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Machining (Part 2)

1. Milling

In milling, the cutting movement is obtained by rotation of the tool (the cutter), while the advance movement is obtained by the movement of the part held in a vane (or a clamp or jaws, depending on the part to be tightened), **see FIG. 1**. Conventional milling mainly makes it possible to obtain prismatic shapes, but milling by CN makes it possible to obtain shapes which can be very complex.

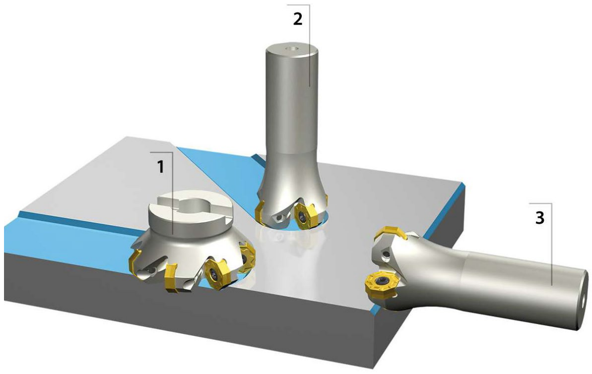


FIG. 1 Milling-piece movement

1.2 Machine tool (Milling machine)

A milling machine is a machine tool used to machine all types of mechanical parts, by removing material, using a cutting tool called a ***milling tool*** (**see Figure 2**). Apart from this tool that gave it its name, a milling machine can also be equipped with forest, tap or bore.

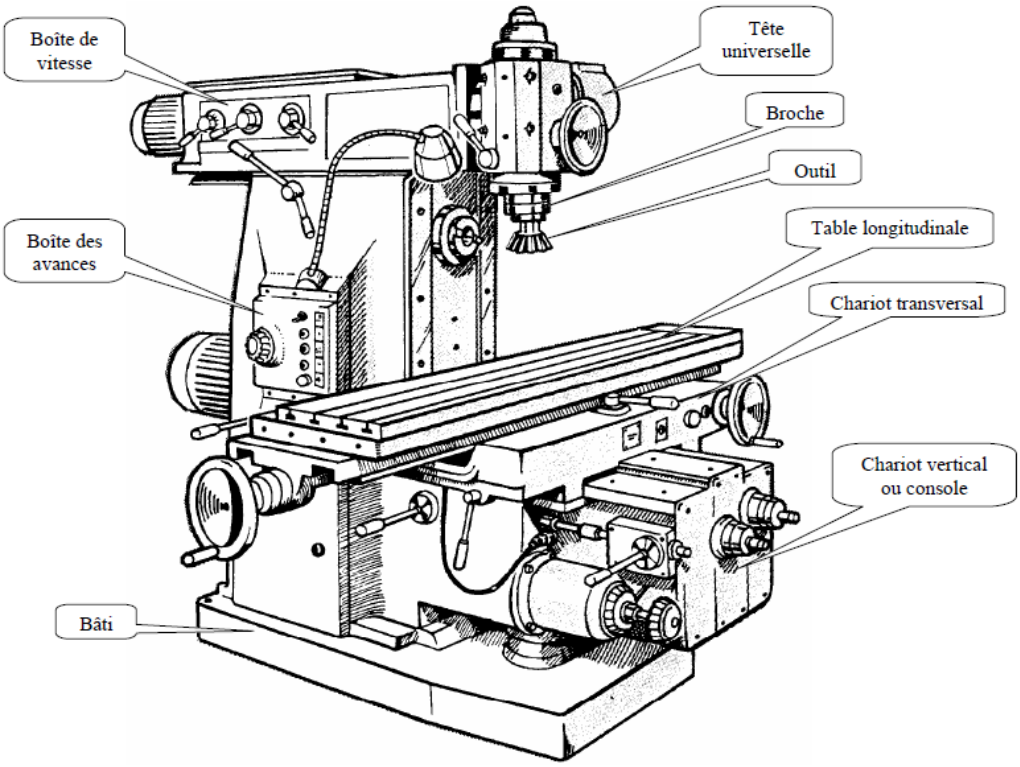


FIG. 2 Machine tool (Milling machine)

There are **conventional** milling machines (manual advance) and numerically controlled milling machines (**CNs**) whose tool advance is entirely programmable.

FIG. 3 Toolholder turret

1.3 Milling Tools and Operations

Surfacing strawberry (or "a size"):
Operation: Surfacing
Strawberry two sizes:
Operation:

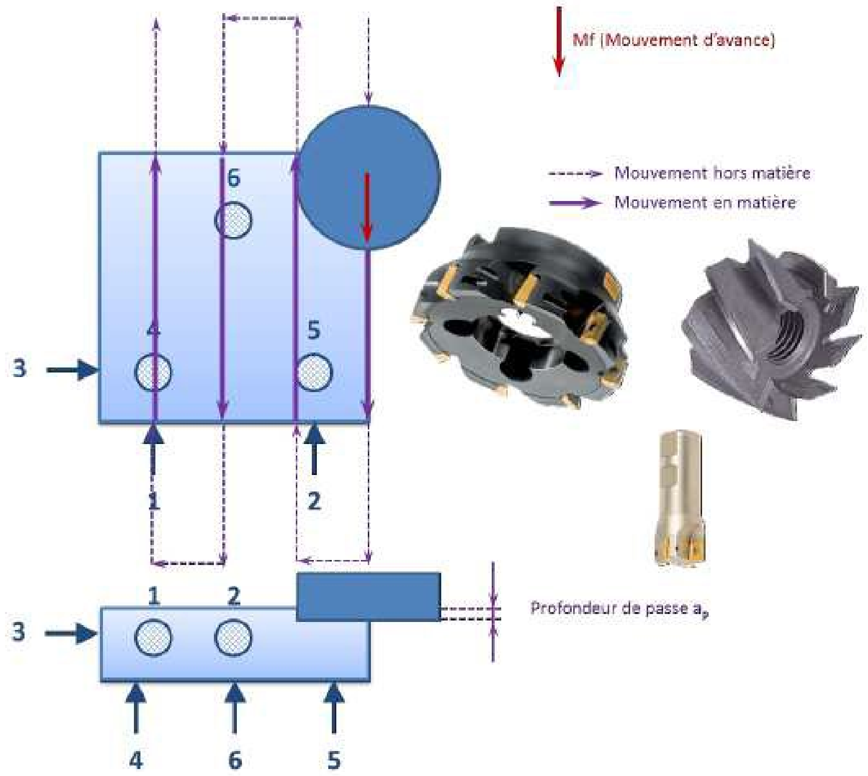
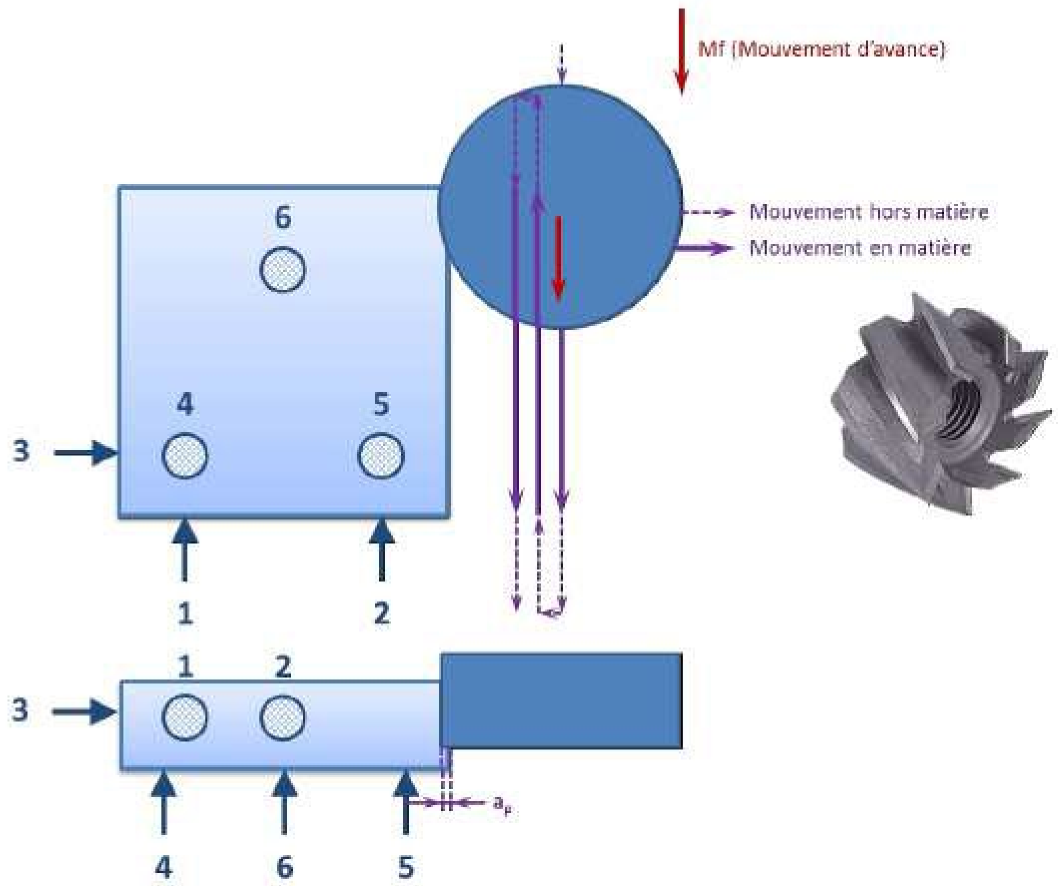


FIG. 4 Surfacing operation

Strawberry two sizes:
Operation: Circumvention



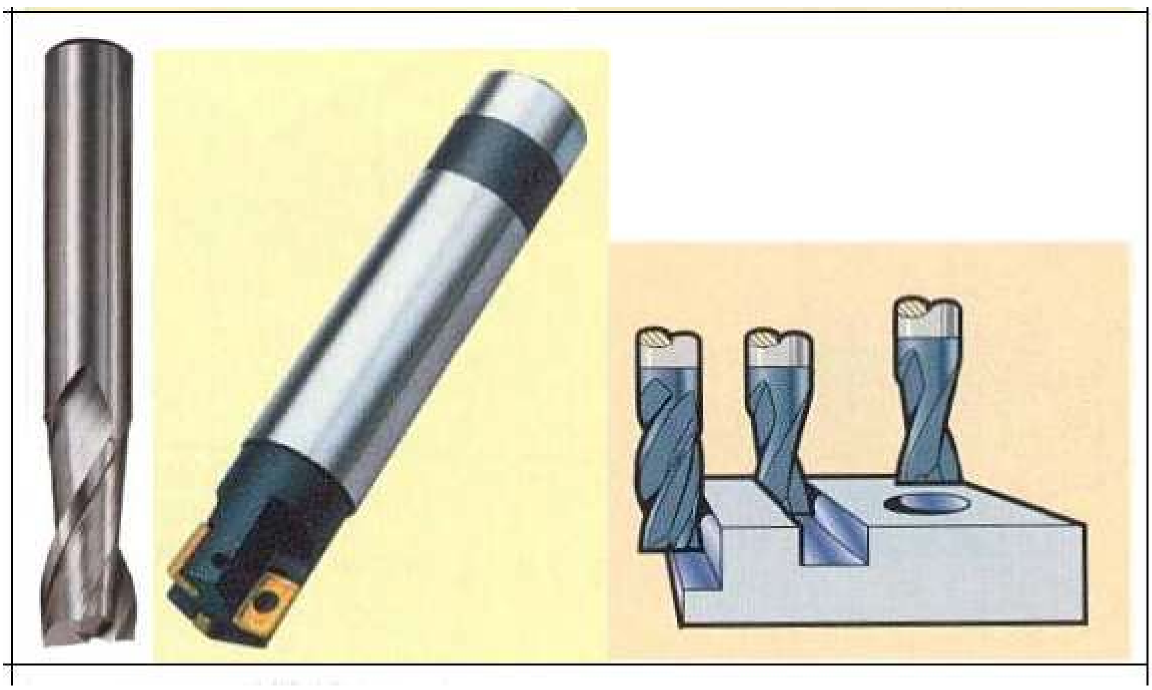


FIG. 5 Circumvention operation

Three-size strawberry:
Operation: Grooving (various shapes)

FIG. 6 Grooving operation

Chamfering cutter (operation = making a chamfer):

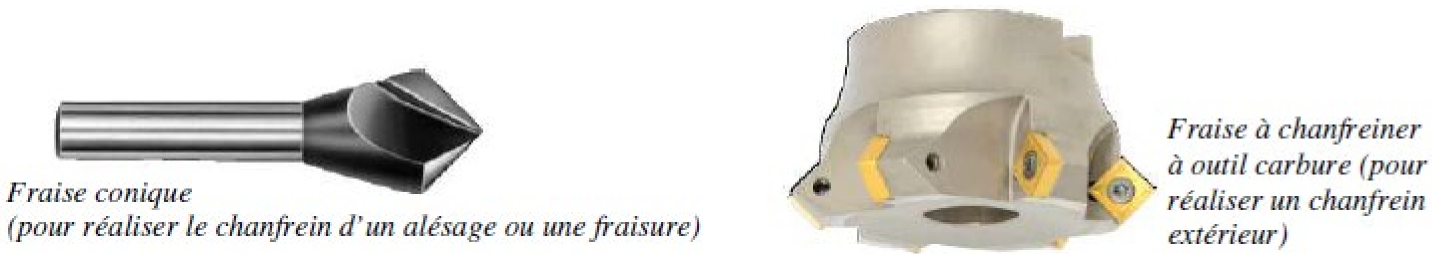


FIG. 7 Chamfering strawberry

Milling cutter (operation = making a milling cutter): see conical cutter above.
Countersink (operation = making a countersink):

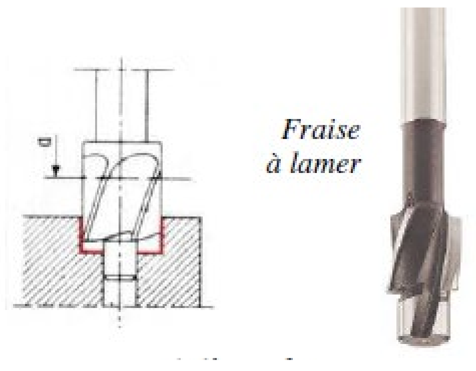


FIG. 8 Milling cutter

Train of strawberries

All types of milling cutters can be assembled one after the other to produce complex forms in a single past.

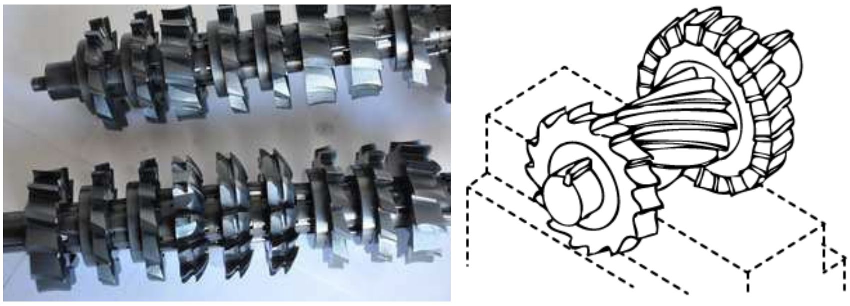


FIG. 9 Train of strawberries

2.1 Working Methods of a Strawberry

- **Milling in opposition**

- The attack of a tooth is done on a zero chip thickness, so no shock.

- At the beginning of cutting, there may be a refusal to cut (minimum chip), therefore a poor condition surface.

The advance movement *Mf* of the piece and the cutting movement M**c** of the cutter are, in the milling zone, in the opposite direction.

This process is to be used only on conventional milling machines.

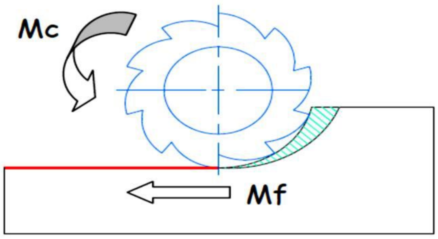


Fig.10 Milling in opposition

- **Milling in agreement or by swallowing**

- The attack is done on a thick chip, so a good surface condition.

- Teeth attack directly on a large width of chip, causing shocks repeated, therefore wear of the tool.

The advance movement ***Mf*** of the piece and the cutting movement ***Mc*** of the cutter are, in the milling zone, in the same direction.

This process is to be used only on machine tools with numerical control (equipped) a system for catching up on games).

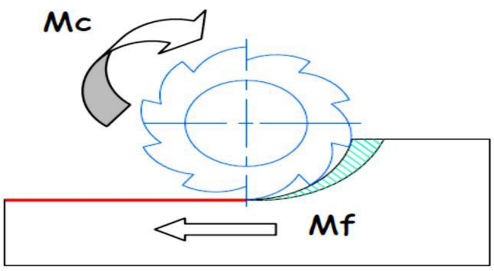


Fig.11 Milling by swallowing.

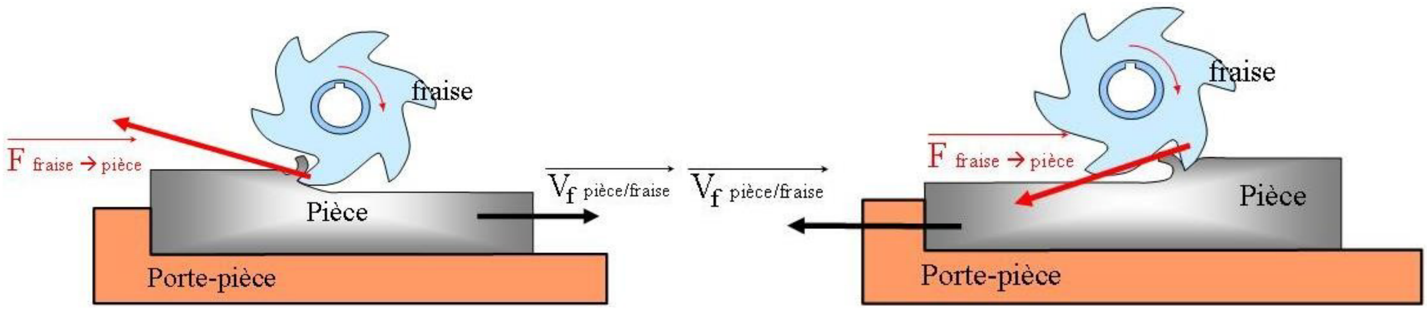


Fig.12 Milling position.

It is said that we must always work in opposition and not in agreement.

2.3 Comparison between the two modes

fraisage en concordance	fraisage en opposition
• L'attaque de la dent se fait avec une épaisseur nulle, ce qui peut entraîner un refus de coupe (copeau mini) sur la surface à générer • Ce frottement entraîne une usure supplémentaire • L'attaque se fait sur une surface écrouie par la dent précédente • Les efforts de coupe sont importants (refus de coupe) • Les efforts de coupe tendent a faire sortir la pièce de la mise en position (efforts vers le haut) • Seul ce mode de travail peut être utilisé sur les fraiseuses ayant des vis sans rattrapage de jeux.	• L'attaque de la dent se fait avec l'épaisseur maximale (pas de copeau mini) • La sortie de la dent se fait sur la surface a générer avec une épaisseur nulle mais le copeau est déjà crée ce qui facilite la coupe • Les dents attaquent sur l épaisseur maxi ce qui généré des chocs, il est intéressant d'avoir plusieurs dents en prise pour limiter les chocs • Si on attaque sur une surface brute de fonderie on a une usure rapide • Les efforts de coupe plaquent la pièce sur ses appuis

the cutting speed depends on the material of the part and the material of the tool. On a milling machine, this speed results from the rotation frequency N (rpm) at which the milling machine rotates.

$$V_c = \pi \, Df \, N/1000,$$

2.4 Comparison of the Differences between Milling and Turning

Although turning and milling are similar machining techniques, there are significant differences between these two techniques. The main differences are:

1. Movement of the workpiece: In turning, **the workpiece rotates about its axis** while the cutting tool is **stationary**. In milling**, the cutting tool rotates about its axis** while the working part is **moved**.
2. Shape of the parts produced: Turning is used to produce **cylindrical parts** while milling is used to produce **flat parts or complex shapes**.
3. Types of cutting tools: In turning, the cutting tool is often in the shape of a tip and is attached to a support that can be moved to adjust the cutting depth. In milling, the cutter is in the form of a disk or cylinder and is fixed to a rotation shaft.
4. Types of movements: In turning, the cutting tool moves **along the axis** of the workpiece while, in milling, the cutting tool can move in **different directions** to create complex shapes.
5. Levels of complexity: Milling is generally used to produce parts that are more complex than turning. Milling is capable of producing parts with complex three-dimensional shapes, while turning is limited to cylindrical two-dimensional shapes.

3. Drilling

3.1 Introduction

(on a drill, lathe or milling machine)

The term drilling (see FIG. 1) means "obtaining a hole (blind or opening) by machining." This hole can be made by a drill bit (on a drill, a lathe, a milling machine...), by a wick, etc.

Fig.1 Machine (drill)

3.2 Drilling Operation

During drilling, the part is fixed while the tool is driven by two simultaneous continuous movements, the cutting movement and the advance movement along the axis of the tool. Drilling is carried out on drilling machines called drilling machines.

3.3 Geometry of the helical forest

The forest essentially comprises two cutting edges approximately situated in the meridian plane. The angle of direction of the cutting edges, K_r, is as always the angle between an edge and the direction of advance, which is none other than the direction of the axis of the drill bit. Examination of FIG. 2 immediately shows that K_r is only half the peak angle of the drill bit. This angle is usually 118 °, which gives.

$$Kr = 59°$$

$$\sin K_r = 0.8572$$

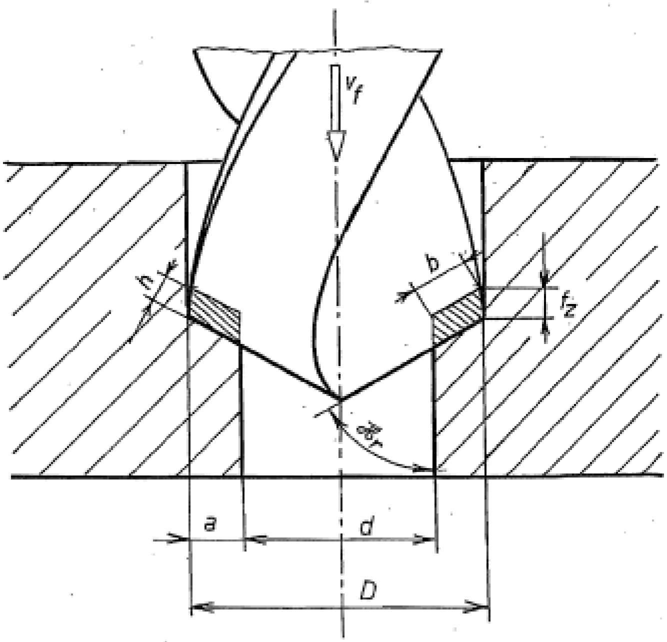


FIG. 2 Tool parameters

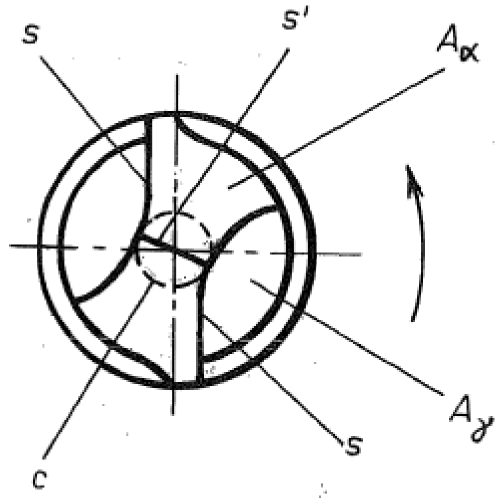


FIG. 3 Tool Tip

FIG. 3 shows the tip of the tool. In this figure, the notation s designates the main cutting edges, A_o. is the stripped surface of the tooth and A_r is the cutting surface. The two stripped surfaces intersect on a secondary edge s ′ perpendicular to the axis of the drill bit. The circle noted is the soul of the forest.

The drilling process can be compared to turning and milling, but with the difference that the requirements for the formation and removal of chips are stricter for drilling.

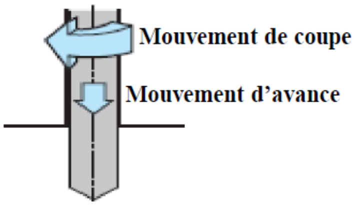


FIG. 4 Cutting and drilling advance movements.

3.4 Types of drills

The drill is the machine which has been designed to carry out a drilling, but the lathe, or even the milling machine, can carry out this machining operation. Drills can be classified according to several types:

Sensitive drills, column drills, radial drills and portable compressed air or electric machines.

(a) (b) (c)

FIG. 5 Drill types, (a) column drill, (b) drill sensitive, (c) radial

3.5 Cutting Conditions

In drilling, the two main movements are described by the tool (rotation plus translation).

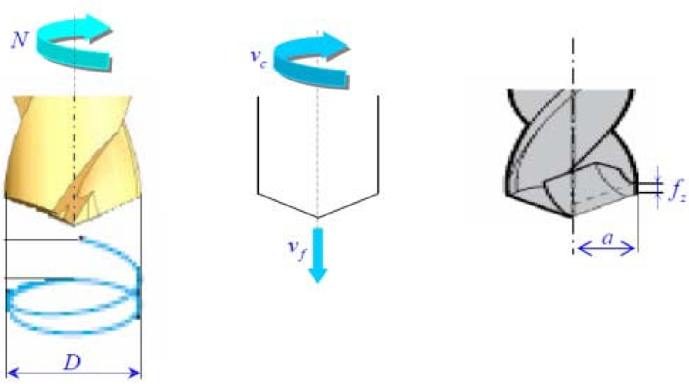


FIG. 6 Drilling conditions.

3.5.1 Cutting speed

The cutting speed v_c *(m/min)* is determined, in drilling, by the peripheral speed of the rotating element and can be calculated by the same formula already presented in turning and milling.

3.5.2 Advance or penetration speed

The advance or penetration speed f_v (*mm*/min) corresponds to the displacement of the tool with respect to the part, expressed in length per unit of time. It is also referred to as an advance.

The advance per revolution *f* (*mm/rpm*) expresses the movement made by the tool at each revolution.

The drilling tool being equipped with several cutting edges Z, the advance per tooth *fz* (*mm/tooth*):

$$f_z = z/f \ (mm/edge)$$

3.5.3 Determination of Cutting Time

The cutting time is calculated by the following formula:

$$t_c = \frac{\pi D\left(L + l + \frac{D}{2}\right)}{1000 * f * v_c}$$

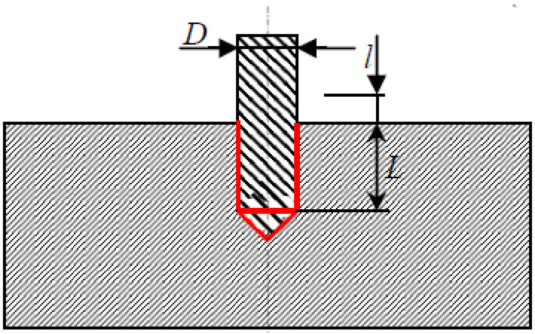


FIG. 7 Representation of the drilling operation.