5) – Basic of milling

Frontal milling

The frontal milling using the properties of the cutting edges of milling cutter having the rotation axis normal to the plane to be machined.
Indeed also with this method are always the peripheral cutting edges that remove the material in the form of chips because the frontal edges remove material only if the cutter have a feed in the axial direction, as in drilling.
Therefore the definition does not refer to active cutting edges, but to the part of milling cutter that offers the greatest area of contact with the workpiece.
The frontal edges of the cutter normally carry only an action of smoothing of the surface machined by peripheral cutting edges .

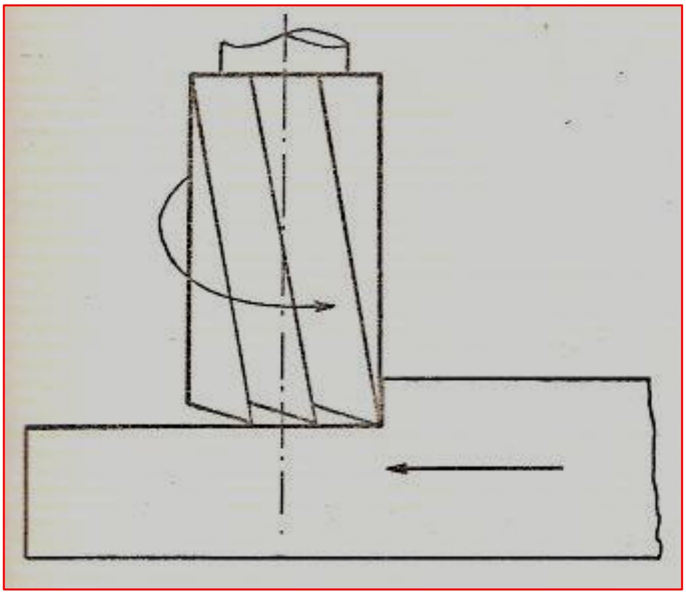

Fig.N°1- *Scheme of frontal milling*

This milling method offers better conditions for the formation of the chip. The chip, bigger than generated by the peripheral milling, can absorb a large amount of heat, in a better way therefore disperses the heat generated during the operation and allows a higher chip removal per time unit.
This advantage is also due to the fact that the frontal milling cutter is not mounted on a long spindle, but on a short shaft or directly on the spindle of the milling machine.
The vibrations that are generated in this type of milling are much lower than those present in peripheral milling.
In addition, an eccentricity of the milling cutter in peripheral milling directly affects the quality of the machined surface, while in frontal milling a possible eccentricity has only the effect of varying the thickness of the chip without any significant influence on surface quality.
The cutter must attack the material possibly in a position where the cutter axis does not coincide with the axis of the machined surface.
With reference to figure N°2 the recommended shift between the two axes is indicated by the quote C.
There are relationships considered optimal between the milling cutter diameter **D**, the width **L** of the piece and the amount **h** that the extreme point of the trajectory of the cutting edges, on the side of entry, shall extend beyond the limits of the worked surface.

Based on various materials machined and with reference to Figure N ° 2, you have the following relations.

- *For cast iron:* $D = \frac{3}{4} \cdot L$ $h = 0,05 \cdot D$
- *For steel:* $D = \frac{5}{3} \cdot L$ $h = 0,05 \cdot D$
- *For cast steel*: $D = \frac{4}{3} \cdot L$ $h = 0,05 \cdot D$
- *For aluminum alloys:* $D = \frac{4}{3} \cdot L$ $h = 0,05 \cdot D$

With this position, the frontal milling cutter is always working with a good grip on the material, because the chip thickness varies from the attack to the exit with ratio of about ½. That is, the chip thickness in the exit is about twice than the entry one.

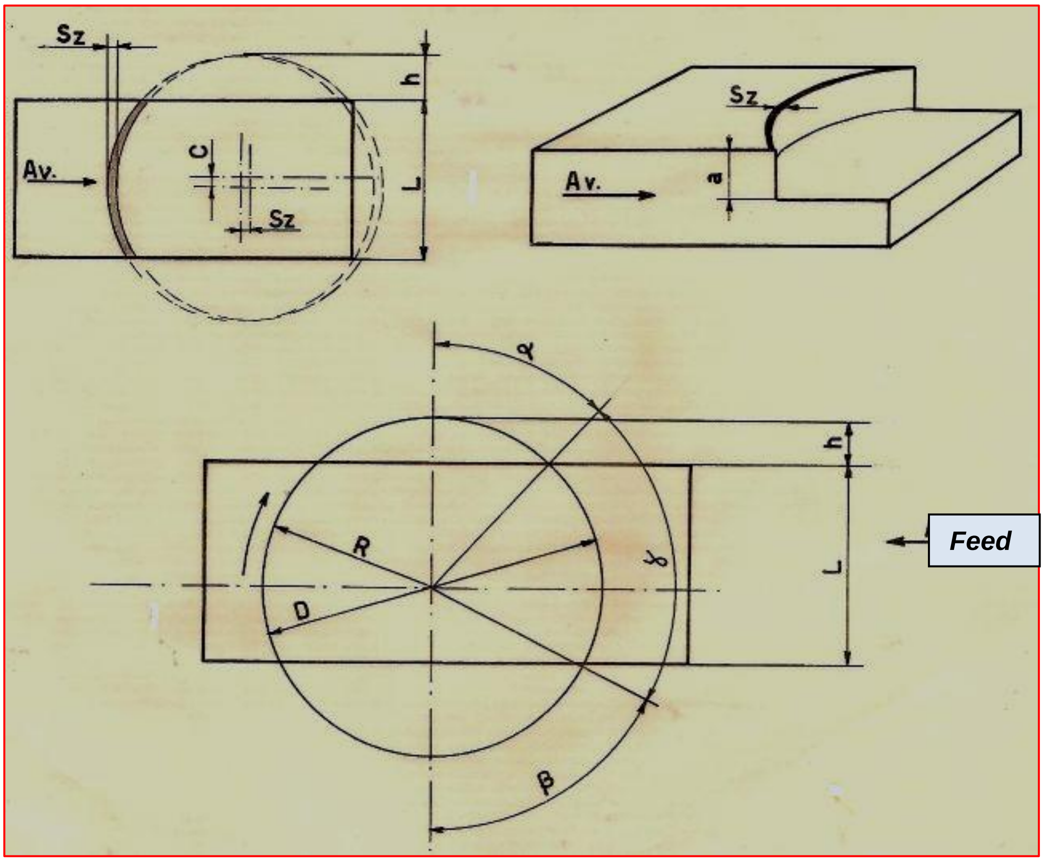

Fig.N°2- *Position of the milling cutter to the workpiece*

The average chip thickness is defined as the value of the feed per tooth. The length of the chip is the development of the arc engaged **γ** given by the following expression.

$$\gamma = 180° - (\alpha + \beta) \quad \text{dove}$$

$$\cos\alpha = \frac{R-h}{R} \qquad \cos\beta = \frac{L-(R-h)}{R}$$

In frontal milling, especially in the finishing operations, it is appropriate to give a slight angle to the axis of the milling cutter, as shown in figure N°3.
The value of this angle may be 1 '- 3' that indicated on the size "i" is equivalent to 0.3 - 0.8 mm per meter, from small to large diameters.

The effectiveness of the inclination of the axis occurs mainly in the reduction of traces of the trajectories that intersect the cutting edges.
However this will generate a slight depression but is generally negligible.
With this inclination is also possible to avoid an unnecessary wear of the cutting edges that slither on the machined surface on the opposite side of the feed direction.
The axis must be oriented in the opposite direction to the feed of the table.

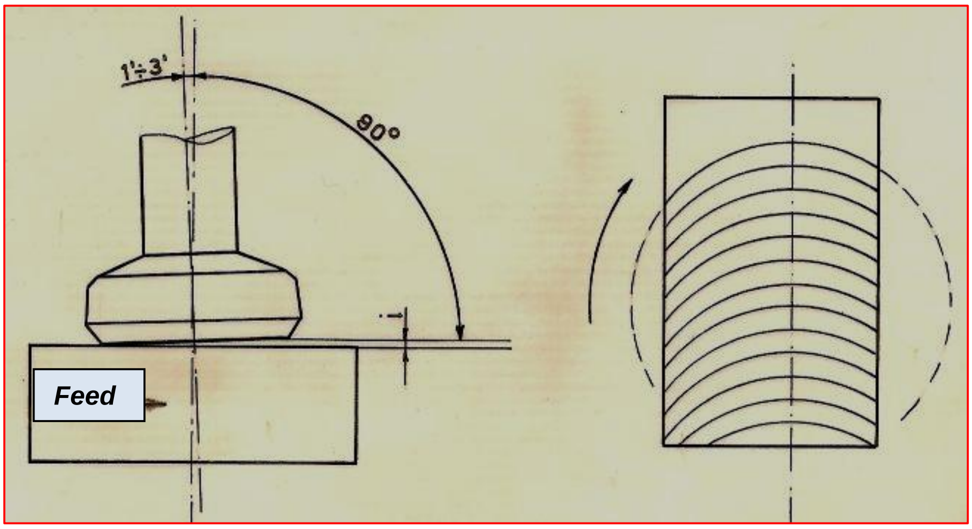

Fig. N°3- *Inclination of the axis and traces of the cutting edges*

As mentioned above, the inclination of the axis causes a slight depression which, indicated by **δ** the angle of the milling cutter, can be calculated using the following formula:

$$f = \frac{\tan\delta}{2} \cdot \left(D - \sqrt{D^2 - L^2}\right)$$

Assuming an inclination of 1 'and 3' with different diameters are obtained the values of concavity f shown in the following table.

Milling cutter diameter	*Values of* ***f*** *for inclinations of:*	
	1'	*3'*
250 mm	0,036 mm	0,108 mm
300 mm	0,017 mm	0,058 mm
400 mm	0,012 mm	0,038 mm

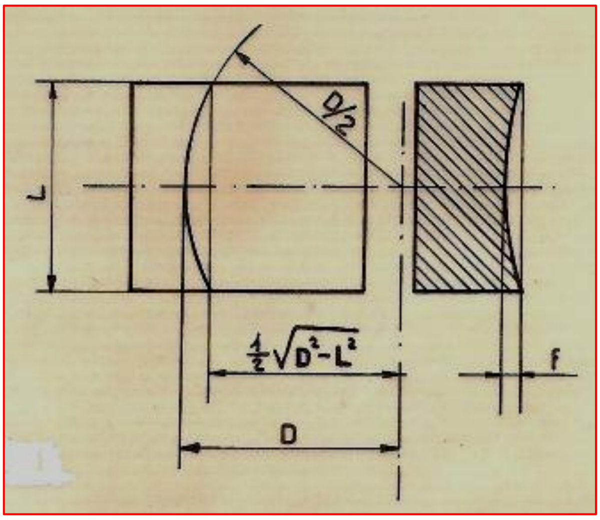

Fig. N°4- *Depression caused by the inclination of the axis of the milling cutter*