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SPIRAL BEVEL GEARS HARD CUTTING

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Abstract

The paper describes methods of hard cutting spiral bevel and hypoid gears. From the Gleason system TAN-TRU method and conventional generating methods using cutters with hard cutting edges of blades are described. In the Klingelnberg method two methods HPG (High Power Gears) and HPG-S (High Power Gears Special) are showed. All these methods (Gleason and Klingelnberg) are very useful in finish cutting of hard gears on the same machine-tool. To achieve good quality of the form and surface of teeth only one machine-tool with high rigidity is needed.

Keywords

Hard cutting, spiral bevel gears, hypoid gears.

l. Introduction

Spiral bevel gears hard cutting is used as second method of finishing tooth (first is grinding) after heat treatment.
This method eliminates heat treatment deformation and gives very good tooth surface quality. For using hard cutting the following conditions must be satisfied:
• Very hard and protective for broken and worn cutters materials.
• Using machine tools of a very high stiffness coefficients.
• Using very stiff supports of cutter and work holding equipment.
• Equipped machine tools in instruments for easy introducing a hard tool between teeth to achieve good stock dividing for finishing. At present there exist two centers which make hard cutting of bevel gears.

They are Gleason Works- and Hurth G.R. (before WMW MODULL), which is integrated with Gleason Corporation and firm KLINGELNBERG G.R. Now any information about hard cutting in Russian Center of bevel gears manufacturing is available in Saratov. Each firm: Gleason and Klingelnberg has separate conception of hard cutting of spiral bevel gears.

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2. Gleason methods of hard cutting spiral bevel gears

Gleason system elaborated two variants of methods for spiral bevel gear hard cutting. Variant I is used for big spiral bevel and hypoid gear pairs. As the tool a four blades cutter with very hard cutting edge is used. The cutters named TAN-TRU are manufacturing in 6 diameters 16", 18", 21", 630 mm, 800 mm and 1000 mm. Formate blades are thinned to cutter body with screws. Scheme of the cutter TAN-TRU is shown in Fig. l.

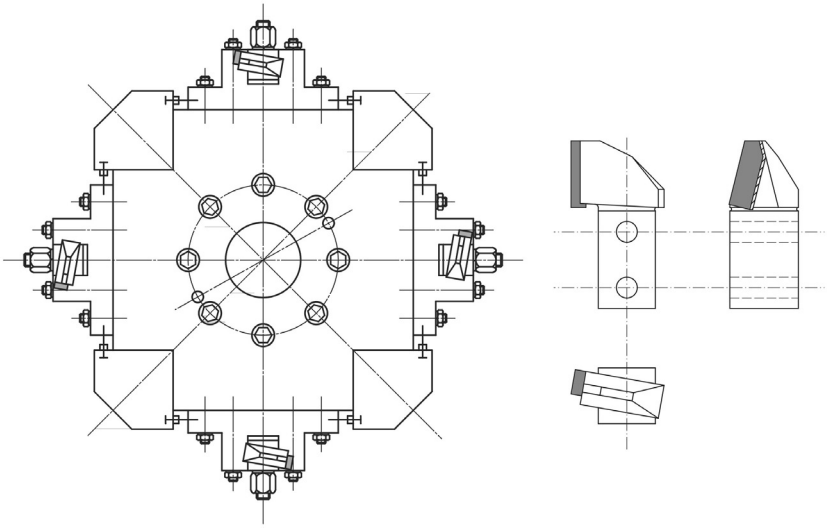

Fig. l. Cutter and blade for TAN-TRU method

Cutting spiral bevel and hypoid gears using this method is possible on machine tools 650, 655, and 675. This machine can cut gear from diameter 34" on model 650 to diameter 90" on model 675. Cutting process is realized in following manner:
The blades cut only when cradle is stopped and hydraulically braked. In the time when the blades do not contact with the cutting gear the cradle is unbraked and is driven in rolling motion. This solution gives higher rigidity of system machine tool, cutter, and work-piece.
Variant II is used for hard cutting of gears of30" diameter. In this case the cutting process follows on machine tools with high rigidity equipped with cradle, mechanically-controlled 645 and computer-controlled GMAX2020, or without cradle full CNC with table in two axes controlled PHOENDC 250HC and 450HC.

Tooth cutting process on these machine tools is continued by using normal cutter with blades, which have cutting edges, made of covered carbide. The carbide is coated by borazon.
Ali the four machine tools 645, GMAX2020, PHOENIX 250HC and 450HC have drive system without clearance. Comparison of rigidity is shown in Fig. 2.
Large forces in hard cutting are possibly only in the generated methods.

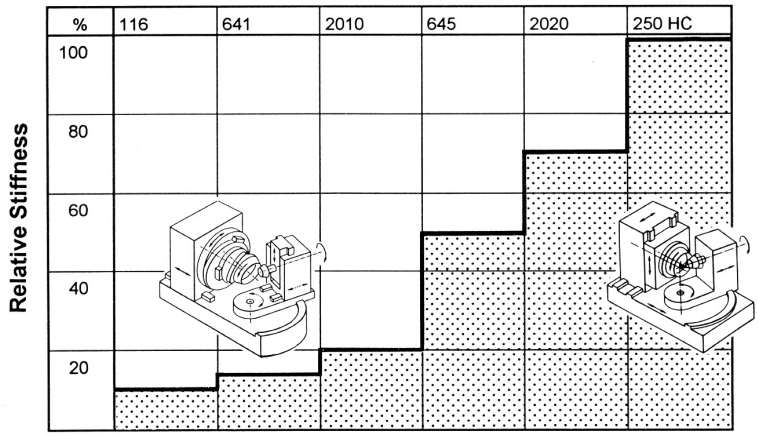

Fig. 2. Relative stiffness of Gleason machine - tools

3. Hard cutting of spiral bevel gears in Klingelnberg system

General hard cutting in this system can be realized only by using cutter head by cyklopalloid methods.

There exists two kinds of the method: HPG (HIGH POWER GEARS) and HPG-S. The method HPG is used for module m_n >8 mm and is realized on machine-tools AMK635, AMK852, AMK1601 and AMK1603. Ali the machines, excluding the last AMK1603, can cut at the same time two sides of tooth by two parts synchronically driven cutter head. They can cut spiral bevel and hypoid gears. Machine-tool AMK1603 is designed only for spiral bevel gears with range of diameter 2000-2500 mm and because for this range heavy work spindle do not permit to move in vertical direction, therefore make higher rigidity. Machine tool AMK1603 works with 3-group one part cutter. Ali machine-tools produced by Klingelnberg are equipped in the cradles, which are driven by two worm gears. Each worm has other spiral direction. Backlash is reduced by hydraulic system. The Klingelnberg machine tools with numeric control KNC24, KNC40 and KNC60 have the same cradle with mechanically-controlled system. Work spindles in all Klingelnberg machines are driven by two worm gears. Kinematic scheme of machine-tool AMK635 is illustrated in Fig. 3.

Oldham's clutches realize synchronous drive system of two parts of the cutter in Klingelnberg machines. Generally, for cutting module m > 8 mm cutter heads 4 and 3 groups with prismatic blades are used. Mounting of the blades to the cutter body is done by screws. It is shown in Fig. 4.

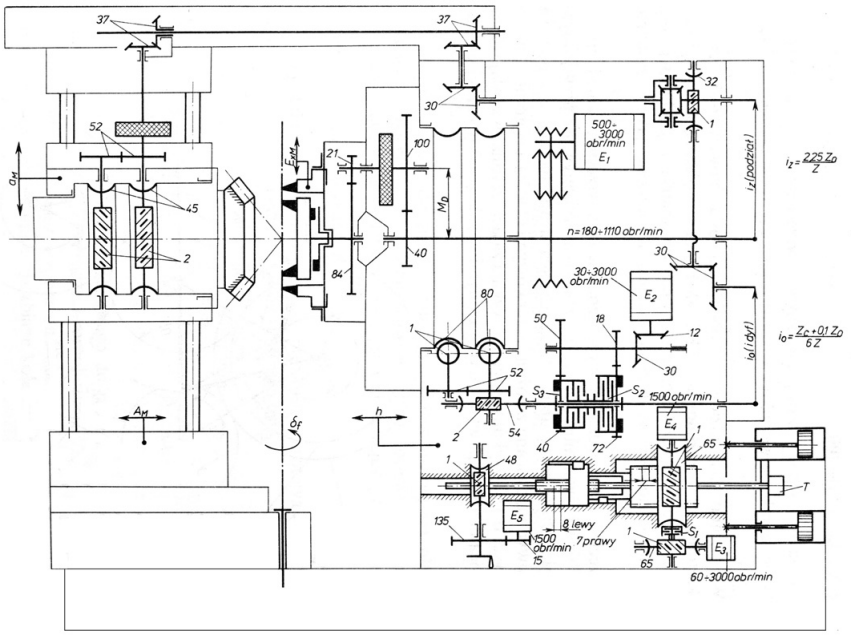

Fig. 3. Kinematic scheme of AMK-635 Klingelnberg machine - tool

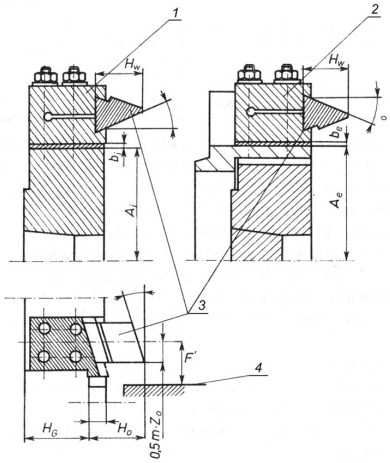

Fig. 4. Klingelnberg two – part cutter

In method HPG as the cutting part of the blade a small granulate of wolfram carbide plate is used, clamped by three mechanical holders to the blade body.
Scheme of cutting element for methods HPG is shown in Fig. 5.

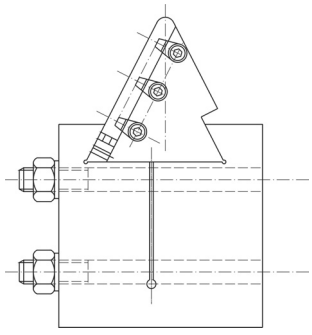

Fig. 5. Prismatic blade for Klingelnberg HPG method

Chips thickness for method HPG depend on module and is kept in range of 0.04-0.08 mm on one cutting operation. During cutting time a cooling medium is not supplied. Cutting is done in dry way: cutting speed is used in range 50-60 m/min.

HPG-S method is used for module 2.4-8 mm. For cutting two kinds of tool are prepared. Spiral bevel gears in range of module 3-8 mm are cut with prismatic blades in which the cutting edge is made of borazon. Wolfram carbide platte is one-sided and this side is fastened to the body of the blade (Fig. 6).

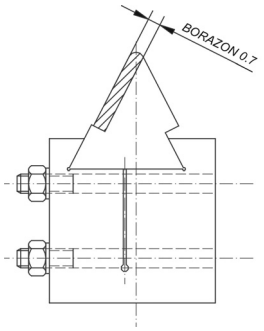

Fig. 6. Prismatic blade for Klingelnberg HPG-S method

The second side is coated with borazon. This coat of borazon creates the cutting edge. Hard cutting of small module spiral bevel gears in range of module 2.4-3 mm is done by using cutters with ring blades (Fig. 7). The ring blades which have diameter l" are created from coat of borazon. By methods HPG-S as cooling medium is used paraffin oil. Chip thickness in HPG-S method is 0.03-0.05 mm. Cutting speed is optimal in range 100-120 m/min. After one sharpening is possible to cut 20-30 gears.
Hard cutting of spiral gears is possible to be used only in the generated method.

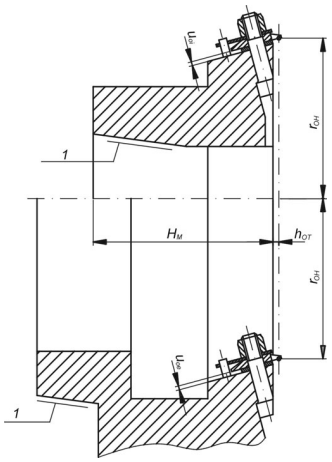

Fig. 7. Klingelnberg two – part cutter with ring blades; 1 – base surface

4. Conclusion

Hard cutting is now one optimal solution for manufacturing precisely spiral bevel gears for high power transmissions. This method needs only one machine tool for soft

and hard cutting. This possibility minimizes costs of machine tools.

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