THE INTERNATIONAL CONFERENCE OF THE CARPATIAN EURO-REGION SPECIALISTS IN INDUSTRIAL SYSTEMS
6th edition

IMPACT OF SPUR-GEAR-HOB DIAMETER ON TOOTH PROFILE ACCURACY

Slavko Pavlenko*[1]*, Jozef Haľko*[2]*, Ján Paško*[3]*,
[1,2,3]*Assoc. Prof. PhD. Eng*
Technnical University of Košice, Faculty of Manufacturing Technologies with the seat in Prešov, Bayerova 1, Prešov, Slovak Republic

Abstract: *The paper investigates the impact of a spur-gear-hob diameter on tooth profile accuracy of a workpiece. In the process of analysis, the vector method of notation of the screw surface of the cutter and flat sides of the rack, which represents the ideal profile, was used. The presented method enables to analyse the impact of non-precision adjustment of the milling head of the spur-gear-hob on tooth profile of the workpeace. The obtained results can be used for designing of more precise methods of profiling, especially of high-duty assembled spur-gear-hob used for tooth system manufacturing.*
Keywords*: spur-gear-hob, profiling, precision, tools manufacturing.*

1. INTRODUCTION

Spur-gear-hob are highly efficient tools used to produce toothed wheels as well as fluted shafts, chain wheels, trigger gears, and other parts with screw surfaces. They are highly productive and universal. Graphical, analytical and graphical-analytical methods are used for their profiling [2]. In the process of computer technology development, mainly analytical methods, which make use of mathematical apparatus of differential geometry in space, are used [2].

2. VECTOR NOTATION OF HOBBING CUTTER SCREW SURFACE

To produce involute toothed wheels, a spur-gear-hob represented by basic involute worm, is used. It is typical for this worm that with the change of radius of a rolling cylinder, mesh of its lateral screw surface with gear rack does not change [2]. For practical purpose, theoretical surface of the involute worm (cutter) is replaced by Archimedes' screw surface because of possible radial relief. In the process of such simplification , there occur deviations of profile, which are minimised by different methods (e.g. replacement according to Lashnev) [5].

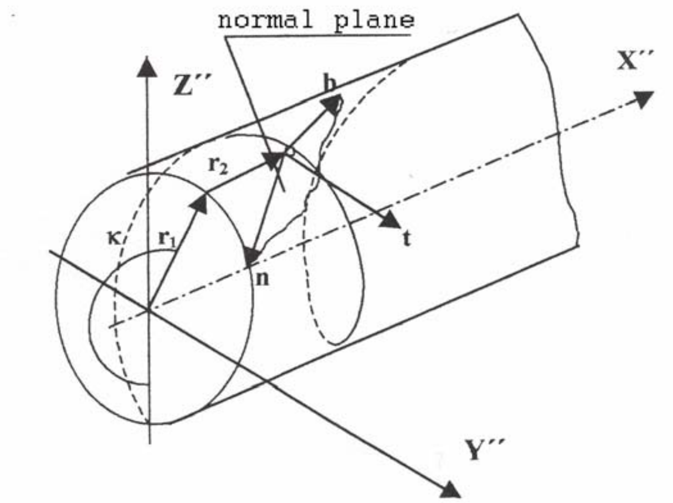


Fig. 1. Defining of vectors and planes

Let us describe the screw surface of the hobbing cutter. In Figure 1, the vectors $\boldsymbol{r_1}$, $\boldsymbol{r_2}$ can be seen. At the end point of the vector $\boldsymbol{r_2}$, the corresponding triangle *A(**t**,**n**,**b**)* in coordinate system *O (X'',Y'', Z'')* is defined. According to figure 1 we can write

$$\mathbf{r}_1 = -\mathbf{j}'' R \sin\kappa - \mathbf{k}'' R \cos\kappa, \qquad \mathbf{r}_2 = \mathbf{i}'' R\kappa\, \mathrm{tg}\,\gamma_f \qquad \mathbf{r} = \mathbf{r}_1 + \mathbf{r}_2$$

where γ_f – is the lead angle on holding cylinder of the cutter.

For unit vectors t,n,b we can write the following

$$\mathbf{t} = \mathbf{i}'' \sin\gamma_f - \mathbf{j}'' \cos\kappa \cos\gamma_f + \mathbf{k}'' \sin\kappa \cos\gamma_f$$
$$\mathbf{n} = \mathbf{j}'' \sin\kappa + \mathbf{k}'' \cos\kappa$$
$$\mathbf{b} = \mathbf{i}'' \cos\gamma_f + \mathbf{j}'' \sin\gamma_f - \mathbf{k}'' \sin\gamma_f \sin\kappa$$

At the end point of the vector $\boldsymbol{r_2}$ we can define trapezoidal profile by the vectors ***t,n,b*** and thus to profile the hobbing cutter in normal plane or to define linear profile in axis plane as the substitution by Archimedes' screw surface.

3. VECTOR NOTATION OF RACK PROFILE

To evaluate how the screw surface of the profiled cutter "cuts into'' the rack profile after the mentioned above substitution it is necessary to define its profile (Figure 2).

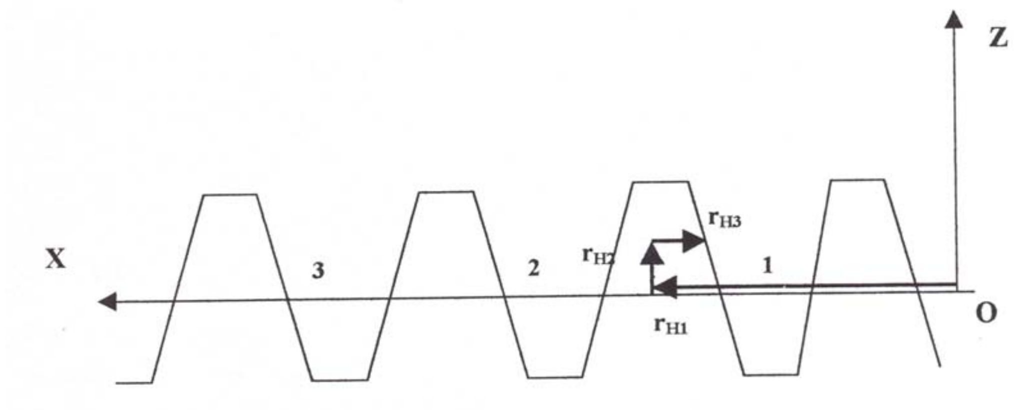


Fig. 2. Defining of the rack profile

Partial vectors of the resultant vector $\mathbf{r}_H$ are as follows:

$$\mathbf{r}_{H1} = \mathbf{i}\left(p\, i + \frac{p}{2}\right), \qquad \mathbf{r}_{H2} = \mathbf{k}\, z, \qquad \mathbf{r}_{H3} = -\mathbf{i}\left(\frac{p}{4} - z\, \mathrm{tg}\, \alpha\right)$$

where p- is the tooth pitch i – number of the tooth.

The resultant vector is given $\mathbf{r}_H = \mathbf{r}_{H1} + \mathbf{r}_{H2} + \mathbf{r}_{H3}$.

Evaluation of the deviations of the profiles between the theoretically accurate rack profile and the hobbing cutter profile can be obtained by introducing of the set of axis sections by screw surface of the cutter and by the system of plane sections of the rack for certain z =constant. Deviation of profile points of both plane sections Δp will be given as follows:

$$\Delta p = (x_H - x)\, 1000, \quad [\mu m]$$

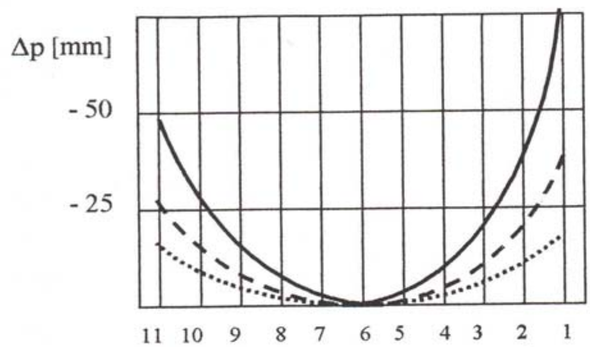
where x - is the coordinate of the point of the cutter profile in corresponding axis section and the point lying in a certain plane z = constant [mm],

x_H - is the coordinate of the point of rack profile lying in a certain plane constant [mm].

To determine the deviations, 29 axis sections by screw surface of the cutter and 11 plane sections by rack profile were used.

4. IMPACT OF DIAMETER OF THE HOBBING CUTTER

Figure 3 represents the development of deviations Δp when profiling the hobbing cutter in axis plane for 11 plane sections (horizontal axis z /-12,12/ mm) for the module m = 10mm.



Rh – main diameter of the cutter,

__ **Rh**= 57,5 mm,

--- **Rh**= 67,5mm,

…. **Rh** =77,5mm,

numer of the plane section

Fig. 3. Dependence of deviations of the hobbing cutter profile on its diameter

Development of deviations proves generally known fact of little non-accuracy in profiling with bigger diameters of hobbing cutters. Development of deviations on manufactured teeth of a workpiece proportionately corresponds to deviations of the tool [3,4] but their computation is more time consuming.

4. REFERENCES

[1] Wu DA-ren, Luo Jia-shun: A Geonetric Theory of conjugate Tooth Surfaces, World Scientific Publishing Co. Pte. Ltd., Singapore,1992.

[2] ŘASA, J. a kol.: *Výpočetní metody v konstrukci řezných nástrojů*, STNL Praha, 1986

[3] PAVLENKO, S. – ČEPEĽ, j. – BRZÝ, P.: *Príspevok k analýze vplyvu profilu a nastavenia odvaľovacej frézy na presnosť profilu zuba obrobku,* STROJÍRENSTVÍ 34, č.3, 1994

[4] PAVLENKO, S. – CHROBÁK, J. – ŠEBEJ, P.: *Teoretické podklady a programové vybavenie pre návrh profilu odvaľovacej frézy,* Výskumná práca v rámci HZ pre TST VUNAR Nové Zámky, MVVZ ROBOT, 1986

[5] LAŠNEV, S. I.: *Formoobrazovanije zubčatych detalej reječnymi a červjačnymi instrumentammi*, Moskva, Mašinostrojenie, 1971

The presented paper is the partial solution of the grant KEGA 3/3150/05