SOME PRACTICAL RESULTS REGARDING CYLINDRICAL GEAR FINISHING BY SKIVING METHOD

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Abstract:

In the paper it is presented the technology of finishing using cylindrical gears with worm hob having negative rake angle. This processing method is possible nowadays due to the development of hard-alloy tools which allow cutting steel with hardness of 62 HRC.

INTRODUCTION

The completion of gears is carried out with various methods, such as traditional grinding, honing, shaving and skiving. Each of these methods has advantages and limitations, so that the application of the proper one is strongly case dependent. Gear skiving has gained in the recent years considerable reputation among gear producers and is nowadays a powerful alternative to traditional grinding.

In this work it is presented the skiving technology of cylindrical gears (pinion) with tooth hardness of approximately 62HRC. The tooth is processed using milling worm hob with two operations using two different tools, the first processing is roughing with worm hob having positive rake angle and correction of tooth which is processed after the heat treatment with worm hob having negative rake angle. This processing is possible because the development of tools made of hard alloys that allow processing of this hardness.

This hob finishing method has the advantage that the number of manufactured parts per unit time is bigger than in other types of finishing. Due to the resistance of hard alloy tools the hardness of work pieces is limited to 62 ±2 HRC.

CURRENT TECHNOLOGICAL ASPECTS OF TOOTH FINISHING USING SPECIAL WORM HOBS

Finishing gears with worm hob has increased greatly in recent years among producers of gears and it is considered an alternative to traditional grinding. Reasons for development are automatic machines and advanced development of methods to be practical and economical. [Ant 01]

Determining systematic opportunities to improve the shape of tools for increasing efficiency of the process is significantly more difficult than processing gears with worm hobs or with other types of methodologies.

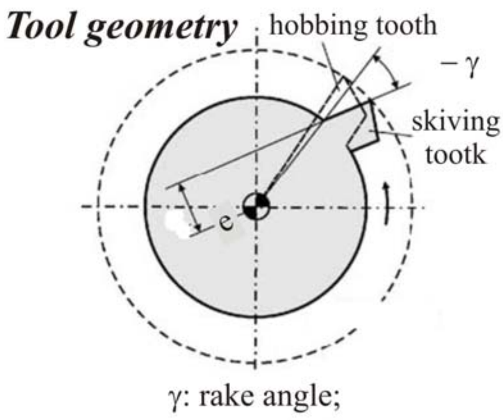
Some recommendations on gearing with worm hob:

- due to advantages in the industry it is prefered a meaning helical surface of tool in the same sense as the manufactured gear that we want to process. [NN 02]
- in practice it is used for hobbing the Pfauter principle [NN 03] with axial feed, first adjusting the radial depths of the cutting value, in which case a strategy with a single passage represents the depth of the tooth.

- for reasons of attrition, especially in dry-milling, hobbing is executed in the sense of feed.

TOOL CONSTRUCTION

The figure 1, a illustrates a typical gear skiving cutter. The geometry of such cutting tools is very similar to hob cutters. The special geometry of the skiving tool cutting tooth is presented in the figure 1,b. The main differences between skiving and gear hobbing cutting teeth are the negative rake angle γ and the tooth rake offset e. The negative rake angle protects the carbide cutter from shocks and instantaneous over loadings. In case of hob teeth the rake angle equals to zero, whereas the rake plane includes the hob axis.



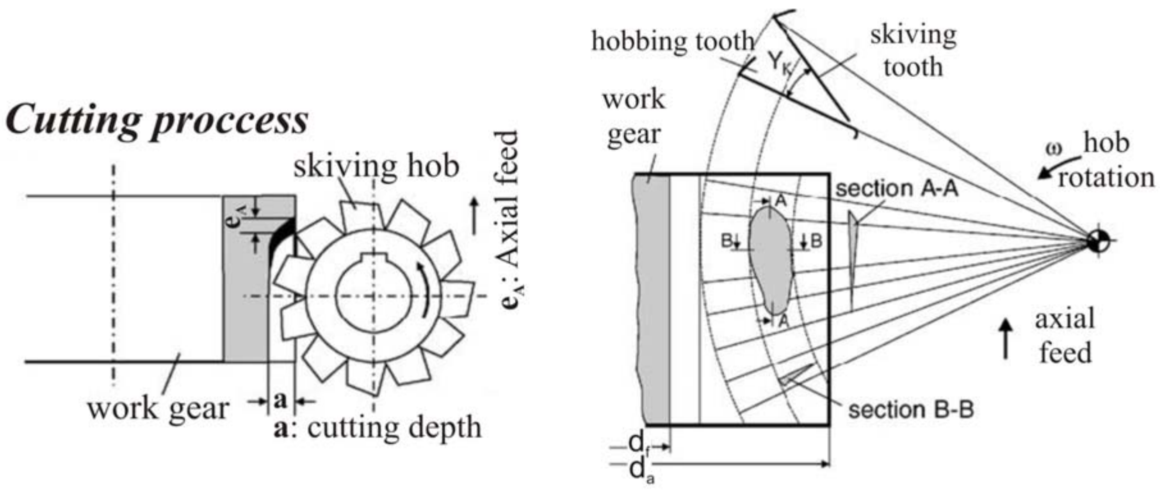
a) b)

Fig. 1 *Skiving hob and tool geometry*

From figure 2 it is clear that skiving with worm hob having negative rake angle produced chip only on the flanks and therefore are used for the roughing hobbing used tool with protuberance.

The same occurs considering the tool work piece system, as it is presented in the figure 2,a. The skiving tool is rotating against the also rotating precut gear, whereas it is simultaneously displacing along the direction of the axial feed.

As in gear hobbing, owing to its complicated kinematics, the skiving process brings on modeling problems, since each gear gap is produced through successive penetrations of the tool teeth into the work piece, in the individual generating positions. Considering also the tool rotation during each hob tooth penetration, a number of revolving positions are used to describe the chip cross-sections in the corresponding generating positions. The figure 2,b illustrates a confrontation between the cutting tooth kinematics of gear hobbing (rake angle = 0°) and skiving tools (rake angle = −20°), respectively. The dashed area in this figure corresponds to the active part of the skiving profile. As expected, the active parts of the skiving tooth profile are onto its flanks.



a) b)

Fig. 2 *Cutting process and the skiving surface of a tooth*

To establish a form of constructive geometry section of the worm hob tooth it have been developed several methods and software for the calculation. In Fig. 3 an example of constructive form of the two profiles for the roughing processing (in the form of protuberance) and the finishing is being presented. Moreover, the initial and the final profiles of the tool gap are compared in a single diagram, whereas a magnification of the material to be removed by the skiving process is also inserted.

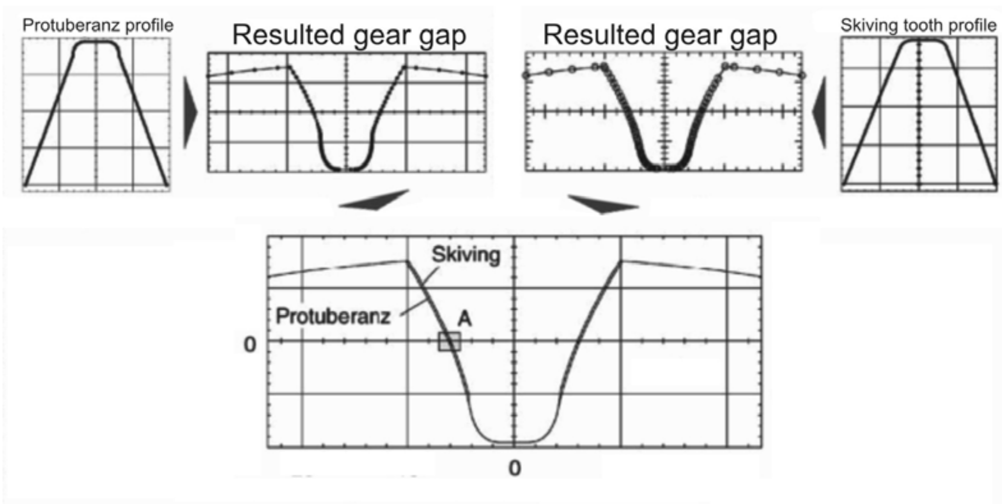


Fig. 3 *Type of determination of the protuberanz and skiving hob profiles*

DETERMINATION OF CHIP FORMATION IN GEAR SKIVING

The aforementioned method is presented in figure 4 for one specific manufacturing case. This cutting event was found to require 31 successive positions (−15 to 15 including 0), in order to be competed. The diagram of the bottom left part of this figure illustrates the maximum produced chip thickness by the leading and the trailing flanks, respectively. The upper left part of the same figure presents the chip cross-sections of generating position zero, over the development of the skiving profile. The tool penetration is produced using 15 reference planes, according to the previously described algorithm. On the other hand, the diagrams inserted in the right part of figure 4 illustrate the corresponding 15 reference planes after the end of the cutting process. Diagram 15 exhibits the final formation of the gear gap.

With the aid of this algorithm the chip geometry is precisely determined and the developed program is able to determine the cutting force components. [Ant 01]

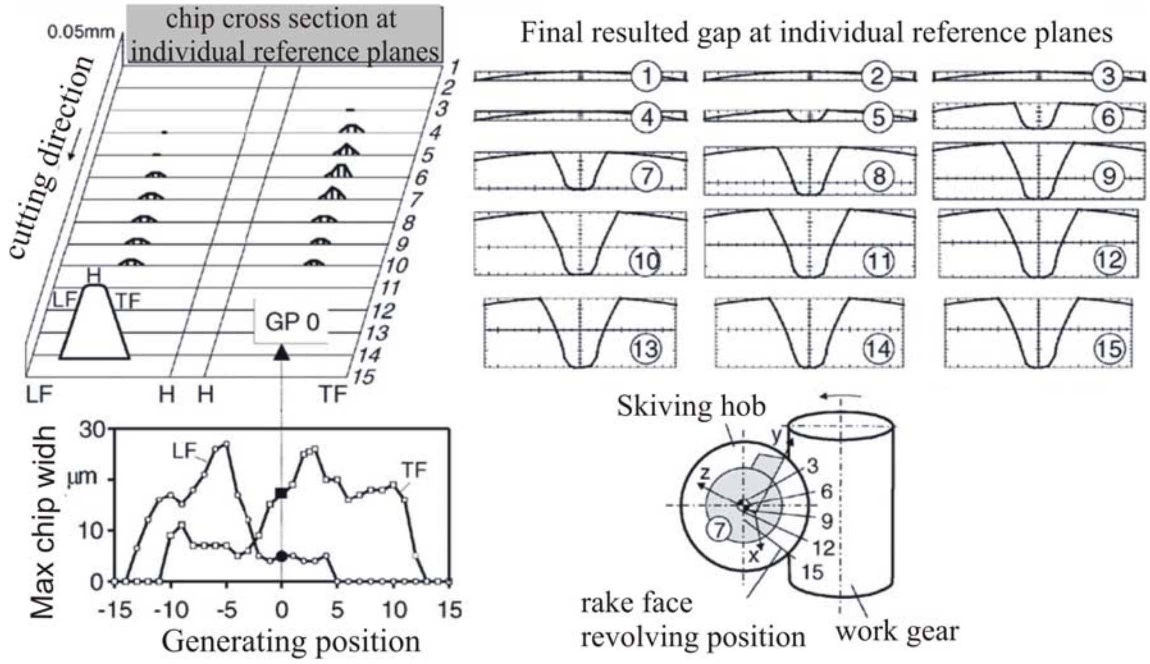


***Fig. 4** Chip cross-sections in gear skiving*

PRINCIPAL DATA OF FINISHING GEAR

Further on, a case study is described for a gear (Fig. 5) wheel having the following characteristics:

- processing gear material is 16CrMo4,
- number of teeth z = 11,
- module m = 1,75,
- denture length d = 36,5 mm,
- normal mate angle α = 20°,
- bevel angle of the teeth on the basis circle β_0=24°15’14” (RH);

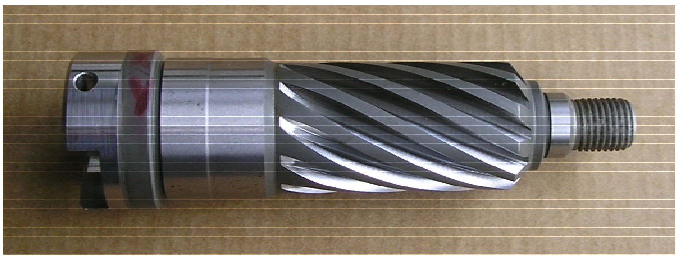


***Fig. 5** Finished gear*

The roughing is made with protuberance following a profile like the one in figure 6. The second denture correction operation is made using worm-cutters having a negative departure angle. **The material addition** on the one the profile of the resulting flanks is of **0,12 mm**, which is removed on a single pass. The high hardness is obtained by carburetion heat treatment, hardening (around 62 HRC). During the denture correction process the foot of the tooth is not processed.

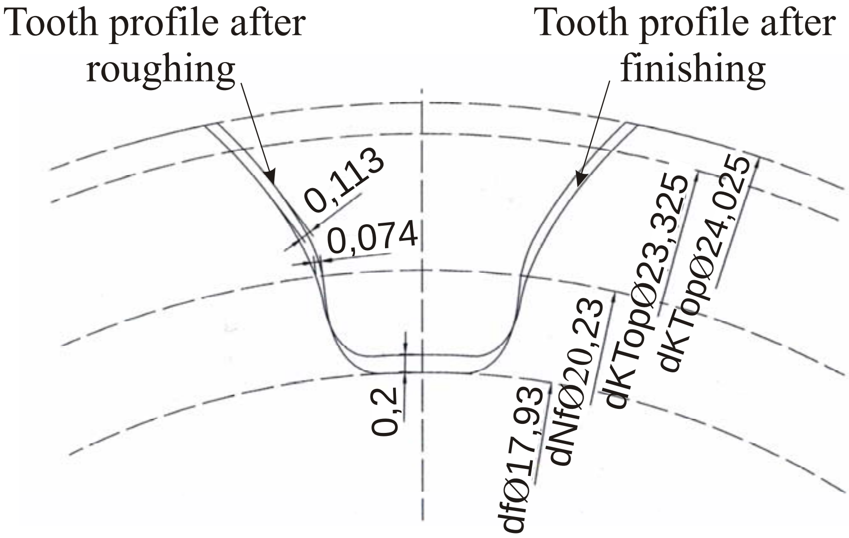


Fig. 6 *Material addition*

CUTTING PARAMETERS AND SOME TECHNICAL DATA

The axial feed and **the chipping speed** were determined on the recommendations of the tool producer and the experience of the specialists from STAR TRANSMISSION CUGIR Company. It has been used an **axial feed** value of **1,10 mm/rpm** and a **chipping speed** of **145 m/min**.

In order to ensure an even exploitation of the cutter the **shifting** method has been used and around 4800 pieces have been produced using the same tool. With these data a **basis time** of t_b=0,44 min and the **depth of the roughness on the tooth** direction of R_{max}=3,1 μm have been obtained.

CONCLUSIONS

Gear skiving is nowadays an attractive alternative in gear finishing process. After processing the data and measurements obtained gear teeth precision included in accuracy IT6. Productivity in comparison with grinding with abrasive wheel is 10 to 20 times bigger. Further work in this field aims to step forward the optimization of the skiving process, implemented also the wear progress prediction of expensive tools, which are required in this gear finishing method.

References

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