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INFLUENCE OF UNIT EFFECTIVE FEED ON WEAR OF HOB MILLING TOOL

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Abstract

For transmitting high power with high efficiency, gears are the most durable, reliable and strongest of all mechanical drives. Gears usually transmit rotary motion from one shaft to another although gears are also used to give rise to linear motion through rack. The motion is transmitted by means of successively engaging teeth. The hob milling process is one of the most important elements in the chain of gear mechanical machining, since productivity, final accuracy and quality of the gear depend heavily upon it. One of the basic cutting parameters, which influence the machining time and process economy, is the feed. The increase of feed has a less significant influence upon the wear increase than the increase of cutting speed. The paper presents the correlation of wear and unit effective feed per hob miller gear, which was a basis for learning that it was possible to increase greatly a feed in mm/feed, especially in gears with a greater number of teeth.

Key words: *unit effective feed, wear, hob milling tool, gear, cutting parameters*

1. INTRODUCTION

Gear like manufacturing task has been always a special problem for research as well as practice. Since, a gear is needed to transmit power and turning moment and it is a element used to transmit revolving motion in large number of manufacturing and usable products the rationalization of gear manufacture is very important task. There are several types of gears (Fig.1.).

Production techniques and organizational forms which can be used to manufacture gear depend on:

- gear size and its geometry,
- gear material,
- requested accuracy,
- character of series in gear manufacturing,
- other conditions in section.

Development of the methods for gear serration machining cutting is characterized by two basic

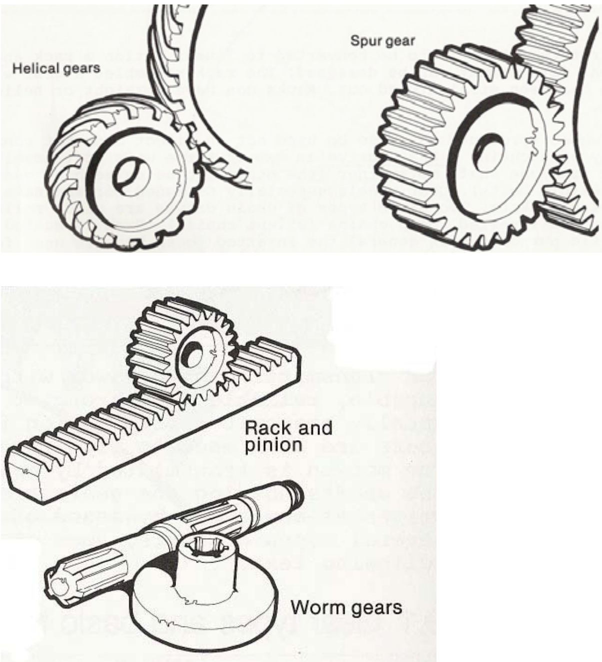

Figure 1: *Types of toothed gearing*

tendencies: to increase the economy of the machining methods and enhance the quality of serration in order to decrease additional dynamic overload and noise. These basically opposing requirements have induced a significant development of machining cutting tools and machines. To manufacture cogs hob-milling, particular hobbing process, cold rolling, planing, hob milling with tool in gear shape, special procedures for large serial production can be used.

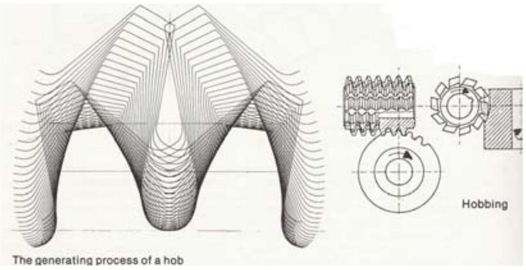

Figure 2: *The generatting process of hob and hobing*

The economy of the hob milling depends principally upon the tools wear nature. A great number of parameters and their alternate effect complicate the investigation of the wear process. A detailed analysis of the most important parameters is a basis for finding ways of increasing the economy of hob milling machining [7].

The investigation of the hob milling process is, because of its complexity and duration, and respectively high costs, directed towards real production conditions, which enables a reliable identification of the processes and creation of the conditions for its optimization.

As a part of the research, a suitable methodology for tracking relevant hob milling parameters was created; it enabled a systematic gathering of data needed for hob milling process analysis and optimization (the cost being minimal and without disturbing the regular production cycle) **[5].** Such methodology enabled experiments, which confirmed that there are considerable reserves in the hob milling process and the possibilities for tool and machine utilization; it also brought about interesting new issues in this area.

2. HOB MILLING WEAR

Development of wear on a hob milling tooth depends on the size of axial displacement and the feed number; it is also influenced by a combination of hob miller material and gears, machines, a coolant and a lubricant. There are other machining parameters, which significantly influence the process development, and the majority of these are variables with a wide range of values. The wear process is present with all hob miller cutting elements. However, not all of them are equally important. The most important are the primary wear processes. The cutting capability of the hob miller is dependant upon them, since the influence of the secondary wear processes is very small or insignificant.

The wear process of the hob miller tooth is manifested in wear zones. Wear zones, which are a consequence of the hob milling wear process, differ in form and location. They can appear in the form of a wear zone at the back or a crater at the front surface of the hob miller tooth. Which of the wear zones will be primary depends upon numerous technological conditions: workpiece material, hob milling procedure, cutting speed, feed, module etc. The wear of the back surface of a tooth includes the wear of an inlet side/back cutting edge, inlet front/back cutting edge and outlet side/back cutting edge (Fig.3).

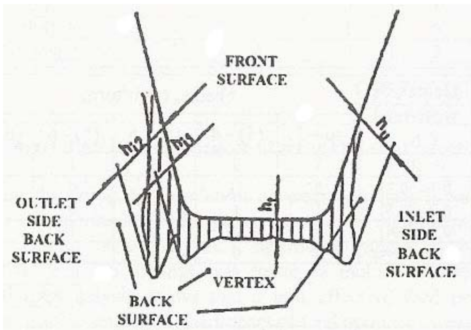

Figure 3: *Basic types of back zone hob miller tooth wear*

Modern manufacture is today characterized by the necessity to face the problems of limited resources of high quality materials and rational use of the existing materials, which means to increase the durability of exploitation.

The wear issues have the greatest impact on the durability of exploitation.

In order to undertake appropriate measures to decrease the wear of hob millers the causes for this occurrence should be known. These causes can be divided into three groups: mechanical wear, welding with pressure and fatigue of materials wear.

Mechanical wear and fatigue of materials have a constant impact on hob millers, while welding with pressure occurs at higher cutting speed and higher temperature respectively.

The tool and workpiece material, cutting regime parameters, cutting angles, cutting geometry, coolants and lubricants have the greatest influence on the hob miller wear.

In machining cutting, the increase of the feed and cutting speed has an immediate impact on the serration machining time decrease, but it also causes the increase in wear intensity. The main issue in all machining cutting is determination of the optimal values of these parameters.

A great number of researches show that in the area of regular cutting speed, the feed has a slower impact on the wear increase than the cutting speed [2, 5, 7]. The wear increase is at the beginning slower and it rapidly starts growing at a feed value. This is explained by the fact that while the feed increase, at the same time the overall length of the cutting edge contact with the material is decreased, which decreases the adverse impact brought about by the cutting edge load increase.

The intensity of wear increases when the cutting temperature increases over the hob miller material resistivity.

3. EXPERIMENTAL RESULTS

Feed is usually expressed as mm/workpiece turn. In order to determine whether feed, thus expressed, characterizes appropriately the occurrence of wear, a table of correlation between the feed and degree of wear was made (3). The table contains only results with the correlating speed of less than 1m/sec. The table analysis shows that there is a very weak correlation between feeds (mm/workpiece turn) and degree of wear, which can lead to a conclusion that feed, thus expressed is not suitable for investigating the influence of feed upon the hob milling wear.

Degree of wear-feed h	Feed s_a (mm/turn)				
	to - 3	(3) - 4	(4) - 5	(5) - 6	(6) - 7
0 - (0,1)	3	8	0	1	0
0,1 - (0,2)	5	11	3	0	2
0,2 - (0,3)	1	1	1	0	0
0,3 - (0,4)	5	2	0	1	1
0,4 and over	2	0	0	0	2

$P(X^2) = 0.88$

Figure 4: *Correlation between degree of wear and feed*

Papers [3, 5, 7] have made clear the formation process and saw dust shape which appears with hob milling. Programmes for modeling the hob milling process have made it possible to get a closer look at the shape and cross-sections of the saw dust.

In order to include the influence of at least some parameters upon the shape and cross-section of the saw dust, and resulting cutting resistance thereby, a unit effective feed was introduced:

$$s_{ez} = \frac{s_a \cdot z_1}{z_2 \cdot n_i \cdot \cos \beta_2} \cdot 1000 \quad (\mu m \, / \, teeth) \qquad (1)$$

This parameter is actually a feed in the direction of hollow between teeth axes for hob milling rotation time from one tooth to another. The influence of the module, hob milling outer diameter, and profile angle were omitted since the area of these values is very insignificant.

In order to determine the way in which feed value, thus defined, characterizes the hob milling wear occurrence, the experimental results were distributed in a different manner (Fig.4), i.e. a table of wear and unit effective feed table was made and analyzed (Fig.5).

Degree of wear-feed h (mm)	Unit effective feed s_{ez} (μm)				
	0-5	(5)-10	(10)-15	(15)-20	over 20
0 - (0,1)	0	5	4	3	0
0,1 - (0,2)	2	6	10	3	0
0,2 - (0,3)	1	1	0	0	1
0,3 - (0,4)	1	4	1	3	0
0,4 and over	0	1	3	0	0

$P(X^2) = 0.88$

Figure 5: *Correlation between degree of wear and unit effective feed*

The percent of correlation is in this case considerably greater, so that we can draw a conclusion that a feed, expressed in terms of unit effective feed per tooth, is a better indicator of hob miller feed than the feed expressed in terms of mm/workpiece turn.

Further investigation would require including other values as well The expression expanded In such a way and a guidance of investigation towards discovering this correlation, would surely Increase **the** percent already mentioned.

Thus expressed feed and conclusion drawn direct us toward using different feeds, expressed as mm/workpiece turn, for different serrations, which was not the case. If is very important to note in gears with greater number of teeth, feeds can be greater than the usual, which can lead to considerable reduction of costs.

Finding and determining the curve of correlation of wear and feed is very complex, which requires a great number of experiments and a

greater number of significant factors. The cross-section of the essential part of saw dust has a significant impact on the wear degree. By introducing unit effective feed, an attempt was made to include a certain number of the influential values. A simple analysis shows that a unit effective feed per hob miller tooth includes, in a certain but insufficient degree, he impact of feed upon tool wear.
The application of the programme "Bivariate data transforms" from a set of ready programmes provides a correlation:

$$h = 0.32 \cdot s_{ez}^{-0.58} \quad (2)$$

The curve and the results are given in Fig.6.
When determining the curve, all experimental results were included [5] regardless of the machining type and serration geometry with limited culling speed in the first passage in the interval: 0,62 $< v_1 <$ 0,82 (m/sec) and durability Tin the interval: T < 560 min. In the chosen experiments significant parameters such as: tooth angle of inclination, hob milling procedure,

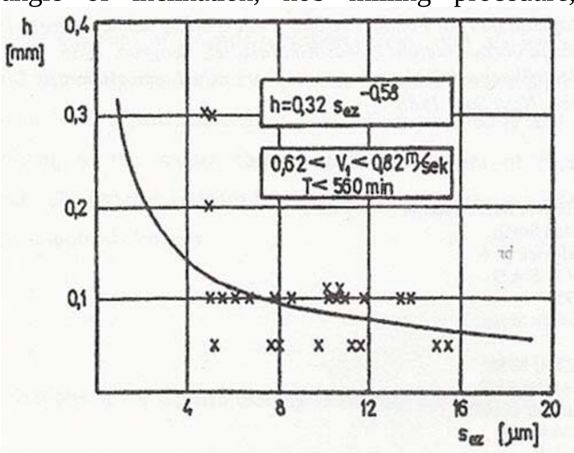

Figure 6: *The wear curve in correlation to unit effective feed*

cutting speed, and second passage feed were not excluded; the influence of cutting speed and durability were excluded in a broad sense; we can therefore regard this curve as a reliable basis for obtaining conclusions about the influence of the unit effective feed, that is the influence of feed upon the tool wear degree.

4. CONCLUSION

1. Feed is usually expressed in mm/turn, which is not suitable for investigating the influence of feed upon the hob miller wear. A far better correlation between wear and feed is obtained by using a unit effective feed per tool tooth.
2. By using the expression of feed in μm/hob miller tooth, we have come to a conclusion that it is possible to enhance the feed in mm/turn, especially with gears with a greater teeth number.
3. The Increase of unit effective feed enabled to decrease the wear. This, at the same time points to the fact that in this research optimal values were not reached from the point of view of tool wear.

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