TEKA Kom. Mot. Energ. Roln. – OL PAN, 2009, 9, 54–60

SIMULATION OF HYPERBOLOID GEARS MODELLING

Victor Gribanov, Denis Ratov, Tatiana Balitskaya, Nataliya Korobka,
Tatiana Pecholat, Anna Smorodina

East-Ukrainian National University named after V. Dahl

Summary. An approach is considered to drawing up a mathematical model of the process of building an edge surface of tooth transfer with the subsequent construction of a computer simulation model of assembly transfers.

Key words: computer simulation, hyperboloid gears.

INTRODUCTION

As is known, gear details are one of the most widespread classes of details in modern mechanical engineering. Seriality of their release reaches hundreds thousand details a year. Their manufacturing, as a rule, is made by methods of removal of a shaving. Replacement of processes of cutting at processing of gear details by processes of plastic deformation — rolling is one of ways of progressive technology of mechanical engineering.

Presently modeling on digital computers is one of most powerful tools of research, in particular of difficult dynamic systems. As well as any computer modeling, it gives the chance to make computing experiments with just projected systems and to study systems with which natural experiments are not expedient due to safety or economical reasons. Moreover, this research method is accessible to a wider and wider range of users.

The purpose of the present article is based on conclusions of works [2], [6] concerning quasihiperboloid tooth gearings in the form of a computer model.

OBJECTS AND PROBLEMS

Model object is like any other object whose unique properties in full or in part coincide with the initial properties initial [8]. The imitating model is considered as the special form of mathematical model in which system decomposition on components is made taking into account the structure of the projected or studied object and its implementation principles. The experimental data received as a result of natural experiments can be used, and the implementation of system in time is illustrated by the set dynamic images.

Rounding is the crucial issue at the heart of many technological processes forming, i.e. receptions of a surface of a detail by the cutting tool. Thus the form of the received surface of a detail differs from the form of a making surface - a geometrical place of infinite number of cutting edges.

Let us state the approach to drawing up of mathematical model involving a big group of technological processes forming, used in mechanical engineering at manufacturing of details of the various form by the rolled tool. The lines uniting all the processes forming are the following:

- Bent around the making surface whose form is considered to be known in advance;
- The surface processed by the cutting tool whose form is unknown in advance is bending around;
- The bent around surface of rather conditionally motionless system of readout connected, for example, with the machine tool, can make the difficult movement which is set of rotary and rectilinear progress, and position of a making surface in the specified system of readout is defined by one parameter - movement parameter;
- Preparation in the same system of readout can rotate around its own axis; the corner of turn of preparation depends on the parameter of movement of a making surface, and this dependence is known in advance
- The purpose of drawing up of mathematical model is the reception of the equation of the processed surface and its analysis when needed.

Thus, we will describe a mathematical model of technological process forming with a concrete definition of the form of a making surface and a kind of its movement (Fig. 1).

Let in a motionless system of readout one parameter characterize ψ position of a moving surface Ω, and another parameter define φ position of rotating preparation in the same system. Between ψ and φ there is a functional dependence so it is possible to assume that movement of the specified objects is defined by one parameter.

The mathematical model of technological process forming includes the description of the form of a making surface and Ω the law of its movement concerning preparation, and also reception of the equation of the processed surface, Ξ as bending around families of making surfaces.

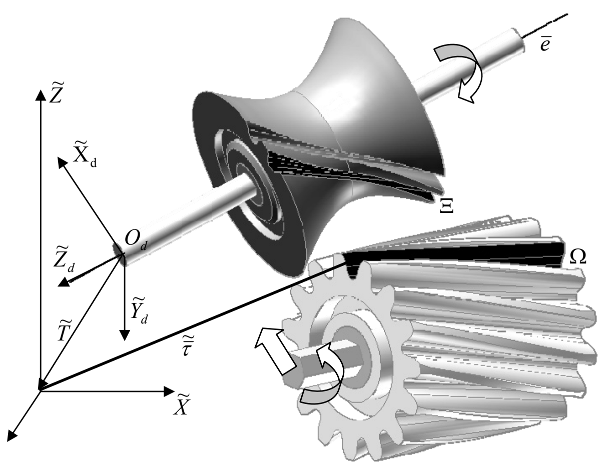

Fig. 1. The chosen systems of readout at reception of a bending around surface Ξ

For drawing up of mathematical model we will enter into consideration three systems of readout:

1. Σ_d - Mobile Cartesian, the system rigidly connected with preparation, rotating about the axis e. In this system we will receive the equation bending around, Ξ i.e. the equation of the processed surface. The system beginning lays Σ_d on an axis e preparation rotations in a point O_d.

2. $\tilde{\Sigma}_d$ - Motionless Cartesian system with axes $\tilde{x}_d$, $\tilde{y}_d$, $\tilde{z}_d$. In initial position when, $\varphi = 0$, $\psi = 0$ systems also Σ_d and $\tilde{\Sigma}_d$ coincide with each other.

3. $\tilde{\Sigma}$ - Motionless Cartesian system with the beginning in a point and $\tilde{O}$ with axes $\tilde{X}$, $\tilde{Y}$, $\tilde{Z}$. In this system it is convenient to describe making surface Ω in initial position, i.e. at $\psi = 0$.

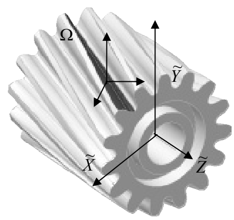

Fig. 2. Lateral profile of a tooth

Sequence of drawing up of mathematical model is the following:

1) In the system we write down $\tilde{\Sigma}$ the equation of a making surface Ω in initial position;

2) We make transition in system $\tilde{\Sigma}_d$ and there the equation of a making surface in Ω any position registers;

3) We pass in the system $\tilde{\Sigma}$ rotating together with preparation. In this mobile system there is defined bending around families of making surfaces Ξ which serves as model of the processed surface.

Let us consider computer modeling hyperboloid gears. Construction of each detail in the environment of designing represents the consecutive description of constructive elements making it. Constructive elements can be set by means of form-building sketches (for example, the elements received by expression, rotation, shift on a trajectory), and also are created on the basis of already available elements (for example, apertures, facets, rounding off, covers, edges of rigidity, a partition, foundry biases, carving elements). As an initial contour of burnisher we take a contour with two lines of gearing (Fig. 3)

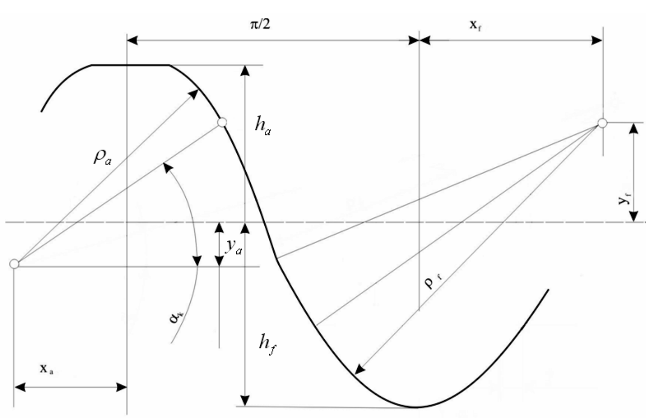

Fig. 3. An initial contour

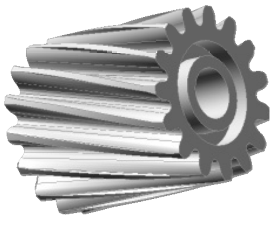

Fig. 4. Burnisher

Fig. 5. An initial hyperboloid

Construction of a lateral profile of a tooth is accompanied by the exact task of all sizes specified in state standard specification, therefore the profile is received exactly, without approximation by a spline. We will create on the initial cylinder a hollow of a tooth by an expression method as an initial contour along length of the cylinder. Tooth profiles are presented by screw surfaces:

$$\overline{p}(\theta,v)=\begin{bmatrix} R\cos(\theta)+v\cos(\delta)\sin(\theta) \\ R\sin(\theta)-v\cos(\delta)\cos(\theta) \\ p\theta - v\sin(\theta) \end{bmatrix}.$$

Operating on the duplicate of the sample of a hollow on separatory circles of burnishes we create other teeth (Fig. 7).

In the beginning the sketch and a body can be executed approximately, which corresponds to practice of real designing. Then the form is specified by the task of two kinds of dependences — dimensional (the values of parameters concrete or set by means of formulas) and geometrical (parallelism, perpendicularity, relation, concentricity, symmetry).

Proceeding from functional dependence of the normal module of burnisher and parameters of rolled preparation (hyperboloid) there are calculated base points of the hyperbole, $y=\pm\sqrt{r^2+tg^2(\beta)z^2}$ which rotating round an z-axis gives a hyperboloid axoid (see Tab.1, Fig.5).

Table 1. Base points of a hyperbole

y1	101,673		z1	0
y2	110,09587		z2	42,23388479
y3	118,51873		z3	60,9039525
y4	126,9416		z4	76,00507362
y5	135,36447		z5	89,36520789
y6	143,78734		z6	101,673
y7	152,2102		z7	113,2720039
y8	160,63307		z8	124,3607018
y9	169,05594		z9	135,0648394
y10	177,4788		z10	145,4693333
y11	185,90167		z11	155,6342905

In the context of working assemblage (process rolling teeth) on burnisher and working preparation assembly dependences (the center-to-center spacing equal to the sum of radius of a mouth of a hyperboloid and radius of burnisher are imposed; a corner between crossed axes; the relation of angular speeds of burnisher and a hyperboloid). After the task of assembly dependence such arrangement of details in assemblage which does not contradict the given dependence is only possible. It allows to model the real behavior of the mechanism at moving and rotation of its components. Moreover, the designing system allows defining assembly dependence as the managing director, to set a range of change of its parameters (such as distances between the interfaced elements). As a result of expression operation we receive teeth on hyperboloid axoids (Fig. 7). The lateral surface of teeth represents the bending around surface received in the course of rotation of the forming surface on a tooth of burnisher. Having made assemblage from two hyperboloid gear wheels, we receive model hyperboloid gears with gearing Novikova (Fig. 8).

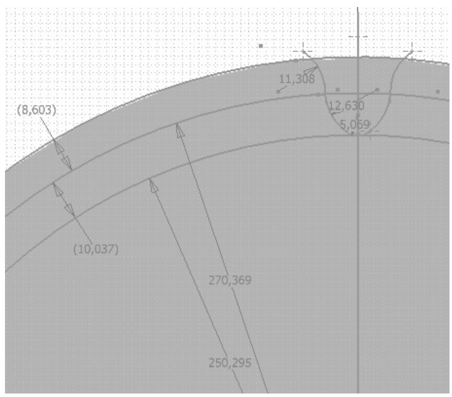

Fig. 6. A profile of a hollow of a tooth in face section of a hyperboloid

Fig. 7. Process of knurling teeth's

The system of the automated designing gives a possibility of the automatic analysis of assemblage on crossing of details (revealing of area of interference) with the subsequent calculation of co-ordinates of the centre of a platform of instant contact and its sizes for the purpose of a further research of model of gearing.

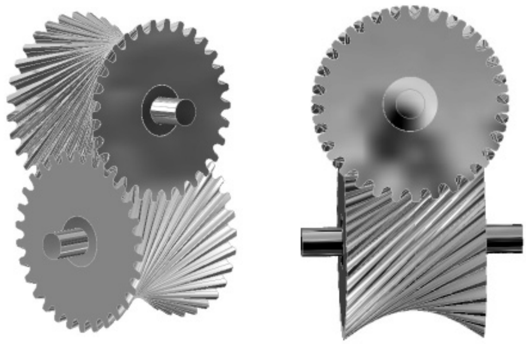

Fig. 8. Interfaced hyperboloid pair

CONCLUSION

It is possible to draw a conclusion: the mathematical model by means of which a computer can simulate quasi hyperboloid tooth gearing allows creating solid-state quasi hyperboloid cogwheels by rolling (Fig. 8). The geometry of initial surfaces of cogwheels at rolling as much as possible comes nearer to theoretical initial surfaces – hyperboloid axoids [2]. An analysis of working out hyperboloid (screw and hypoid) transfers is important from that point of view that the information received as a result of the analysis will allow each industrial enterprise of Ukraine applying spatial transfers, to estimate degree of their conformity to modern requirements of manufacture.

REFERENCES

GOST 16530-70. Transfers gear. Terms, definitions and oboznachenija. th.: Publishing house of standards, 1971.

Gribanov V.M.: Teorija hyperboloid tooth gearings. - Lugansk: East-Ukrainian National University named after V. Dahl, 2003. – 272 p.

Gribanova Y.V., Balitskaya T.Y.: Comparative geounderground research – kinematics parameter gear hypoid transfers // Reporter ZMTU – 2004 - № 2 – p. 83 - 86.

Zhuravlyov G. A, Iofis R. B.: Hypoid gears. Problems and development. – Rostov-on-Don: Severo-Kavkaz. The higher school centre. – Publishing house RGU, 1978. – 147 p.

Litvin F.L.: Theory of gearings. -- M: the Science, 1968. – 584 p.

Kirichenko I.A.: Creation hyperboloid transfers with linear contact of teeth’s on the basis of special cutting tools: Dis. Dr. Sci. Tech.: 05.02.02 – “Science of machines”. – the East-Ukrainian National University named after V. Dahl. – Lugansk. – 2004. – 274 p.

Pismanik K.M.: Hypoid gears. – M: mechanical engineering, 1964. – 227 p.

Benkovich E.S., Kolesov J.B.: Practical modeling of dynamic systems.–Petersburg, 2002 p.

SYMULACJA MODELOWANIA PRZEKŁADNI ZĘBATYCH

Streszczenie. Rozważono metodę sporządzenia modelu matematycznego procesu budowy krawędzi przekładni zębatej a następnie przeprowadzono komputerową symulację transferów zespołów.

Słowa kluczowe: symulacja komputerowa, hiperboloidowe przekładnie.