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SOME CHARACTERISTICS ASPECTS REGARDING THE MODELING AND OPTIMIZATION OF VIRTUAL TECHNOLOGICAL SYSTEM IN GEAR MANUFACTURING

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ABSTRACT
In the paper the authors present the results of more than 10 years research in the field of modern gear manufacturing. In this context there are presenting the high quality worm gear hobbing, the new type of used tool and CNC testing.
Keywords: gear , worm gear , virtual manufacturing **,** CNC testing .

1. INTRODUCTION
It is well known that the requirements of customers in the field of gears is increasing continuously. In order to satisfy this requirements , the manufacturers and researchers are looking for new performant technologies, concerning general performances, which require a lot of theoretical studies.
One way of manufacturing competitive worm gears, having different constructive changes, is that which uses all the complex possibilities of CNC.
In order to have good programming of the CNC hobbing machines it is necessary to determine the virtual gearing systems and to elaborate the needed algorithms for optimization.
This paper presents the basic aspects of virtual technological gearing , the necessary elements for their CNC programming and testing.

2. THE VIRTUAL GEAR MANUFACTURING SYSTEM

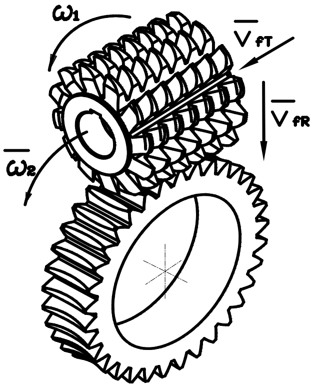

Figure 1 Position and relative motions of worm gear VGM

In real gear manufacturing (**RGM**) the generation of gear tooth is continuous process in witch both the cutting tool and the worm wheel rotate in a constant relationship with the hob is being fat into the gear blank. But in virtual manufacturing system (**VGM**) the worm gear is fix and the hob rotate in two directions and moves in axial or radial direction depending on the manufacturing method (fig.1), one is around the own axis and the other is around the work piece axis. , rather than the work and hob both rotate around their own axis in practical hobbing. However, the relative motions of the work piece and the hob in **VGM** and **RGM** are the same. Image that the observer sits on the work in RGM process, the motion of the hob the observer observed is exactly the same as the virtual hob motions in VGM .
So when the hob process finished, the gear process in VGM and RGM are identically [4].

3. DETERMINATION OF RELATIVE RELATIVE SPEED

In order to determine the relative speed, we will use the mathematical method from [1]. Based on fig. 1, in order to move from Σ_1 system, of the virtual enveloping surfaces) , to Σ_2 system, of worm gear and vice versa , one can use the auxiliary systems Σ_3 and Σ_R (Fig.2).

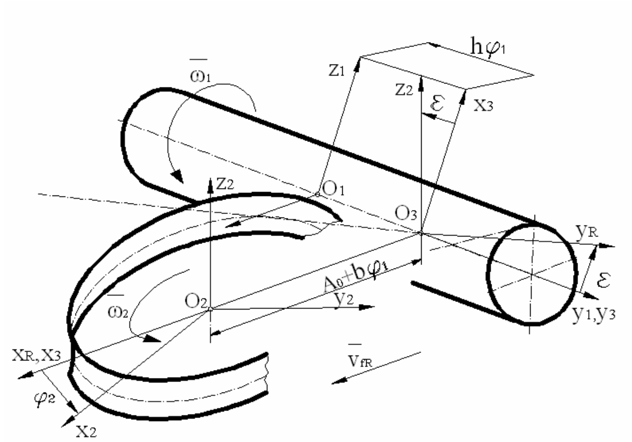

Figure 2 Determination of the relative speed in the virtual technological gearing

When processing with the radial feed method along OX direction, the relative position of the systems Σ_2 and Σ_R is determined by the following transfer matrix :

$$M_{2R}=\begin{Vmatrix}1 & 0 & 0 & 0\\ 0 & \cos\varphi_2 & \sin\varphi_2 & -A\cos\varphi_2\\ 0 & -\sin\varphi_2 & \cos\varphi_2 & A\sin\varphi_2\\ 0 & 0 & 0 & 1\end{Vmatrix} \qquad (1) \qquad M_{R2}=\begin{Vmatrix}1 & 0 & 0 & 0\\ 0 & \cos\varphi_2 & -\sin\varphi_2 & A\\ 0 & \sin\varphi_2 & \cos\varphi_2 & 0\\ 0 & 0 & 0 & 1\end{Vmatrix} \qquad (2)$$

where: $A = A_0 - b\varphi_1$

The parameter is determined as follows:

$$b = s_R\,\frac{z_1}{z_2}\cdot\frac{1}{2\pi} \qquad \left[\frac{mm}{rot}\right] \qquad (3)$$

where s_R is radial feed.

In systems Σ_R and Σ_3 , in the same way, result the matrices M_{R3} and M_{3R}

In the auxiliary system Σ_3 and the worm-hob system, there are M_{31} and M_{13}

Finally the transfer matrices, between Σ_1 and Σ_2 systems are determined as follows:

$$\begin{matrix} M_{12} = M_{1R}\cdot M_{R2} = M_{31}\cdot M_{3R}\cdot M_{R2} \\ M_{21} = M_{2R}\cdot M_{R1} = M_{2R}\cdot M_{R3}\cdot M_{31} \end{matrix} \qquad (4)$$

Based on these relationships, the matrix operator of relative speed is:

$$\Omega_0 = M_{12}\frac{\partial M_{21}}{\partial\varphi_1} = \begin{Vmatrix} 0 & -\sin\varepsilon & 0 & (A_0-b)\sin\varepsilon \\ \sin\varepsilon & 0 & \cos\varepsilon & bi_{21} - h\varphi_1\cos\varepsilon \\ 0 & -\cos\varepsilon & 0 & (A_0-b)\cos\varepsilon - hi_{21} \\ 0 & 0 & 0 & 0 \end{Vmatrix} \qquad (5)$$

where $i_{12} = \frac{z_2}{z_1}$ is the transfer ratio.

In conclusion, the relative speed is:

$$v_{21} = \Omega_0\ddot{\rho}_1 = \begin{Vmatrix} (A_0 - b - x_1)\sin\varepsilon \\ z_1\sin\varepsilon + (y_1 - h\varphi_1)\cos\varepsilon + bi_{12} \\ (A_0 - b - x_1)\cos\varepsilon - hi_{12} \\ 0 \end{Vmatrix} = \begin{Vmatrix} v_x \\ v_y \\ v_z \\ 0 \end{Vmatrix} \qquad (6)$$

where x_1, y_1, z_1 are the coordinates of M , on the virtual enveloping surfaces of the worm-hub ..

4. THE WORM AND WORM WHEEL CNC TESTING

The complex control of manufacturing worm gear is made with a measuring control machine Brown&Sharpe ghibli-trax (fig.3)

Figure 3.Measurement of worm wheels for cylindrical worms on Brown&Sharpe ghibli-trax

By means of the QUINDOS Option WORMWL worm wheels for cylindrical worms can be measured. The worm wheel is considered as conjugate gearing of the cylindrical worm i.e. the surface points of the worm wheel including normal direction are calculated by using only the geometrical parameters of worm and worm wheel. Included are the worm types ZI, ZA, ZN, ZK and ZC (see e.g. DIN 3975).

The measurement of worm wheels will be executed with a regular probe star which in general consists of 8 probe pins (fig.3). The used probe pins must have all the same name distinguished by an index. The diameter of the probe pin has to be small enough to allow access to the start of the profile near the root. The outside dimension of the star cluster needs to be sufficient in size to avoid collisions with the other teeth. The probe pin selection during measurement is done automatically. To avoid inaccuracies the probe pins should always be calibrated in 3 axis and with TRAX, before measurement.

Once the coordinate system of the worm wheel is established the complete measurement and evaluation of the worm wheel is processed by the command **WWHEEL**. The different measuring tasks can be executed altogether or individually by several calls of the command.

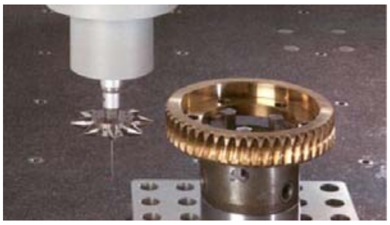

Figure 4. Mask for worm wheel parameters machine

Executing the WWHEEL command invokes automatically other masks where the user can enter the geometrical parameters and details for the selected measurement tasks.

The geometrical parameters includes both wheel and worm parameters, introduced in separate mask

After the last input mask the probing mask appears with the advice to probe both flanks of a gap or a tooth. These probing are used for the rotational orientation of the worm wheel, defining the reference tooth or gap. After the probing the automatic measurement starts immediately. After every single task e.g. measurement of a profile the plot evaluation is executed.

The evaluation charts from figure 5 can be obtained:

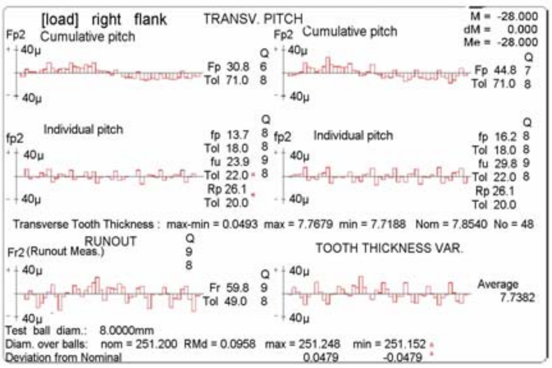

Figure 5. Run out and pitch evaluation chart

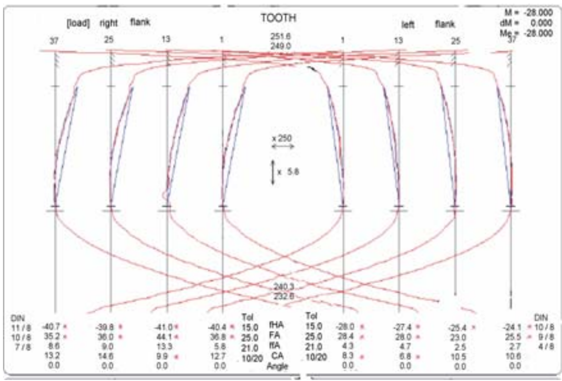

Figure 6. Profile evaluation chart

The profile measurement can be executed at right, left or both flanks (fig.6). Default is the complete measurement. If no tooth numbers are entered 4 equally distributed numbers are determined by the program.

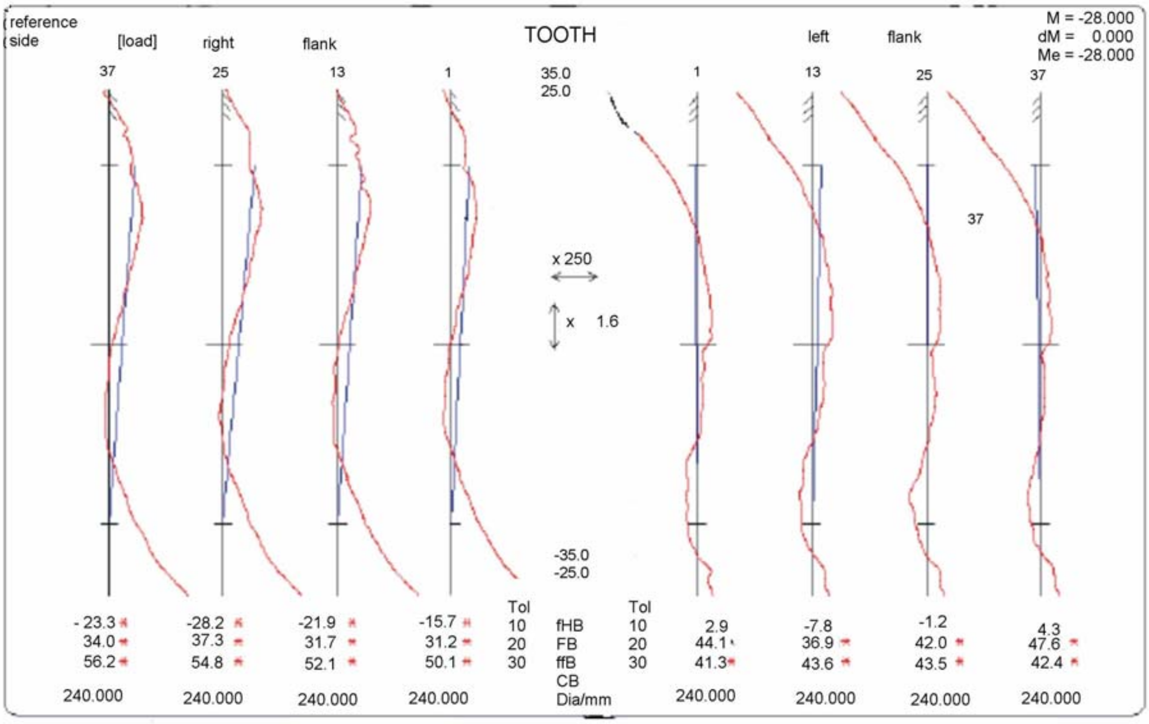

Figure 7. Flank traces evaluation

For the topography evaluation the deviations of the tooth flank at grid points perpendicular to the surface are displayed. The deviations are shown at a symbolic tooth with their true value without prospectively shortage . To allow the usage of usual magnifications in case of local large deviations (e.g. near the border or root) an error limit was introduced. The large deviations which would make the plot unreadable are cut off by the amount given in the input mask. The points concerned are marked with a small circle in the base grid. The limiting value is notified at the lower left corner of the plot.

5. CONCLUSIONS

For achievment of the high performance worm gears and by using CNC modern equipments is necessary the precise evaluation of the relative speed and also defining the generating and cutting surfaces of the afferent hob.

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