Shaving cutter performances

Conditions influencing performances

Considering the very high number of parameters influencing some how the cutter life, it is practically impossible to establish a rule to define how many parts should a cutter shave in order to be considered a good one.
A partial list of what could determine the shaving cutter performances, is the following:

Gear

- Gear material (its resistance and workability, isothermal annealing treatment, etc.).
- Gear geometrical characteristics (module, pressure angle, number of teeth, helix angle, face width, etc).
- Gear status before shaving (cutting method, profile accuracy, protuberance, etc.).
- Gear accuracy after shaving and eventual profile and helix corrections.
- Stock removal.
- Single open gear or cluster gear with shank (and danger of flexion).

Shaving Cutter

- Type of steel used.
- Hardness and structure of the steel (heat treatment quality).
- Manufacturing accuracy and precision in resharpening.
- Serrations characteristics (dimension and finish , especially of side walls).
- Geometrical characteristics (bore , faces , …).
- Accurate design (even contacts, number of teeth, outside diameter, etc.)

Working condition

- Shaving method.
- Feed and cutting speed.
- Number of passes.
- Cross of axes angle.
- Type of lubrication.

Shaving machine condition

- State-of-the-art CNC machine.
- Machine in good conditions and of medium life.
- Old machine in bad condition.
- Type and status of the clamping fixtures for gear and cutter.

You can understand how awkward could be to draw out rules to previously establish which is the number of pieces that a shaving cutter can work.
We can only state some case studies, reminding that you cannot draw precise indications for new processes, rather only giving an approximate idea of what could be the average life of cutter.
In general, we can say that if you have a gear requiring higher accuracy and particular corrections, such as the 4^{th} and 5^{th} gears of automobile gearbox, the maximum number of pieces per resharpening cannot be very high; a good result can be considered 3000 pcs/per resh.
For 1^{st} and 2^{nd} gears , instead , the quantity can increase as up as 5000 / 6000 pcs/per resh. while for the reverse gear the quantity can go as up as 10000 pcs/per resh.
We are hereby referring to normal gears , with module around 2 mm .
If you shave final drive wheels (module ranging from 2.25 to 2.5 mm and a high number of teeth, then 1500/2000 pcs/per resh. could be possible.
For the shaving of larger module gears, e.g. 3.5 ÷ 4.2 mm and, with faces width around 30 mm, i.e. industrial vehicles, a normal shaving cutter performance is 400 ÷1000 pcs per resharpening.
In other words, if you definitely want to know how many parts can a shaving cutter make per resharpening, you have to try it. Also in this case you need to pay attention to the trials schedule and to how performances are going to be performed .

When do you have to replace the shaving cutter?

Let's suppose that a cutter assembled onto the machine and that gives good results, i.e. involute and helix are within the prescribed tolerances and that surface finish has an acceptable R_a.
After a certain number of gears the shaving cutter starts wearing out: the cutting edges starts getting rounder and their penetration on the gear tooth becomes more and more difficult.
If the cutter is working Parallel, the wear will be concentrated in the middle area of the tooth, while if you are using the other methods, the wear will be more distributed and the performances will be better, in general.
When the cutter becomes blunt, the chipping get removed with more effort and sometimes some cutting edge slides and do not remove material. In these cases the cutter will require more force to remove the chipping.
More cutter pressure force exerted onto the gear, means that balancing conditions are varying. This causes a gradual variation in profile and, to a lesser extent, helix.
In practice a slight deterioration of profile takes place and parameters values get close to the tolerance limit.
This phenomenon never happens all of a sudden, but sooner or later the profile gets out of tolerance and needs to be replaced (see figure N°1)

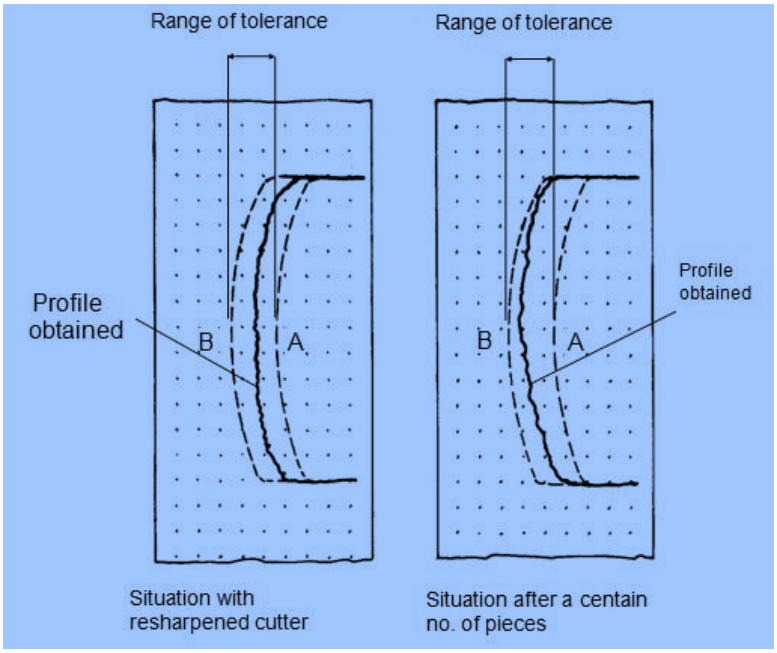

Fig.N°1- *Profile variation according to shaving cutter wear*

You can immediately observe that is the profile obtained by the just resharpened cutter had been closer to the A limit of tolerance, the cutter would have shaved more gears before taking the profile on the opposite side. On the contrary, if the cutter had been too close to B limit of tolerance the cutter would have become useless after a few shaved gears.
You can see, then, that in order to correctly test a shaving cutter you have to take into due account the profile produced at the beginning of the test.
This consideration is more and more valid when you have to compare the performances of two different cutters.
It is essential, for this purpose, that the starting profile, in both cases is perfectly identical and in the same position inside the tolerance range.
It is also obvious that stating that a cutter cuts, for instance, 3000 pcs per resharpening, without stating all the side data, does not tell much.
Things can be simpler, for instance, when the workpiece has a wide tolerance. In this case you reach the point that the worn cutting edges produce a bad surface, partially glossy, with imprints of

serrations which becomes more and more evident on the gear surface, all this happening before the gear goes out of the prescribed tolerance.
In this case is easier to obtain a good repeatability of results and a comparative trials between the two cutters is more reliable.

How many resharpenings can a shaving cutter undergo ?

The possible number of resharpenings depends, of course, on the size of the removed wear at each resharpening an on the depth of the serrations.
Serrations depth at the end of life can arrive up to 0.3 mm as maximum exploitation in the smaller module cutters, while it can go as up as 0.35÷0.40 mm for the bigger modules.
The removable material per flank is of 0.50÷0.60 mm, then.
As previously stated, wear very much depends on the type of gear you are shaving: if a gear is very accurate, then the cutter needs to be removed from the machine fairly often, and wear results low, while is tolerance range is wider you can shave more gears and generate a bigger wear.
In any case the removal rates you normally carry out in resharpening are included within 0.02 and 0.05 mm per flank, which means that the possible number of resharpenings ranges from 10 to 15, very rarely more.

Fig.N° 59- *Serration conditions at beginning and end of life*