POSSIBILITIES OF PULL BROACHING OF GEARS

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Abstract: In the following paper the possibilities of gears' machining by means of pull broaching as well as profitability, the seriality, efficiency and exactitude of production were analyzed. The advantages of pull broaching in comparison with traditional methods of processing were shown.
Keywords: pull broaching, gears.

1. INTRODUCTION

Pull broaching is one of machining techniques. Separation of material is achieved by use of tool equipped with many blades placed one after another. These are uniform tools, or in case of pull broaches for gears, tools consisting of bearing pads. Three types of tool blades can be distinguished: roughing, finishing and spare or calibrating ones. It is then possible to perform roughing as well as finishing with the help of one pull broach. The most often applied depth of machine cutting is from 0,01 mm to 0,15 mm for roughing, and from 0,003 mm to 0,0225 mm for finishing. The depths for casting materials are as follows: for roughing - 0,02 mm to 0,2 mm, for finishing - 0,01 mm to 0,04 mm. These values are applied in course of machining of very thin sides in order to avoid deformations caused by extensive strengths of machine cutting. The blades of pull broaches are not subjected to very intensive blunting in comparison with other machine-cutting tools. Depending on type of machined material it is then possible to process from 500 to 2000 pieces, and in special cases even 70000 pieces by means of one tool only. The tool can be regenerated approximately 10 to 20 times. These are used both for machining of external as well as internal surfaces. The only limit is the quantity of elements produced. These cannot be small series regarding price of tool as well as shapes, which can be obtained by linear movement. This method of machining allows very exact fabrication of elements at quite low production costs.

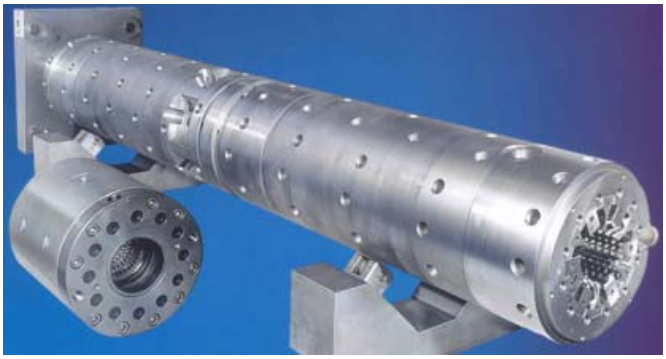

Fig. 1. Folding pull broach for roughing along with a smaller finishing one

2. PROCESS CHARACTERISTICS

Gears are machined by means of internal pull broaches (Fig.1) produced uniformly or consisting of bearing pads. Push broaching of external toothing can be performed as follows:

- with motionless gear seated on vertical work arbor and moving "downwards" the push broaching toolset,
- with motionless push broach and sliding wheel with work arbor "upwards".

Push broaching of external toothing is the shortest way of teeth shaping and can be the most effective one. With diameters of approximately 100 mm, working transverse module mt = 1,2 mm and width of toothed ring at approximately 18 mm the helical gears are produced in 18 seconds.

Pull broaching of internal toothing can be executed for gears of reference diameter that does not exceed 152,4 mm and modules of mn = 1,27 to 4,25 mm. The hardness of pulled wheels should contain within limits of 179 to 217 HB. The thickness of layer machined by one pull broach blade should be approximately 0,09 mm. In order to achieve low work surface roughness of machined teeth there is such division of machined surface so that no traces after the following blade passage can remain.

The most optimum dimensions are assumed for wheel diameters of 80 mm to 160 mm as smaller dimensions cause difficulties in tool realization while larger wheels cause the weight of pull broach to increase. However meeting the needs of industry both smaller and larger wheels are produced. Gear produced by means of pull broaching by THE BROACH MASTERS Company is shown in Fig. 2. The production of such small, specific surface causes many challenges for designers of tools.

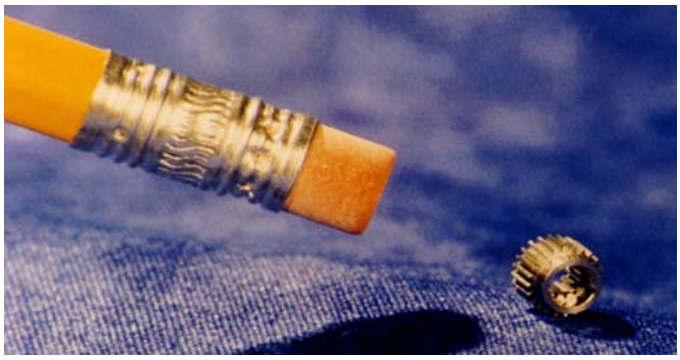

Fig. 2. A gear produced in course of external pull broaching

The example can be tool-steel gear with 40 teeth pulled entirely from the cast. The machine is the unit of automatic line. Semi-finished products are provided and gravitational forwarding feeder then transfers finished pieces. The machine is, in most cases, capable; elements are completely machined in one passage of pull broach, maintaining dimensional tolerance and machined surface comparable with the one achieved by means of other techniques such as milling or hobbing for production of 490 elements per hour. In addition it is about ten times faster. Internal pull broaching is cheaper because it is fundamentally simpler in its construction. The exactitude and repeatability of gears production is very high and gears can be produced in 9^{th} accuracy class. For working speed from 1m/min to 30m/min and even to 60m/min the number of machined elements can be increased by simultaneous machining of two details at a time, by which the number of machined elements is doubled. The high process speed is maintained mainly by special feeders and receivers, which feed the socket of machine tool. The feeder precisely positions the roller for production of gear. Owe to easiness of process automating both short realization time and exactitude of positioning of

element can be achieved. The process of machine cutting is based on continuous machine cutting of material, where through the high exactitude as well as low level of noise connected with realization of operation are provided.

Ways of forming tooth space of gears are shown in Fig. 3. Method C and D are disadvantageous ones since they cause quick wear of blades and the tool has to be frequently subjected to regeneration. The reason of this is friction of sides, that does not occur in A and B methods.

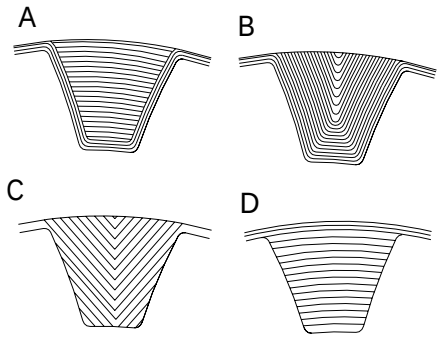

Fig. 3. Examples of machined layer removal methods

3. TOOL IN THE PROCESS OF PULL BROACHING OF GEARS

Pull broaching tools are produced mainly of HSS steel (70% of pull broaches), but also TiN coated HSS steel (about 20 %) as well as of cemented carbides (10%).
The durability of gear pull broaching tool depends on alignment of machine, the length of processing as well as type of cooling.

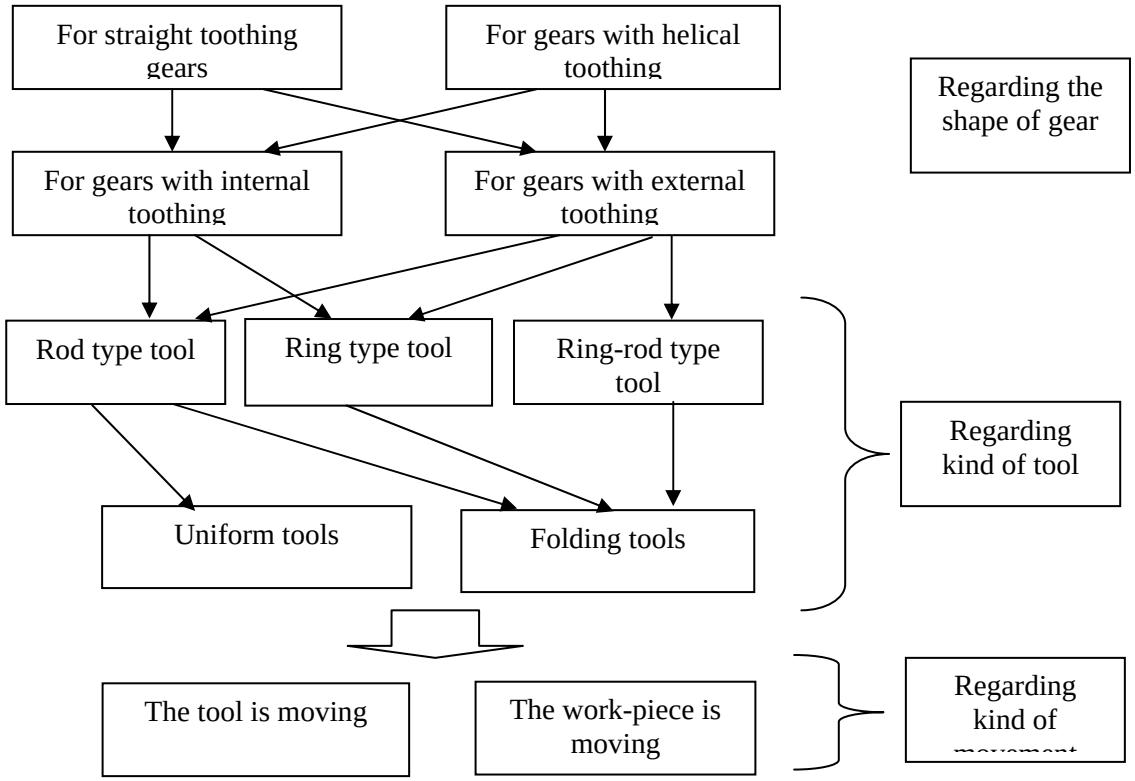

Fig. 4. Classification of pull broaches

The rod type pull broaches consists of two-piece pull broach holder, which has four base rods supporting a series of precisely seated muffs holding the pull broach. Such construction is used for gears with small exactitude of realization. The ring type pull broach consists of two-piece holder, in which series of individual rings are seated with outline of teeth marked. They are positioned by radial grooves. Each of them can be easily disassembled for sharpening. This type of pull broaches is used in the production of high precision gears at very small position errors, alignment and perfect surface machined. The ring-rod type is a combination of the previous types and is to provide precise shape of teeth along the phases of teeth.

The durability of tool during processing of casts is higher than during processing of steel units. The typical lifetime of tool for machining of iron castings elements is up to 75000 pcs./blade. For steel elements it is 2000 pcs./blade.

4. ADVANTAGES OF PULL BROACHING OF GEARS

The method of machining by means of pull broaching is also used for machining of gears both with external and internal toothing, with straight and helical teeth. The run time of gear production is about 50 times shorter by means of pull broaching than with traditional methods whereat in the process of pull broaching we can machine several elements at a time thus increasing efficiency of the process hundreds of times. Owe to this the method is highly cost-effective and competitive in comparison with other methods of surface processing; in this case of gears. The easy process of automation is very important feature of this method where through it is then possible to shorten machine available times to minimum, entirely automating production process. Gears produced in this way are competitive regarding price as well as exactitude of realization in comparison to gears produced in traditional way. The automation, except shortening of auxiliary times, assures the exactitude of positioning and there through the exactitude of realization, that is very important in present production. The only limitation is the batch of elements produced, which cannot be too small as the average cost of pull broach is, depending on size of gears, from several to tens of thousands Euro. Apart from increasing the efficiency and dimensional repeatability of production such way of manufacturing is moreover connected with elimination of finishing processes as well as large durability of tool.

Fig. 5. Internal gears machined by means of pull broaching

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