) tool
4. Important is the definition of reference points on the raw part and the design of the correct allowance thickness
5. The excess of material to be removed is called (cutting) chip and its shape and dimension must be controlled in order to improve the surface quality and the cleanness of the part
6. The cutting operation generates heats and the keep the temperature of the part inside an acceptable range fluids called coolants are used, in order to favor the elimination of chips as well.

Metal cutting base concept

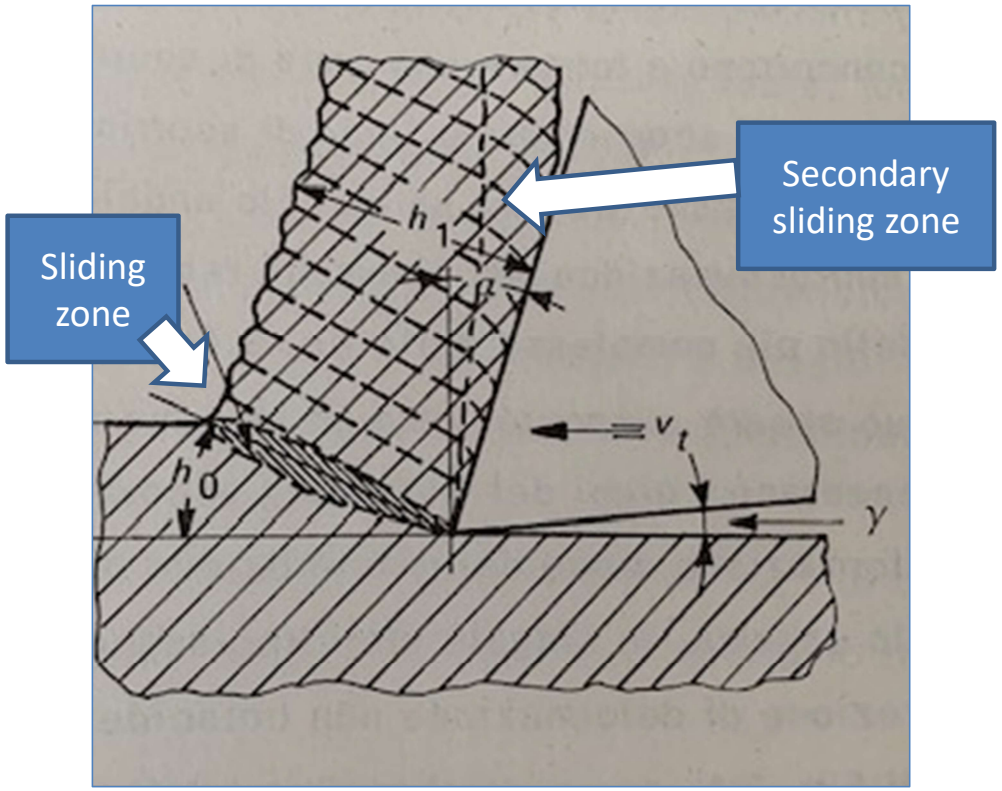




Most of the cutting operation can be summarized in this picture. Very important is the rake angle (α)

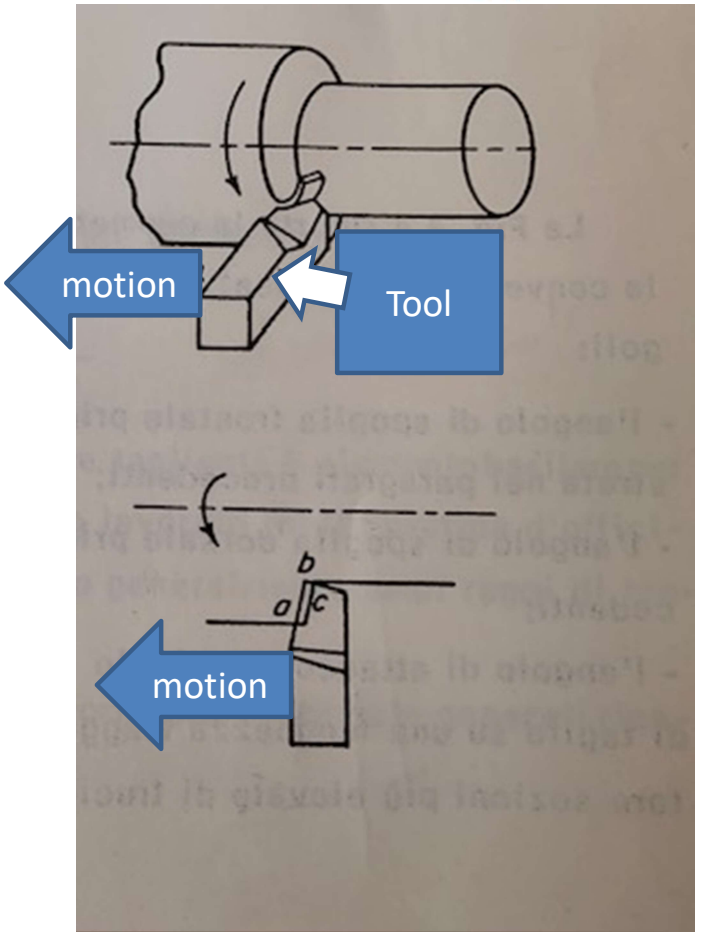
Chip forming

- The chip is separated from the original surface but the result is in a compressed, tougher and thicker material



Turning

- Turning is the simplest and basic machining operation where the cutting tool with a single cutting edge is used to remove material from a rotating workpiece **to generate a cylindrical shape**.
- The primary motion is provided by rotating the workpiece, and the feed motion is achieved by moving the cutting tool slowly in a direction parallel to the axis of rotation of the workpiece.

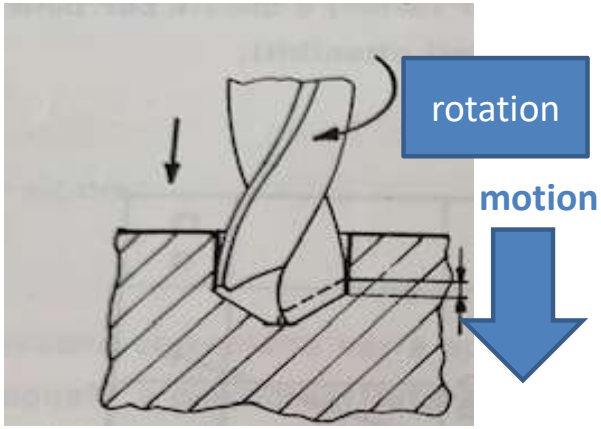


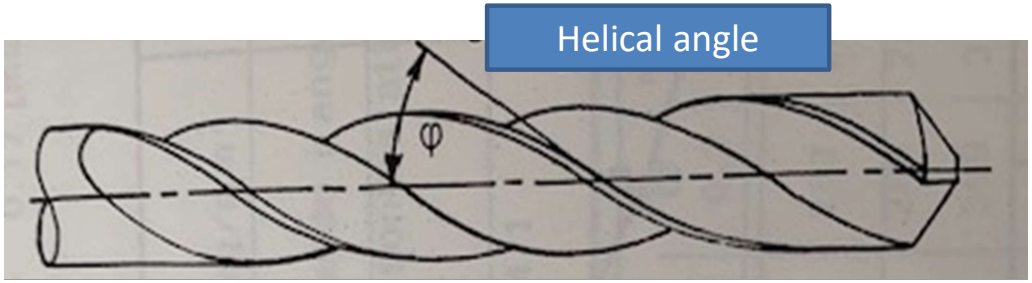
Drilling and boring

Drilling is another simple operation used **to create a round hole**.

It is accomplished by a rotating tool that typically has two or four helical cutting edges.

The tool is fed in a direction parallel to its axis of rotation into the workpiece to form the round hole.





Boring is a finishing operation.

A rotating tool with a single bent pointed tip is advanced into a roughly made hole in a workpiece **to slightly enlarge the hole and improve its accuracy.**

It is used in the final stages of product manufacture.

Milling

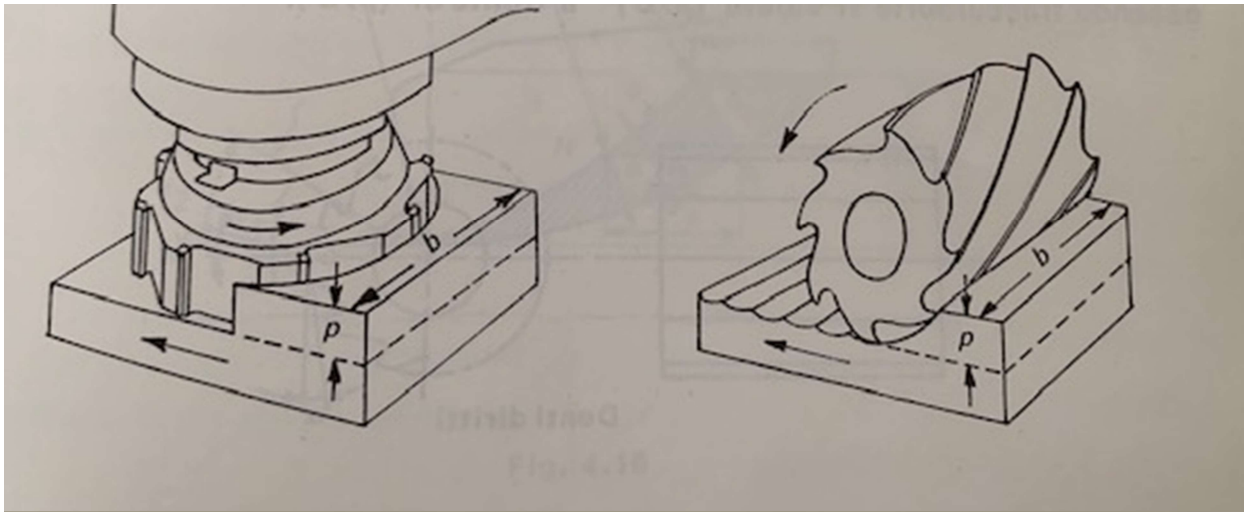
Milling is a prismatic machining operation done with a rotating tool with multiple cutting edges that is moved slowly relative to the material and is used to get a to generate a plane or straight surface.

The direction of the feed motion is perpendicular to the tool's axis of rotation.

The speed motion is provided by the rotating milling cutter driven by the spindle

The two basic forms of milling are:

- Peripheral milling
- Face milling



Auxiliary equipment

- Measurement: gauges and 3D machines
- Washing
- Coolant filtration Systems
- Mist collections
- Tool management