Cutting times and disposable hobs

An important part of overall hobbing cycle is taken up by the actual tooth cutting operation, that is the time that the hob is in contact with the workpiece.
When setting up a hobbing operation, we must firstly select the type of cycle to use from the various options available.
The hob must first moved to the final centre distance value (radial stroke) and then it must travel across the whole length of the tooth face width(axial stroke).
We must then decide whether the radial stroke is performed away from the workpiece or whether the hob should start cutting the teeth during this phase.
In the first case, the axial stroke would be longer but the radial stroke, which brings the hob into contact with the workpiece, would be made with a much quicker feed.
In the second case the radial penetrating stroke must be made with a notably inferior radial feed since the hob is under significant pressure during this phase.
This is not something which can be decide immediately since the length of the stroke depends on the hob diameter, on the cutting depth and therefore on the module, on the δ inclination of the hob compared to the workpiece and, to a smaller extend, on the hob pressure angle.
With reference to figure N°1 we see that the stroke L_a is greater than stroke L'_a and this increase depends on the hob diameter and on the cutting depth.

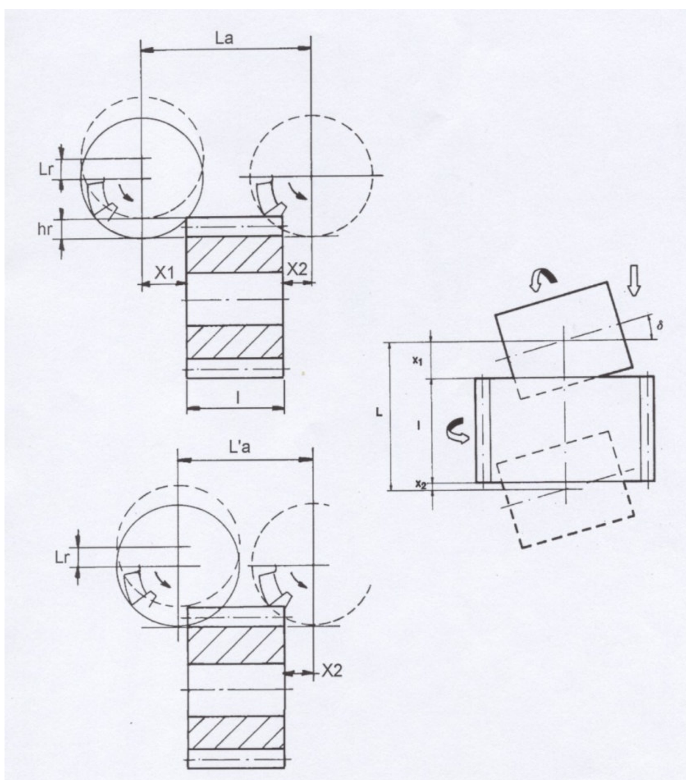

Fig.N°1

Since the radial feed during workpiece penetration should be about 1/3 of the axial feed and since, when hobbing gears that are used for small and medium-size transmission, hob diameters tend to be smaller than in the past, it is normally preferable to bring the hob towards the workpiece quickly and without contact and then to cut into the workpiece with just the axial feed.

With reference to figure N°1 it is possible to write:

$L_a = l + x_1 + x_2$ where x_1 and x_2 are calculated with the following formulae.

$$x_1 = tg\delta \cdot \sqrt{\left(h_r \frac{d_1}{sen^2\delta} + d_2 - h_r\right)} \quad \text{where} \quad \delta = \beta_2 \pm \gamma_1$$

$$x_2 = \frac{h_{k1}}{tg\alpha_2} \cdot sen\delta$$

δ = hob inclination angle
β_2 = helix angle of gear
γ_1 = helix angle of hob
d_1 = outside diameter of hob
d_2 = outside diameter of gear
h_r = cutting depth
h_{k1} = addendum of hob
α_2 = pressure angle of gear

At this point, considering that the feed per workpiece revolution is f_a , the feed per minute is: $A' = N_g \cdot f_a$ where the number of workpiece revolution per minute is:

$N_g = \frac{N \cdot Z_0}{Z_2}$ the following is therefore obtained $A' = \frac{N \cdot Z_0 \cdot f_a}{Z_2}$

The cutting time is therefore:

$$t = \frac{L_a}{A'} = \frac{L_a \cdot Z}{N \cdot Z_0 \cdot f_a}$$

If we remember that the cutting speed is given by:

$V_t = \frac{N \cdot d_1 \cdot \Pi}{1000}$ we obtain $N = \frac{V_t \cdot 1000}{d_1 \cdot \Pi}$ and therefore:

$$t = \frac{L_a \cdot Z \cdot d_1 \cdot \Pi}{1000 \cdot V_t \cdot Z_0 \cdot f_a}$$

This equation leads us making some interesting considerations.
It is, however, immediately apparent that it is possible to reduce hobbing times by carrying out three different actions:

- *By reducing the hob diameter d_1*
- *By increasing the feed per revolution f_a*
- *By increasing the cutting speed V_t*

The cutting speed is something which, as stated previously, depends of many factors but fundamentally it depends on the type of material from which the tool is made and on the type of material being worked.

We have also already seen that the current limits for super-alloy recoated steels are between 120 an 170 m/min.
Beyond this, wear formation becomes too rapid and unpredictable and so it becomes impossible to control the operation.
Having said this, therefore, it is necessary to act upon the remaining elements: the hob diameter and the feed per workpiece revolution.
It is immediately clear, however, that any adjustment that must be made to these two elements would be in contrast with one another.
In fact, if the hob diameter d_1 is decreased and all other conditions are unvaried, the number of gashes should also decrease.
Therefore, to keep the same chip thickness it would be necessary to reduce the feed.
If we decide, however, to decrease the feed per workpiece revolution, there would be more gashes and therefore the hob diameter would increase.
This is only true, however, if we want to obtain the same utilization of the hob.
If the manufacturer is willing to accept a reduction in the mechanical performance of the hob, that is if he is satisfied with an overall lower number of machined workpieces, it is a different matter.
Basically the idea would be to reduce the diameter and to increase the number of gashes as much as possible.
If this concept is taken to extremes, it would lead us to utilizing disposable hobs, that is hobs with a diameter of around 50 mm (or even less) and a number of gashes that are such that the hob can only be used once without resharpening.
The outside diameter of around 50 mm makes it necessary to eliminate the centering bore which means that the hob would be a solid shank type.
It would therefore not be possible to utilize it on all hobbing machines but only on those that cater for this type of tool attachment.
The number of gashes may basically be from 20 – 22 allowing for a tooth of 3,5 – 4 m which would be sufficient to cope with the cutting pressure.
One pint against this type of hob is that it is necessary to reduce its useful length.
For a diameter of 50 mm it is not possible to have a length of more than 200 mm.
Generally a ratio of ¼ between the diameter and the length is the maximum possible.
Traditional hobs with a diameter of 90 – 100 mm may, on the other hand, reach lengths of up to 250 mm.
The cost of disposable hobs is not much lower than those which have so far been used in gear manufacturing even though they do bring some benefits in terms of manufacturing cost.

- *Less steel used*
- *It is not necessary to machine the bore or keyway*
- *The travel of the relieving tool and the grinding wheel is much shorter and less time is spent on these operations*
- *More pieces per job are manufactured since the resharpening operation is eliminated.*

These elements, however, have a low impact on overall manufacturing time and also more time is required t manufacture the higher number of gashes and to sharpen the hob.
Amongst other advantages, we could also say that this type of hob is easier to handle since it weighs less than traditional tools.
This makes mounting and dismounting it on the machine easier, more accurate and quicker.
One final consideration: in the event of an accident due t machine break down or to a faulty workpiece, the economic damage that the breakage of a disposable hob entails is less than in the case of a traditional hob.

As we have already said, this type of hob has not had much fortune, however, also because if the hob diameter is reduced but the feed increases, the lead error greatly increases because of the feed marks.
Furthermore by carrying out just a few modification it is possible to slightly increase the tooth width so that a small number of resharpenings may be possible.
The fundamental idea is, in any case, that we should try to reduce the hob diameter and increase the number of gashes as much as possible.
This has in fact been the main change in term of hob design over the last few years.