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CREATION OF HIGH-LOADED HYPERBOLOID GEARS WITH IMPROVED AND EXTREME GEOMETROKINEMATIC PARAMETERS

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Summary. Creation of high-loaded hyperboloid gears with improved and extreme geometrykinematic parameters on the basis of quasi hyperboloid gearings – a perspective and effective direction in an improvement of technical and economic characteristics of reducers.

Key words: high-loaded hyperboloid gears, improved and extreme geometrykinematic parameters.

INTRODUCTION

A major role in an increase of technical and economic characteristics of reducers – mass production of branches of an economic complex of Ukraine – is played by tooth gearings in many respects concerning durability, reliability and competitiveness of mechanisms in which they are applied. Growing requirements as to an increase in district speeds, loading and resources, reduction of dimensions and weights of reducers all are to a lesser degree satisfied with traditional gears which do not meet in some cases the market economy requirements on such parameters as individual capacity, accuracy, specific material, power consumption and competitiveness. So, in the conditions of occurrence of Ukraine in the World Trade Organization mechanical drives the general machine-building and the special application, issued at the enterprises of Ukraine, are subject to updating in the shortest terms with the account of increase of their technological level, expansion of consumer properties and competitiveness improvements.

The researches directed on creation of effective hyperboloid gears, possessing high loading ability and efficiency, smaller metal consumption, are actual and meet the requirements of scientifically – technical progress of modern mechanical engineering. The research urgency hyperboloid gear does not decrease with the continuous tendency to increase the geared capacity, characteristic for modern mechanical engineering.

Creation of the gears answering high scientific, technical and industrial level, demands a consideration of all parameters of quality of projected gear, and also constructive and technological ways of their maintenance, with an account of business factors, scientific, technical and industrial ones– a subject of multicriterion synthesis and optimization of tooth gearings with improved and extreme geometrykinematic parameters and operational characteristics.

Research is carried out within the limits of works and on the basis of the program of scientific – technical researches of Lugansk branch of transport Academy of Ukraine; under the plan of scientific– research works of the East-Ukrainian National University named after Vladimir Dahl.

OBJECTS AND PROBLEMS

The research objective is the development of the theory and an increase of the technological level of spatial gears by creation of high-loaded hyperboloid gears – screw and hypoid – gears with the improved and extreme quality parameters, as now the greatest part of special reducers and gears, the general machine-building and machine-tool constructing which are offered by manufacturers of the post-Soviet countries, are the models developed mainly in 1960 – 1980ties. They have been applied in the design of numerous machine tools, cars and mechanisms and used till now. However, owing to the different reasons even in new projects the mentioned gears and reducers can no more satisfy the modern technology requirements, are noncompetitive in comparison with foreign analogues, and in most cases their application in modern manufacture is unprofitable.

In various branches of national economy of Ukraine and in the leading industrially developed countries of the world intensive researches are carried out in an area of hyperboloid (spatial) machine-tool and the working of the gearings, directed on an increase of bearing ability hyperboloid – screw, worm, spiroid and hypoid gears which, increasingly, are being made at machine-building factories of the countries of the world. So, from materials of annual international conference on mechanical transmissions (Japan, Fokuoka) it is known, that in the world the release volume hyperboloid gears double each 5-7 years, thus in the beginning of the third millennium annual cost hyperboloid wheels exceeded a few billion US dollars.

The above-mentioned facts allow us to tell, that use of any reserves in manufacture of hyperboloid gears, gears and reducers can give and already really gives considerable economic benefit at the expense of improvement of a design, increase of labor productivity, improvement of quality, decrease in the cost price, increase of competitiveness of production.

The special place among spatial gears and reducers is occupied by hypoid and screw cogwheels with improved (extreme) qualitative (geometrykinematic) parameters, with the contained big latent reserves of increase in their durability and improvement of operational qualities. One of essential reserves is transition from conic and cylindrical initial surfaces to quasihyperboloid initial surfaces least deviating from hyperboloid axoids – theoretical initial surfaces.

Thus, it is possible to assume, that quasihyperboloid gears should possess the best quality parameters among spatial tooth gearings. The offer brought by us on a geometrical reserve of perfection screw, worm, spiroid and hypoid gears and transition from conic and cylindrical initial surfaces to quasihyperboloid gears has the settlement acknowledgement consisting in the following numerical comparative analysis.

To numerical research were exposed quasihyperboloid gears with Novikova gearing, gearing of Novikova type , involute gearing, quasiinvolute gearing, globoidal gearing with the following parameters: m_n = 3 mm, Z_1 = 13, Z_2 = 54 mm, r_1 = 26,344 mm, r_2 = 26,344 mm, a_w = 52,688, u_0 = 0,2407, $\gamma = 90^\circ$ (orthogonal gears), $\beta_1 = 74^\circ\ 34'$, $\beta_2 = 15^\circ\ 26'$.

Results of calculation of quality parameters are reflected in Fig. 1 – 11: №1 – gearing gears with Novikova gearing; №2 – gearing of Novikova type; №3 – involute gearing; №4 – quasiinvolute gearing, №5 – globoidal gearing [6]. In these figures from the five considered types of hypoid gears only №3 possesses linear contact of teeth, other four types of gears – dot contact. In this connection for №3 in Fig. 1, 3, 5, 7, 9 including the additional information, along with a median point of a line of instant contact, as well as its trailer points is placed. Let us analyze the received results.

Relative speed of sliding of teeth (Fig. 2 and 3). The highest "rating" on this quality parameter characterizes gear №1, the lowest - globoidal gears №5, intermediate position occupy hypoid gears №2, №3 and №4: The relative speed of sliding of teeth in gear №1 is 2,4 … 5,3 times is lower than in other four types of gears.

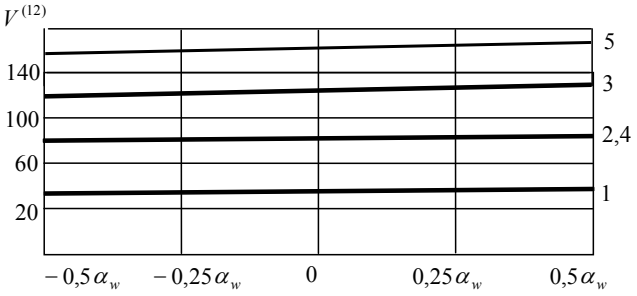

Fig. 1. Relative speed of sliding of teeth, $V^{(12)}$ ммc^{-1} (№3 – a line from *c* (Fig. 2)

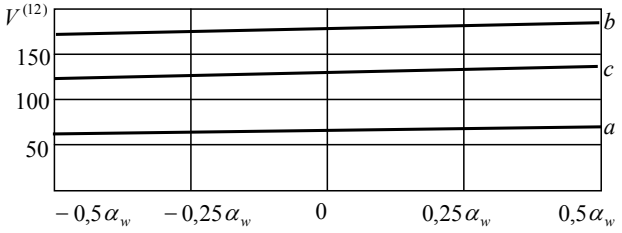

Fig. 2. Hypoid gear №3. Relative speed of sliding of teeth: $V^{(12)}$ ммc^{-1} (*a*, *-b* in trailer, *c* – in median points of a line of instant contact)

Factors of specific sliding of teeth (Fig. 3 - 6). The highest "rating" on this quality parameter characterizes gear №1, as well as the above, hypoid, the lowest – hypoid gear №5, intermediate position is occupied by hypoid gears №2, №3 and №4.

Total speed of rolling teeth (Fig. 7 and 8). The highest "rating" on this quality parameter characterizes gear №5, the lowest - hypoid gear №4 is possessed by hypoid, the intermediate position is occupied by hypoid gears №1, №2 and №3: the total speed ***of rolling*** teeth in gear №5 in is 1,3 … 4,2 times higher than in other four types of gears.

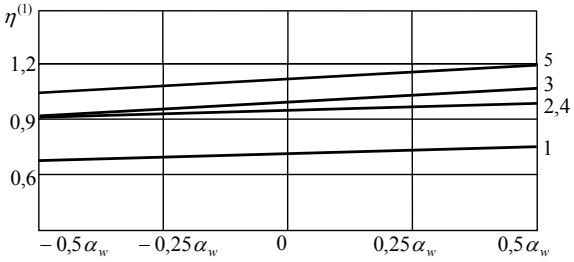

Fig. 3. Factor of specific sliding $\eta^{(1)}$ (№3 – a line from *c* fig. 4)

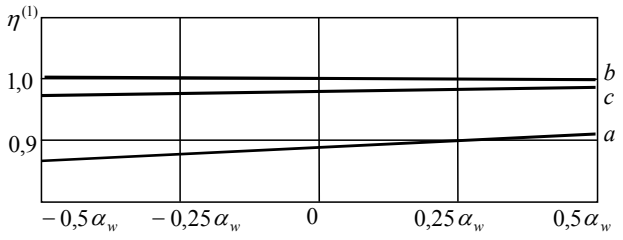

Fig. 4. Hypoid gear №3. Factor of specific sliding $\eta^{(2)}$
(*a*, *b* – in trailer, *c* – in median points of a line of instant contact)

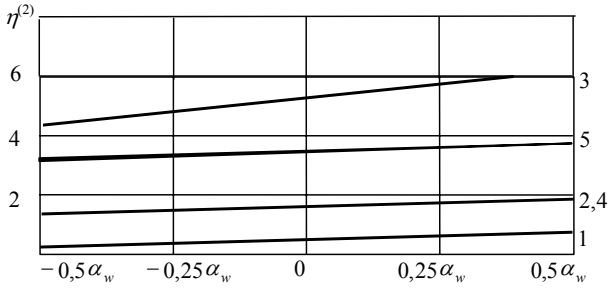

Fig. 5. Fig. 3. Factor of specific sliding $\eta^{(2)}$ (№3 – a line from *c* fig. 4)

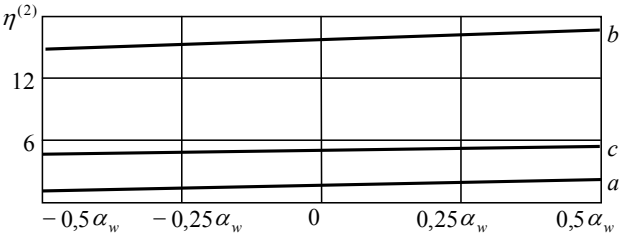

Fig. 6. Hypoid gear №3. Factor of specific sliding $\eta^{(2)}$
(*a*, *b* – in trailer, *c* – in median points of lines of instant contact)

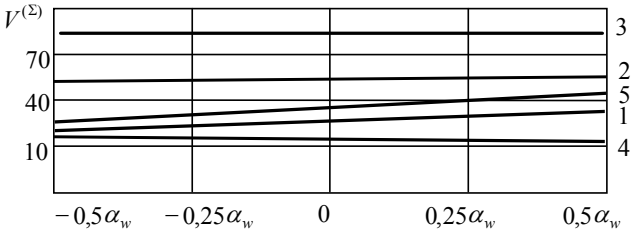

Fig. 7. Total speed of rolling teeth, $V^{(\Sigma)}$ мм с$^{-1}$ (№3 – a line from *c* fig. 8)

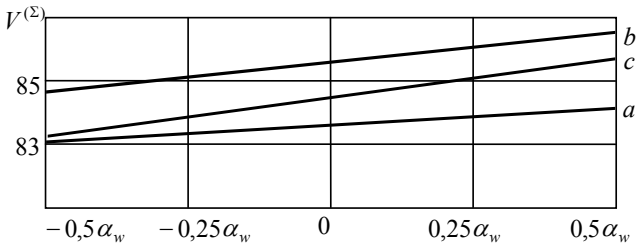

Fig. 8. Hypoid gear №3. Total speed of rolling teeth's, $V^{(\Sigma)}$ мм с$^{-1}$
(*a*, *b* – in trailer, *c* – in median points of a line of instant contact)

Factor of scoring resistance of teeth. (A Fig. 10 and 11). The highest "rating" on this quality parameter characterizes gear №1, the lowest - hypoid gear №4, the intermediate positionis is occupied by hypoid gears №2, №3 and №5: the factor of scoring resistance in gear №1 is 1,5 … 5,7 times lower than in other four types of gears.

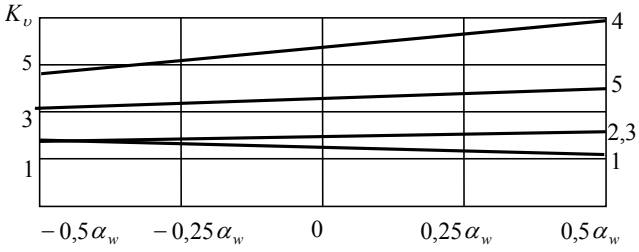

Fig 9. Factor of scoring resistance of teeth K_υ (№3 – a line from Fig. 10)

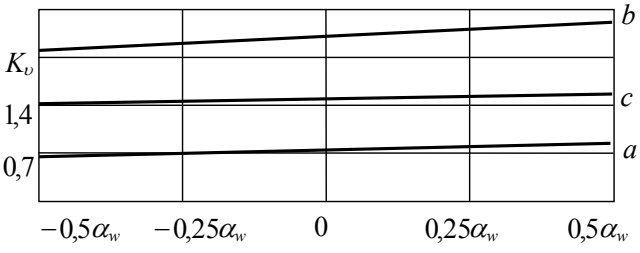

Fig. 10. Hypoid gear №3. Factor of scoring resistance teeth's K_υ
(*a*, *b* – in trailer, *c* – in median points of a line of instant contact)

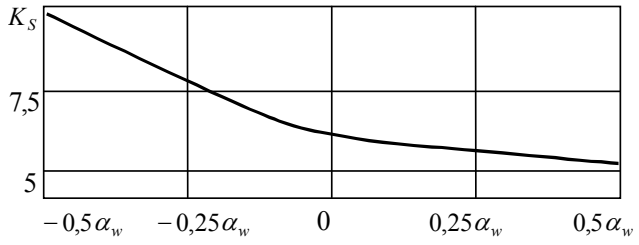

Fig. 11. Factor K_s a comparative intense condition teeth's of gears №2 and №1

Factor of a comparative intense condition of teeth (Fig. 11). The area of a platform of instant contact of teeth in hypoid gear №1 5,5 … 9 times exceeds the area of a platform of instant contact in hypoid gear №2. This statement is fair in relation to gears №3, №4 and №5 as the intense condition of teeth of gear №2 is elastic; under equal conditions is less elastic an intense condition of teeth of gears №3, №4 and №5 is less elastic.

CONCLUSION

Synthesis of spatial gearings on the basis of the initial surfaces least deviating from hyperboloid axoids - a perspective direction of essential increase in durability and improvement performances screw, worm, spiroid and hypoid gears. Gearing of Novikova thus has more perspective than involute gear.

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BUDOWA WYSOKO OBCIĄŻONYCH PRZEKŁADNI HIPERBOLOIDOWYCH Z ULEPSZONYMI I EKSTREMALNYMI PARAMETRAMI GEOMETROKINEMATYCZNYMI

Streszczenie. Budowa wysoko-obciążonych przekładni hiperboloidowych z ulepszonymi i ekstremalnymi parametrami geometrokinematycznymi na podstawie quasi - hiperboloidowych przkładni zębatych – perspektywa i efektywne ukierunkowanie na poprawę technicznej i ekonomicznej charakterystyki reduktorów.

Slowa kluczowe: wysoko-obciążone przekładnie hiperboloidowe, ulepszone i ekstremalne parametry geometrykinematyczne.