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JIF	= 1.500	SJIF (Morocco)	= 7.184	OAJI (USA)	= 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 02 **Volume:** 106

Published: 07.02.2022 **http://T-Science.org**

QR – Issue QR – Article

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GEOMETRIC PARAMETERS OF THE BEVEL GEAR AND ITS CALCULATIONS

***Abstract**: Mechanical engineering is one of the most important industries in the industrial complex of our country. Therefore, the plans for the economic development of the industrial complex of Uzbekistan provide for an increase in the output of engineering products by at least 1.4 times, an increase in the range and renewal of its structure. The solution of this problem is possible with the widespread use of progressive technologies, equipment and tooling, mechanization and automation mean that correspond to modern achievements in science and technology. In turn, measures to modernize the means of production in mechanical engineering make it possible to improve the quality of manufactured products and make them competitive with the best samples of products on the world market.*

***Key words**: gear, teeth, device, material, manipulator, system, alloy, machine, bevel gears, cutting edges.*
***Language**: English*
***Citation**: Djuraev, A. D., & Chuliev, Sh. S. (2022). Geometric parameters of the bevel gear and its calculations. ISJ Theoretical & Applied Science, 02 (106), 74-79.*
***Soi**: http://s-o-i.org/1.1/TAS-02-106-9 **Doi**: crossref https://dx.doi.org/10.15863/TAS.2022.02.106.9*
***Scopus ASCC**: 2200.*

Introduction

The main tasks in the field of mechanical engineering technology and the prospects for its development are: approximation of the shape of the workpiece to the shape of the finished product through the use of plastic deformation methods, powder metallurgy, special profile rolled products and other progressive types of workpieces; automation of technological processes through the use of automatic loading devices, manipulators, industrial robots, automatic lines, CNC machines; concentration of transitions and operations, the use of special and specialized machines; application of group technology and highly efficient equipment; the use of effective cutting fluids with their supply to the cutting zone; development and implementation of high-performance cutting tool designs made of hard alloys, mineral ceramics, synthetic superhard materials, high-speed and high-performance high-speed steels; widespread use of electrophysical and electrochemical methods of processing, deep grinding; introduction of the latest methods of thermal and chemical-thermal treatment, application of wear-resistant coatings; At present, a number of fundamental transformations are taking place in mechanical engineering technology. In particular, the introduction of automatic design systems (CAD). These systems use powerful computers, with the help of which the following operations are performed: drawing a working drawing; calculation and design of the tool; printout of regulatory and technological documentation: issuance of control work programs for CNC machines. Analysis of the design and technical requirements Bevel - the wheel is designed to transmit the torque of the shafts located in parallel in the box. The main value of the bevel gear is to change the position of the axis of rotation, moving from a horizontal shaft to a vertical one. Bevel - the gear works in difficult conditions, so lubrication is done with oil mist. A shaft with two bearings 113 GOST 8338-75 is installed inside the bevel gear, which are fixed along the outer ring of the bearing with a thrust ring B 100 GOST 13943 - 86. Two bearings 2007124 A GOST 27365-87 are installed on the outer surface ring B 120 GOST 13942-87 on the outer ring, the bearings are fixed by a flange. On one of the inner surfaces there is a ring gear that engages with a gear clutch.

They are used in all branches of mechanical engineering, where, according to the layout of the machine, it is necessary to transfer the movement between the intersecting axes of the shafts. Bevel gears are more complicated than cylindrical gears and require periodic adjustment. A special tool is required for cutting bevel gears. In comparison with cylindrical bevel gears, they have a large mass and size, and are more difficult to install. In addition, one of the bevel wheels, usually a gear, is cantilevered. At the same time, due to the increased deformation of the cantilever shaft, the uneven distribution of the load across the width of the ring gear and noise increase.

The main geometric dimensions are determined depending on the module and the number of teeth. The height and thickness of the teeth of bevel gears gradually decreases as they approach the top of the cone. Accordingly, the pitch, module and dividing diameters change, which can be countless. The main geometric dimensions have the designations adopted for spur bevel gears

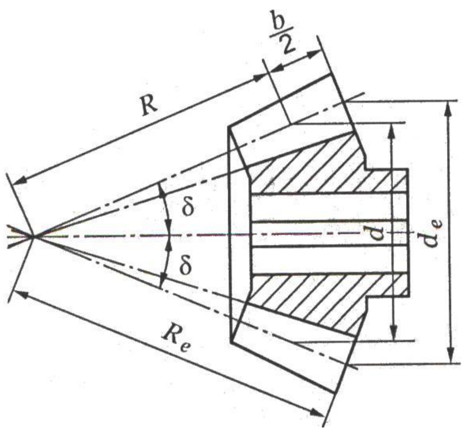

Figure 1. Bevel wheel geometry.

The forces in engagement are determined by the size in the average section of the gear tooth. Three forces act on the gear of a bevel spur gear Fig. 2:

District

$$F_{t1} = \frac{2T_1}{d_1}$$

radial

$$F_{r1} = F_r^1 cos\delta_1 = F_{t1} tg\alpha_w cos\delta_1$$

axial

$$F_{r1} = F_r^1 sin\delta_1 = F_{t1} tg\alpha_w sin\delta_1$$

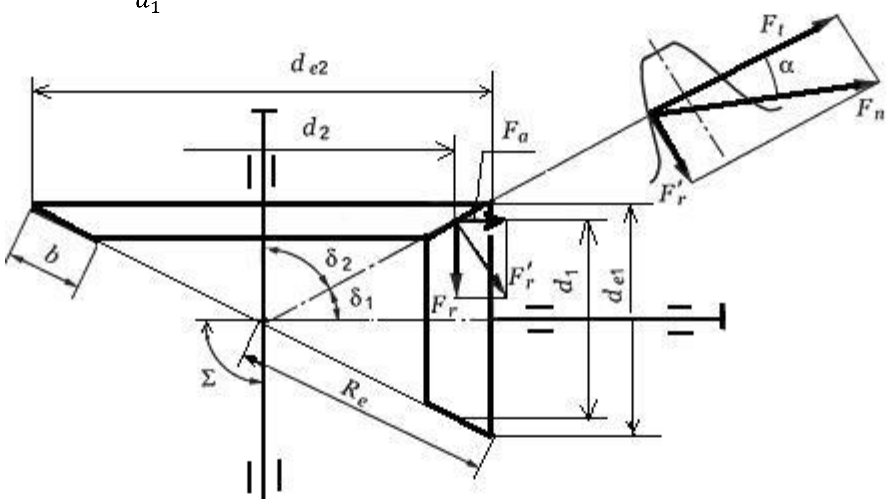

Figure 2. Scheme of the action of forces in the engagement of bevel gears.

For the wheel, the direction of forces is opposite, while:

$$F_{t2} = F_{t1};\ F_{r2} = F_{a2};\ F_{a2} = F_{r2}$$

The direction of the circumferential forces F, as in a cylindrical gear, depends on the direction of rotation of the wheels. Axial forces F_a are always directed from the tops of the cones, radial forces F_r -

to the axes of rotation of the wheels. Bevel gears with circular teeth are predominantly used. Compared to bevel spurs, they are less sensitive to the violation of the accuracy of the relative position of the wheels, their manufacture is simpler. The disadvantage of gears with circular teeth is the change in the magnitude and sign of axial forces during reverse. The axis of a circular tooth is an arc of a circle corresponding to the diameter of the cutting head. Cutting teeth of the cutter head provides high performance and low-cost wheels. The angle of inclination of the circular tooth is variable. The angle on the circle of the average diameter of the wheel is taken as the calculated one, usually the Value is chosen based on ensuring smooth engagement.

It is known that the production of bevel gears with circular teeth is carried out on two types of gear cutting machines based on cone and flat-top production wheels. Tapered producing wheels give a theoretically correct geometry of the teeth of the bevel wheels within the accuracy of the machine tools, due to the use of setting the tilting tool spindle to the calculated engagement angle when using cutters with any values of profile angles. But gear cutting machines of this type are structurally complex, expensive and not widely used in mechanical engineering. They are produced in limited quantities by some machine tool firms in industrialized countries. Gear-cutting machines with a flat-top producing wheel, which are structurally simpler and less expensive, are used much more widely. But such machines do not give the theoretically correct geometry of the gear teeth, and therefore the companies that produce these gear cutting machines supply consumers with guidance materials that allow for corrections that reduce the error in the manufacture of gear teeth.

Instructional materials for the use of gear cutting machines with a flat-top producing wheel contain two types of tooth correction. The first type of correction is performed by a gear-cutting tool with cutters having different angles of cutting-edge profiles for cutting the concave and convex sides of circular teeth. This type of correction allows you to compensate for part of the tooth profile deviations.

Due to the wide variety of geometric parameters of gears, gear cutting heads are produced with a certain numbered range of nominal diameter and a normalized numbered range of cutters with established deviations in the cutting-edge profile angles. Since number cutters with a stepped size range do not allow to fully compensate for deviations in the profiles of circular teeth, the instructional materials provide for a second type of correction, by adjusting the settings of the actuators of gear cutting machines. In the manuals for the operation of machine tools, there are schemes for calculating the deviation of tooth profiles according to nomograms for correcting adjustment settings, which make it possible to partially compensate for deviations in the tooth profile. The final correction is made after the operation of running in the bevel gear on the control-running machine by the method of empirical approximation by successive trials and changes in the machine's adjustment settings, which make it possible to obtain the shape of the teeth close to the theoretically correct geometry of the teeth. At the same time, the basis for the acceptance into operation of a conical pair is the criterion for the location and shape of the contact spot of the engagement of the teeth.

From the foregoing, it follows that the exact analytical dependences of the correction of circular teeth for machine tools with a flat-top producing wheel have not yet been established. Thus, for the production of bevel gears with circular teeth that meet high tribologies for the quality of engagement, it became necessary to develop new methods for correcting the production of bevel gears with circular teeth and conduct theoretical and experimental research, therefore, the topic of the dissertation work devoted to solving this problem is very relevant.

Gears, machined with cutters of gear heads and whose cutting edges are profiled according to new dependencies, give the correct contact patch in the engagement of the pair. This circumstance can serve as a basis for revising the known provisions and developing new normative and technical documentation for the geometry of numbered cutters of gear cutting heads. In order to reduce the range of numbered cutters used in the future, it is advisable to develop new methods for setting up and adjusting gear-cutting machines based on the above provisions to obtain the necessary geometry and the correct location of the contact patch in the gear mesh. It is known that correcting the running-in motion in bevel gear cutting machines with circular teeth is the main means of influencing the surfaces of the teeth of the gear being cut in order to give them deliberate deviations in order to obtain the proper dimensions, shape of the contact patch and eliminate deviations that violate the engagement. The introduction of a correction into the setting and adjustment of the gear cutting machine makes it possible to eliminate the difference between the calculated angle along the convex and concave sides of the circular tooth and the stepped numbered row of profile angles of the cutters of the gear cutting tool.

The bevel gear contains a gear and a wheel mounted rigidly on mutually perpendicular shafts, characterized in that the gear and the gear are made composite, including a hub and a rim with teeth, an elastic element is installed between them, in the form of a conical rubber bushing, while taper which are taken equal to the taper, respectively, of the bevel gear and the wheel and are installed opposite to the tapers of the gear six and the wheel.

The disadvantage of this transmission is the lack of absorption of peak values of load fluctuations (torques) on the transmission shafts when using the transmission in the drives of technological machines operating with variable loads. This leads to rapid wear of the teeth of the wheels, high noise, failure of the bearings, thereby reducing the service life of the gear, especially at high speeds.

In another gear train design, gears are mounted on shafts to obtain a variable gear ratio.

The disadvantage of this design is not a high transmission resource due to increased wear of the teeth, as well as the unbalance of the wheels, which leads to vibrations and breakdowns of the transmission elements.

The main disadvantage of the existing transmission design with bevel gears is also the lack of absorption of peak loads on the shafts in technological machines.

In addition, to keep the shafts in equilibrium, more expensive radial-thrust bearings are used as shaft supports, which are out of fear due to variable technological loads.

This design allows some absorption of peak torques. The disadvantage of this design is the lack of absorption of loads in axial directions. This can lead to increased wear of the wheel teeth due to fluctuations in axial forces when the wheels engage.

It should be noted that the value of axial forces in the engagement of bevel gears depends mainly on the angles of the conicity of the wheels. The greater the taper angle of the wheels, the greater the axial force, according to:

$$P_z = ptg\alpha sin\delta$$

where,

p – district force;

δ – bevel gear taper angle;

α – engagement angle.

It can be seen from the formula that with an increase in the angle δ, the value of the axial force Pz increases. There is no Pz absorption in existing bevel gears.

The objective of the invention is the damping of axial forces in bevel gears, thereby increasing the service life of the transmission and, in general, the technological machine. The problem is solved by damping the axial forces during engagement of bevel gears.

The essence of the design lies in the fact that the bevel gear contains compound bevel gears, including a hub rigidly mounted on the shaft, and a rim with teeth between which an elastic element is installed, in the form of a conical rubber bushing, while the taper of which is equal to the taper of the bevel gear , and oppositely installed in the wheel. The tapers of the rubber bushings of the gear and wheel allow the damping of axial forces in the transmission.

The design is too lazy drawing, where, in Fig.1 is a general diagram of a bevel gear.

The bevel gear transmission contains a composite bevel gear 1 including a hub 5 rigidly mounted on the drive shaft (not shown in the figure), a rim 6 with gear teeth 1, between which an elastic element is installed in the form of a conical rubber bushing 4. The taper of the rubber bushing 4 is made equal to the angle δ_1 taper gear 1, in the opposite direction. The gear bevel wheel 2 is also made composite of the hub 8, the rim 7 with the teeth of the wheel 2 and the conical rubber bushing 3. At the same time, the taper angle of the rubber bushing 3 is set opposite to the taper angle δ_2 of the wheel 2.

The bevel gear works as follows. The rim 6 with the teeth of the driving bevel gear 1 receives rotational motion from the drive motor and shaft (not shown in the figure), the hub 5, through the conical rubber bushing 4. When the teeth of the wheels 1 and 2 are engaged, the rotational motion between the perpendicular shafts is transmitted to the rim 7 with teeth and through a conical rubber bushing 3 hub 8 and further to the output shaft. Under the influence of external loads and technological resistances, the load, torques on the bevel wheels 1 and 2 will change. The rubber bushings 3 and 4 absorb the axial forces that occur when the bevel wheels 1 and 2 engage. The values of the tapers of the rubber bushings 3 and 4 are chosen equal to the corresponding tapers of the wheels 1 and 2; their opposite setting is effective and absorbs the damping of the axial forces.

The recommended bevel gear allows an increase in the service life due to the damping of axial forces in the gear.

Bevel gear refers to mechanical engineering and can be used in drives of technological machines operating with variable loads.

The objective of the invention is the damping of axial forces in bevel gears, thereby increasing the service life of the transmission and, in general, the technological machine. The problem is solved by damping the axial forces during engagement of bevel gears.

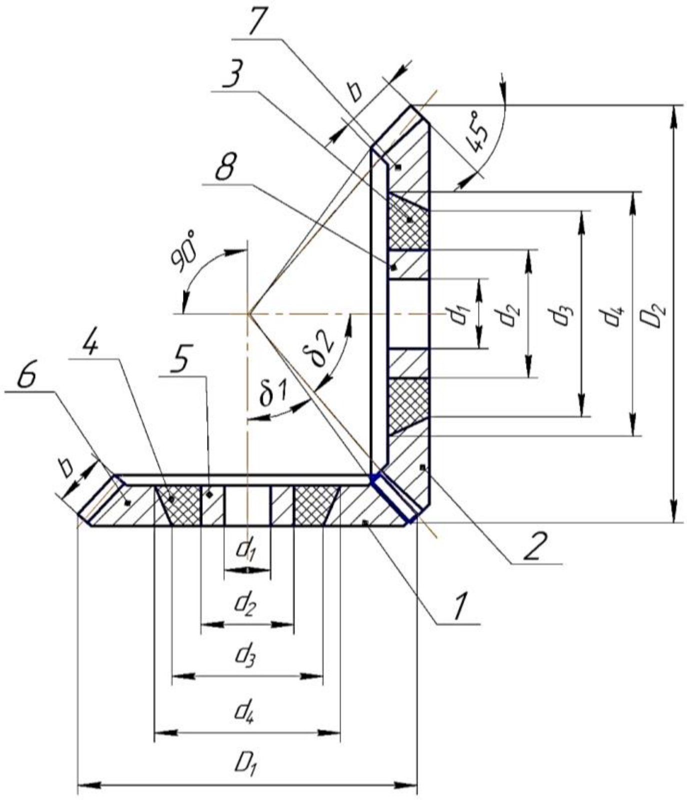

Figure 3. Geometric parameters of the bevel gear.

The essence of the design lies in the fact that the bevel gear contains compound bevel gears, including a hub rigidly mounted on the shaft, and a rim with teeth between which an elastic element is installed, in the form of a conical rubber bushing, while the taper of which is equal to the taper of the bevel gear, and and oppositely installed in the wheel. The tapers of the rubber bushings of the gear and wheel allow the damping of axial forces in the transmission.

The main conclusions and results of the work are as follows:

1. An analysis of the deviation values of the tooth profile, calculated according to the dependence accepted in mechanical engineering and according to the refined dependence, shows significant discrepancies in the deviation values in absolute values, both for the concave and for the convex sides of the circular tooth, which forces us to reconsider the existing calculations of the tooth geometry error and methods for their correction, used as guidelines in the production environment.

2. The obtained formulas for profiling the sides of the cutters of gear-cutting heads made it possible to develop new provisions for choosing the numbers of cutters for high-quality processing of bevel gears on gear-cutting machines. It was revealed that the deviation of the tooth profile takes place along the entire height of the tooth. It has been proven that in order to obtain a more accurate tooth profile, it is necessary to change the geometry of the cutting edges of the cutters of the cutting head. The compensated correction deviation of the profile of the teeth of the cutters in this case should be calculated by the formula, provided that the cutting edges pass the point of the engagement pole of the pair: cut - producing wheels. Gears machined with cutters of gear heads, the cutting edges of which are profiled according to new dependencies, give the correct contact patch in the engagement of the pair.

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