## LARGE MODULE HOBS - A PRODUCT OF ITALIAN EXCELLENCE

A large module hob with a module higher than 12-15 mm is a complicated, expensive tool.
It must be reliable because when cutting large diameter wheels if you have high wear or worse, chipping the financial damage is quite considerable.

**Figure N°1**- *Hobbing of a big gear*

There are different tool-production methods but all require long cycle times both in soft and finishing operations, and precision is often hard to achieve if compared to standards of automotive hobs.
There are few companies in the world able to produce such tools at acceptable quality level amongst which we can mention FETTE (Germany) Saacke (Germany) Gleason (USA) Nachi (Japan) and some others in Korea.
In Italy only one manufacturer is able to cover this range: FUBRI (Viganò – Lecco). Even though FUBRI is not as big as its German and Japanese competitors its innovative production methods and software have put this small company to the top levels of this segment.
Let's go in depth of problems encountered when building a module 30 hob having diameter 300 and length 300mm.
First of all we can't help but mention the fact that moving a 170kg piece through production involves the use of special lifting devices.

**Figure N°2**- *Big module hob*

A tool of this kind once ground actually weighs about 100 kg this means that the chip removed is about 40% of its original weight: : quite a challenge for all tooling through all its production phases!

The traditional cycle mainly foresees:

- *Turning phase*
- *Threading*
- *Milling operation*
- *Relieve roughing*
- *Removal of incomplete teeth*
- *Heat treatment*
- *Bore and face grinding*
- *Sharpening*
- *Profile grinding*

A considerable amount of time is taken to move the pieces from one machine to another operation due to the weight.
Every single phase although done on CNC machines, requires the presence of personnel and the precision of the relieved piece and of the finished tool is strictly linked to the ability of the operator.
To produce such type of hobs machines used for “normal size” hobs are not adequate. This fact summed with the fact there is limited market for such hobs are elements that have demotivated many hob manufacturers into entering this market niche.
We are therefore speaking about a niche which is highly technological and important for the value of each single tool.
It is significant to consider that the raw material for the tool mentioned above is about 3000 Euro.
FUBRI has entered this market two years ago with a strong competitive edge which we will now describe.
The first element taken into consideration was the fact that to reduce delivery time and the cost of the finished tool it was fundamental to cut moving time of these tools on shop floor. This is why FUBRI has concentrated efforts on machining centers able to do several operations without having to redo set up.
On these machine centres the hob can be threaded, milled and relieved without the need of operator.
The advantage is clear: only one machine working around the clock without personnel aid can produce a tool ready for heat treatment overnight.
Obviously costs are limited compared to a traditional production cycle although one can’t help but mention the strong investment needed to start off: the machine center itself obviously, software and the tooling required.
The project evolved in time and several modification were needed on software in order to have a flexibile and reliable service. The project, machine program and all data related to production are now sent on machine directly from technical office and production can therefore be started very quickly.
The biggest advantage obviously is high flexibility of the cycle which has eliminated all downtime allowing FUBRI to reduce delivery time by 50%.
In fact when urgency is needed, these types of hobs can be delivered in 3 weeks thanks to Fubri’s fast track service.
An exceptional result for such dimension tools putting FUBRI on the edge of the global market.
The reduction of delivery does not sacrifice quality in any way. FUBRI technology allows very high precision also on roughed tool (profile, centering, thread helix) reducing stock to be removed on finishing operations, another elements which reduces delivery time.
The final precision is guaranteed by CNC profile grinders developed internally with top level technology such as Siemens Sinumerik CNC with digital technology, linear high speed motors , and high resolution direct drive motors.

**Figure N°3**- *Hob with roughing and finishing teeth*

The advantage in terms of delivery and precision are fundamental with complex hobs as heavy duty type, for both pregrind and finishing profiles (see picture 3). These tools have teeth with different profiles. The key element is that the wear is mainly on tooth-tip and for this reason , the first tooth has a complete profile whereas the second has precise profile on tip and cleared at base, the gash space is more limited and less deep because the second tooth produces little chip, but the total amount of material actually taken off will be spread on a higher number of gashes in order to increase working conditions.
These conditions allow less pressure on the tip of the tooth where normally wear is higher.
Picture 4 shows a typical example of this type of hob, a module 12 mm, not very big therefore, and we can see the rundown on second tooth, gash (B) and the reduced depth of the gash (about half as usual) between the first and second tooth.
This system strengthens the base of the first tooth allowing it to become more resistant to chipping,.
The height of the theoretical profile on the second tooth is about one third the total height of the tooth.

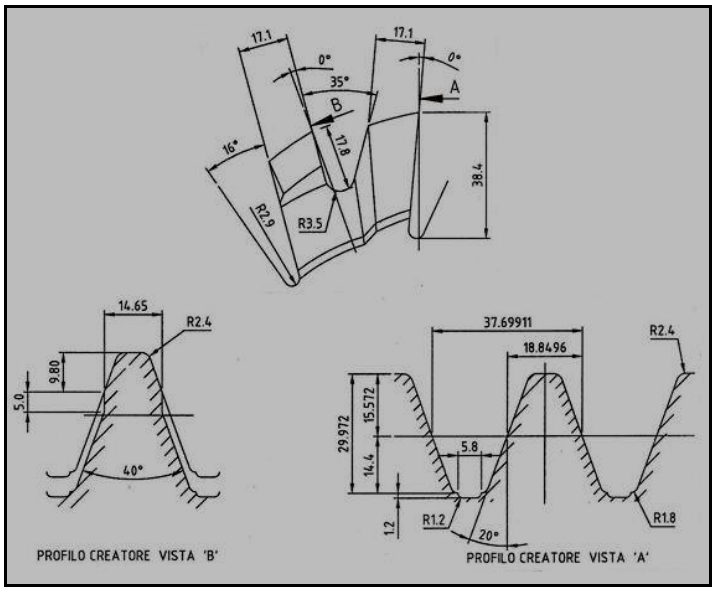


**Figure N°4-** *Different shape of teeth in a hob module 12 mm*

In a traditional production cycle this hob requires afrequent tool change and a precise machine set up, with a dedicated software. Machine centers allow an automatic process without the need for manual regulations.
The following table represents the “standard” Fubri large module dimensions.

| MOD | Ø | L | FORO |
|---|---|---|---|
| 16 | 220 | 250 | 60 |
| 18 | 220 | 260 | 60 |
| 20 | 240 | 260 | 60 |
| 22 | 260 | 280 | 60 |
| 24 | 280 | 300 | 60 |
| 26 | 280 | 300 | 60 |
| 28 | 300 | 350 | 60 |
| 30 | 300 | 350 | 60 |

In terms of delivery we must consider the use of special profile milling cutters for roughing.
If the profile is complex, in other words with protuberance, semitopping, or different teeth the milling cutter ordered by another manufacturer has quite a long delivery time which must be taken into consideration.

**Figure N°5**- *Example of special milling cutters*

However FUBRI also produces special profile cutters , such as pine-tree cutters and other complex profile cutters, (see picture 5). Therefore Fubri is independent also from the tooling point of view.
The complete range of hobs produced by FUBRI , besides large modules hobs, is completed by

- Solid hobs from mod 0.5 -mod. 33 mm
- Spline hobs (parallel or involute such ASA)
- Roller chain hobs
- Inserted carbide hobs
- Worm wheel hobs, shank type or bore type
- Pulley hobs
- HM hobs

The precision class obviously is regulated by international standards such Din 3968 (class A and class AA) and class AAA internal FUBRI norms (30% tighter than a standard clAA)
Picture 6 shows a sprocket hob.

**Figure N°6 –** *Hob for roller chain sprocket*

*Working conditions*

Apart from exceptional cases standard gear-pignon have a 20° pressure angle with tooth height equal to 2.25mm and therefore an addendum equal to module and a dedendum 1.25m

Cutting high module gears, therefore having large diamters and modules higher than mod 20 often requires three working phases..

The roughing is generally done with a biconical inserted carbide TIN coated milling cutter having a 20° angle on flank- with a mechanical blocking device.

The height of the tool is higher than the tooth height between the wheel, this type milling cutter can cut all components regardless module as long as pressure angle remains the same.

The inserts may be substituted and sometimes also resharpened, this is why sometimes this procedure is more used than hobbing.

Roughing with these cutters is not always beneficial. We are speaking about a dry operation, with high feeds and high temperature. We can't avoid to take in consideration possible distorsions during operation.

In case of breakage of the carbide inserts chip must be removed in order to avoid damage in following hobbing operation, and finding the chip is not always easy.

Roughing by hobbing has therefore it's advantages but one hob per each module is needed.

It is also true in case of hobbing one could have a single tool to rough and finish if the root of the tooth is reached and this makes life a bit simpler (bearing in mind chip width must be near 0.15mm)

Modules above 20 hobs have one start., the type of raw material used is generally M35, TIN coated to limit wear. The tool is subject to a high pressure and the volume of chip to be taken off is very high, speed is quite low 70/80 m/min.

Feed is also quite limited, about 2mm/turn; it is not advisable to push too hard to avoid chipping or deep damage of piece with strong financial impact.

A stock of 0.6/0.8 per flank is left for the finishing operation.

Frequent resharpenings are thus recommended, applying the same rule as "standard" tools; 4-5 meters per tooth are considered a good tool life.

The finishing operation is done with the same hob that has done semi-finishing operation and therefore also works base of tooth.

Only wheel having diameters above 3-4 mm are finished by grinding operation.

The feed is slightly higher than what used in semi-finishing operation and due to the reduced stock, the operation can be finished without sharpening of hob (for diameters below 5-6 m) The roughness of the surface is considered acceptable with Ra =3-3,2

*Example of cutting cycle*

Component data

| | |
|---|---|
| Module | 22mm |
| Helix angle | 0° |
| Number of teeth | 250 |
| Prim Diameter | 5500mm |
| Face width | 400mm |
| Steel 34CrMo4 | R=600 N/mm2 |

*Roughing and semifinishing*

With a solid hob 300mm 1 start in M35 TIN coated, z=17, without semitopping and without protuberance. Stock 2mm on each side between the two operations 0.6-0.8 per flank for following operation

- *Speed 70m/min*
- *Feed=1.6 mm/turn*
- *Number of turn: 74.3 turn/min*
- *Number of table turn: 0.297 turn/min*
- *Feed 0.476 mm/min*
- *Time needed for roughing and semifinishing 21 hours without taking into consideration set up of hob between resharpenings*

*Finishing*

- *Speed 80m/min*
- *Feed=2.3 mm/turn*
- *Number of turn: 84.9 turn/min*
- *Number of table turn: 0.34 turn/min*
- *Feed 0.78 mm/min*
- *Time needed for semifinishing is about 13 hours (only time tool/contact)*
- *Precision Class DIN 8-9 with profile Ra=3.0-3.2 micrometers*

*Inserted carbide tools*

For high production lots, where timing must be quicker than elsewhere, we can use tools allowing cutting conditions 3 to 4 times higher than normal HSS.
These are carbide insert milling cutters.
The carbide insert tools are very efficient but even quite expensive and are used with high modules, large diameters and significant widths.
In picture 7 one of the roughing phase can be seen where one side is divided into several sectors to reduce cutting effort and to allow smaller chip formation and easier chip evacuation.

**Figure N°7-** *Insert milling cutter for roughing operation*

The same cutters used for finishing have a tooth to one side and the following on the opposite end.
Picture 8 shows a an inserted carbide milling cutter with staggered teeth, 10 per side.
The distribution of inserts depends on the type of operation.

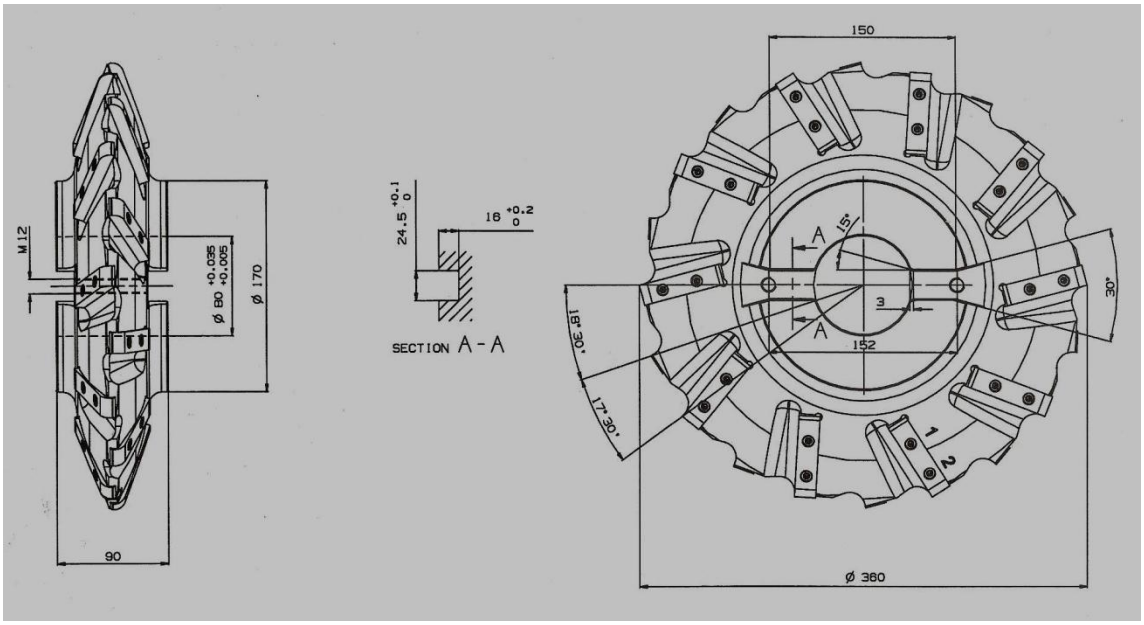


**Figure N°8**- *Insert milling cutter for finishing operation*

Even more expensive are inserted carbide hobs but their high price is justified thanks to the high productivity they allow if used on an appropriate grinding machine.
The advantages of these tools can be summarised by the fact the inserts are mechanically blocked and therefore require no resharpening nor recoating, the setup time is reduced, and the grinding time may be reduced drastically, upto 3 or 4 times standard. Lower number of tools in stock may be kept, and damage is of less impact as tool may be repaired. picture 9 shows this type of tool.

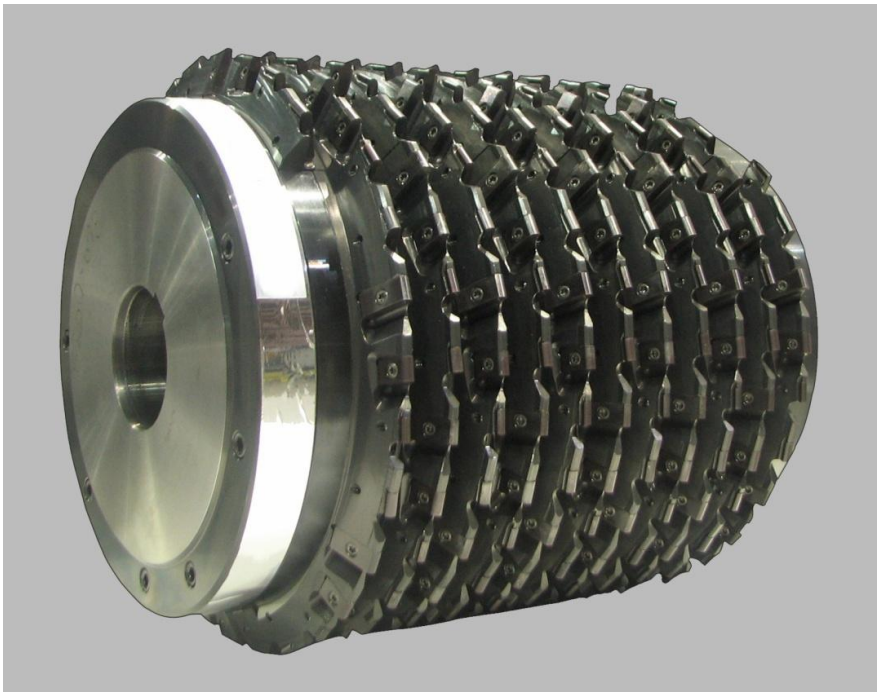

**Figure N°9** – *Example of insert hob*