Hobs for splined shafts

The hob is widely used to cut splined shafts since it offers notable advantages both in terms of manufacturing speeds and indexing and profile accuracy.
Various international associations have issued normative on splined shafts (UNI, DIN, BNA, ASA, etc.) but since these normative are very numerous, the normalization of hobs for splined shafts has not been put into practice.
Consequently the manufacturing characteristic of these hobs must be determined according to the requirements of the particular job at hand.
It is possible to hob teeth to a level of accuracy of up to 0,02 mm. Where a higher level of accuracy is required, it is necessary to grind the profile.
Splined shaft may be divided into two large categories:

- *straight-sided splined shafts*
- *involute profile splined shafts*.

There are various solutions for each type. Let us leave aside hobs for involute splined shafts since these have a profile which is similar to hobs for cylindrical gears apart from the differing size of the teeth.
Let us, however, examine the characteristic of straight-sided hobs splined shafts.

Straight-sided splined shafts
Type N°1. Standard straight-sided profile according to the UNI 222 and 223 tables and to DIN 562 and 5463. This type has a chamfer on the tooth tip in order to avoid interference. The root diameter is radiused to the flanks and this radius significantly reduces the mating area, that is the straight section of the flank; see figure N°1.
It is therefore necessary to increase the bore diameter or to increase the tooth tip chamfer of the male splined shaft to facilitate mating

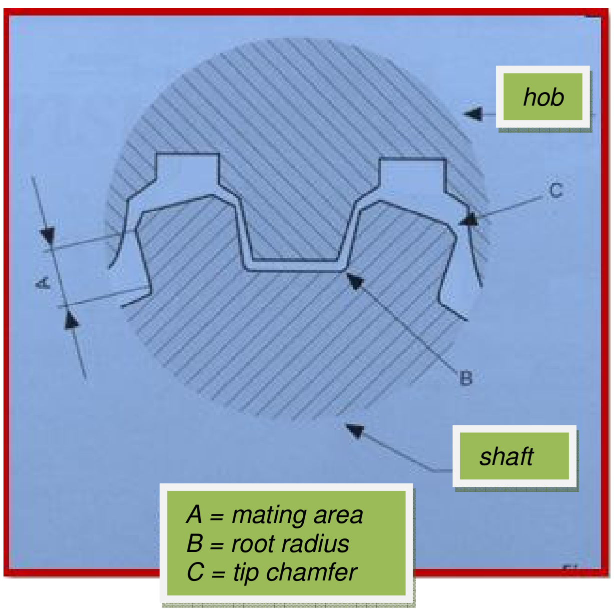

Fig. N°1

If we wish to limit the size of the radius it is necessary to use a hob which is in a fixed position or constant profile milling cutters.
There are, however, other ways of increasing the area of contact such as those offered by the following types.
Type N°2. This is the same as in the previous case but it has two undercuts that are made with a hob that has two protuberances on the tooth tip.
This profile increases the area of contact along the flanks and at the same time facilitates any grinding operations that may be performed on the root diameter.

The figure N°2 illustrates two possible solutions: the first has an undercut at the tooth base to permit root grinding. The second has both undercut at the bottom of the tooth as well as a notch which is cut into the flank in order to make flank grinding easier.

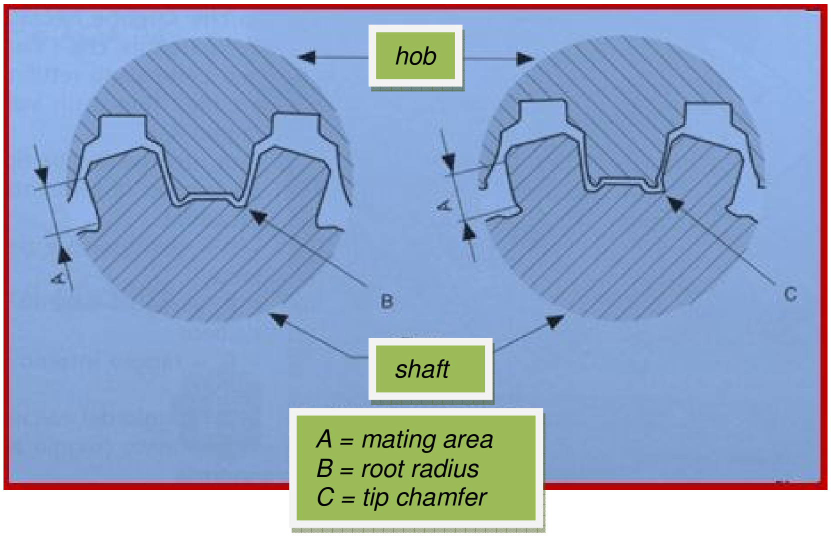

Fig. N°2

The stock which is normally left on the root diameter and on the flanks is 0,15 – 0,25 mm.
As far as the finish on the undercut surface in concerned, this will be slightly indented since it is generated by a series of sharp edges without enveloping. To improve this negative aspect it is necessary to use a hob with a larger diameter so as to have a larger number of teeth.
Type N°3. This tooth profile is made up of straight-sided flanks which are radiused between themselves by a large root radius. The length of the straight section is the same as with the previous type but the root diameter of the shaft is significantly lower.
See figure N°3.

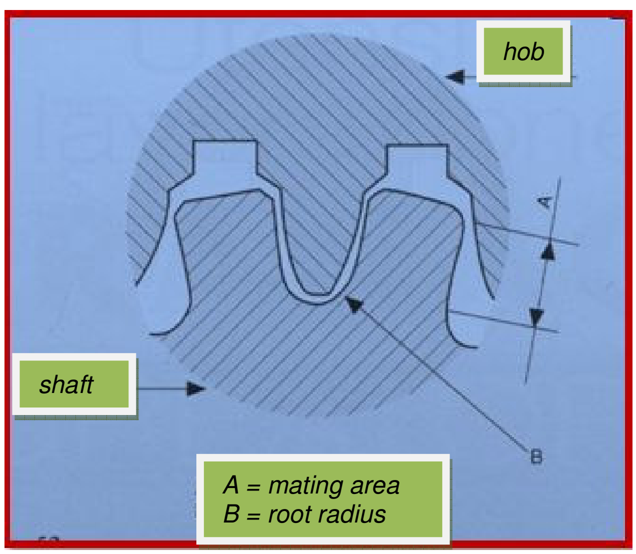

Fig. N°3

Mating only occurs on the flanks. This profile is generates by hobs which have extended teeth.

As can be concluded from the above, one of the fundamental elements of the profile is the length of the straight section of the spline and consequently the tooth root radius.
To determine beforehand whether it is possible to use normal cylindrical hobs or fixed-position hobs with extended teeth to cut splined shafts, it is necessary to check the following:
1)- check the value of the radius R_x at that base of the spline when normal cylindrical hobs are used;
2)- calculate the reduction in the root diameter of the shaft which would be necessary to ensure that the flank of the spline are straight and parallel up until a desired radius R_t.

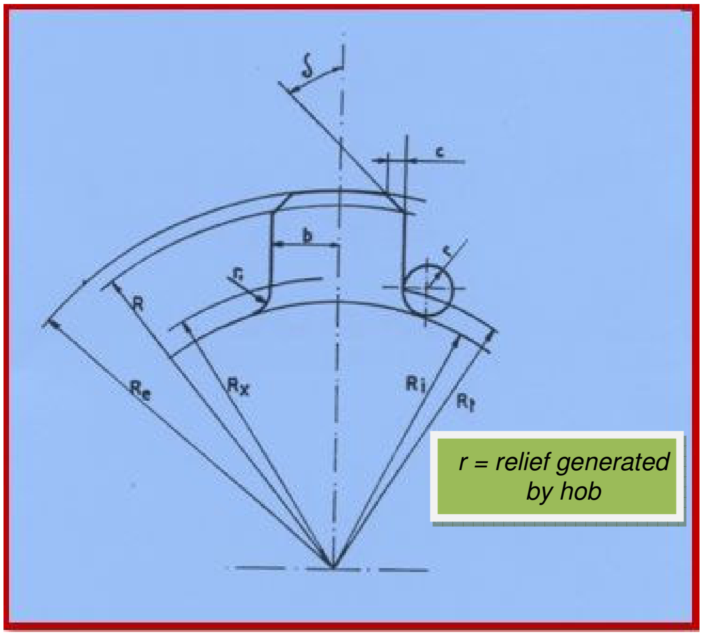

Fig. N°4

With reference to figure N°4 the following apply:

- b = *semi width of the spline*
- R_e = *outside radius of the shaft*
- R_i = *root radius of the shaft*
- R = *radius of the rolling circle (radius of the start of chamfer))*
- R_t = *theoretical radius at the start of the spline base*
- r = *theoretical root radius*
- R_x = *actual radius at the start of the spline base*
- θ = *angular parameter.*

Calculation of the rolling circle radius

$$R = \sqrt{b^2 + \left(\sqrt{R_e^2 - (b-c)^2} - c \cdot ctg\delta\right)^2}$$

For UNI spline shafts $\delta = 45°$ therefore $ctg\delta = 1$ and we obtain

$$R = \sqrt{R_e^2 - 2 \cdot c\left(\sqrt{R_e^2 - (b-c)^2} - b\right)}$$

Calculation of the radius R_t

$$R_t = \sqrt{R_i^2 + 2 \cdot r \cdot (R_i - b)}$$

Calculation of the radius R_x

First of all the value of the angular parameter θ with:

$$\operatorname{sen}\theta = \frac{b + \sqrt{b^2 + 4R(R - R_i)}}{2R}$$

once the value θ is known R_x is found with:

$$R_x = \sqrt{b^2 + R^2 \cdot \cos^2\theta}$$

Calculation of the minimum radius R_i

This is the minimum decreased root radius which must be applied to correctly generate the spline up until the theoretical radius R_t or in any case up to a predetermined radius.

$$R_i = R \cdot \cos^2\theta + b \cdot \operatorname{sen}\theta$$