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APPLICATION OF ASYMMETRIC PROFILE IN GEARINGS WITH ECCENTRIC GEARS

Summary. Gearing was designed to meet specific requirement, during one rotation was continuous change of gear ratio. The gearing consists of two identical gears. The basic shape of the wheel is formed by an ellipse. One of the foci is the center of rotation. Wheels are designed for only one direction of rotation. Active and passive side involute curve were created by rolling the basic evoluta elliptical wheel independently. It was used for the production of NC cutting machine for EDM 005 B EIR with managing RS-ER5. This machine allows you to create a constructed shape gears, keeping the necessary accuracy of 0.01 mm and roughness of Ra 1.6 micron. The basic of production, a draft gear was designed using AutoCAD software. Thus follows designed and manufactured elliptical gearing was subjected to the tests and meets all the requirements that were imposed on the gear. Proportion loads of teeth are different from the standard load of circular gears.

Keywords: ellipse, evoluta, continuously variable gear ratio

ZASTOSOWANIE ASYMETRYCZEGO PROFILU ZĘBA W PRZEKŁADNIACH Z NIEKRĄGŁYMI KOŁAMI ZĘBATYMI

Streszczenie. Na podstawie specyficznych wymagań została zaprojektowana przekładnia, która podczas jednego obrotu wału napędzajacego umożliwa ciągłą zmianę przełożenia. Przekładnię tworzą dwa identycznie koła zębate. Podstawowy kształt koła jest elipsą. Jedno z ognisk jest środkiem obrotu. Koła są zaprojektowane tylko do obracania się jednym kierunku. Aktywne i pasywne ewolwenty profilów zębów zostały utworzone niezależnie na postawie odpowiednich fragmentów ewolut eliptycznego koła. Do proukcji została użyta maszyna do cięcia elektroiskrowego NC z zarządzaniem RS-ER5. Maszyna ta umożliwia tworzenie skonstruowanego kształtu kól zębatych przy utrzymaniu wymaganej dokładności 0,01 mm i chropowatości Ra 1,6 μm. Podstawą produkcji było zaprojektowanie koła zębatego przy użyciu oprogramowania AutoCAD. Tak zapjektowane i wyprodukowane przekładnie zębate z kołami eliptycznymi zostały poddane testom i spełniły wszystkie wymogi, które im postawiono. W przypadku przekładni z kołami zębatymi o kształcie eliptycznym w przeciwieństwie do przekładni z kołami zębatymi okrągłymi, wartość siły międzyzębnej znacznie zmienia się w czasie jednego obrotu koła, co wpływa na różne obciążenie poszczególnych par zębów.

Słowa kluczowe: elipsa, ewoluta, przełożenie w sposób ciągły

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1. INTRODUCTION

Based on practical requirements, it was necessary to propose an unconventional toothed gear, with a smooth change in its gear ratio, continuosly repeating in the the range u=0.5 to 2. Another requirement for the gearing was for it to consist of two identical toothed gears with teeth $z_1 = z_2 = 24$, and a module gear $m_n = 3.75$ mm, for a center distance a = 90 mm in one direction of rotation. The designer's final was to create a model using AutoCAD software, thus producing a model serving as the basis for the production of spark machining.

2. PARAMETERS OF THE ELLIPTIC GEARING

Given that each gear must satisfy the conditions of proper meshing, it was necessary to determine the geometric shape of the wheels. The gearing is designed such that the pitch curve is composed of an ellipse formed with the basic parameters shown in Fig. 1. A geometric center of the gear is not the center of wheel's rotation. The center of gear's rotation is in the focus point of the ellipse.

The pitch ellipse has a large half-axis x = 45 mm, which is half of the axial distance. The second half-axis is determined by the distance from the focus point 45 mm (Fig. 1), whose position is determined by considering the desired gear ratio.

In this case, one of the conditions of a correct mesh is that the measurements of the pitch on the ellipse pitch must be kept constant. A geometric separation of the pitch ellipse into 24 identical sections is mathematically much more difficult than in the case with the standard gear pitch circles.

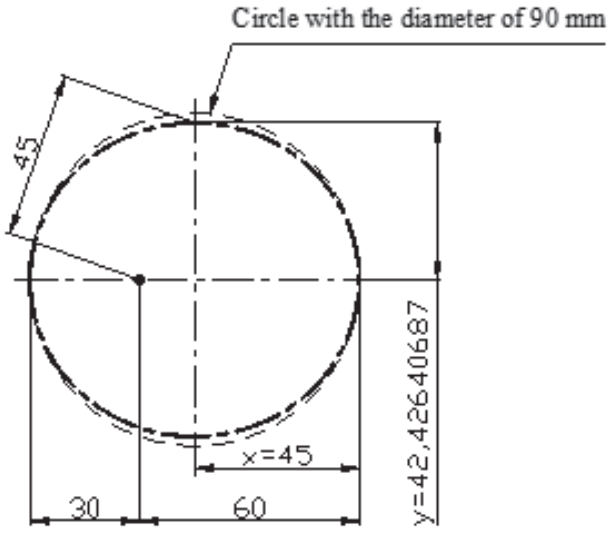

Fig. 1. Determination of dimensions of a pitch ellipse
Rys. 1. Określenie wymiarów elipsy

3. MESH ELLIPICAL GEARING

In pursuit of kinematical conditions of the proposed gearings with eccentrically selected centers of rotation, we start from one of the conditions of a correct mesh, which says that the circumferential velocities in the pitch point are equal and their projections into the profile normal line are the same. The conventional gearing involute starts from the base circle, in

which case it is the base of the evolute of the ellipse. The evolute for the left and right side teeth is not the same. Each of the twelve teeth is different; the next twelve teeth of the same wheel are the same. The side curve is the involute, and is different for active and passive side of the tooth; the teeth are asymmetrical. The geometric model of the proposed gear is shown in Figure 2. Teeth of gearing are numbered; the picture depicts the mesh of the tooth No.2 and No. 10.

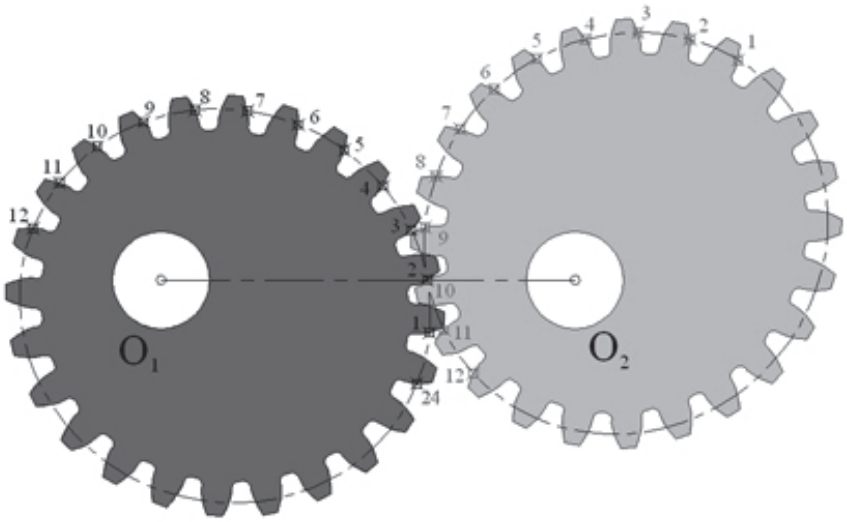

Fig. 2. Mesh gearing for teeth No. 2 and No. 10
Rys. 2. Zazębienie zębów nr 2 I 10

In Fig. 3 is a course of continuously changing gear ratio in one mesh generated by elliptical gear, which continuously varies in the range from 0.5 through 1.0 until 2.0 and back. Thus the gear ratio changes over the time of one revolution. A gear ratio value that is less than 1.0 signifies that this is an overdrive, and a gear ratio value greater than 1.0 signifies a speed reduction.

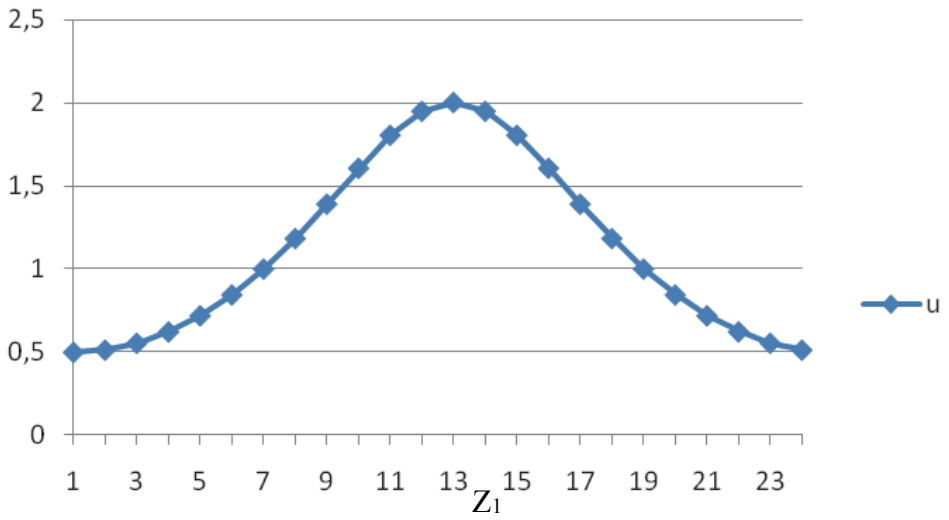

Fig. 3. The course of a transmission ratio
Rys. 3. Przebieg przełożenia

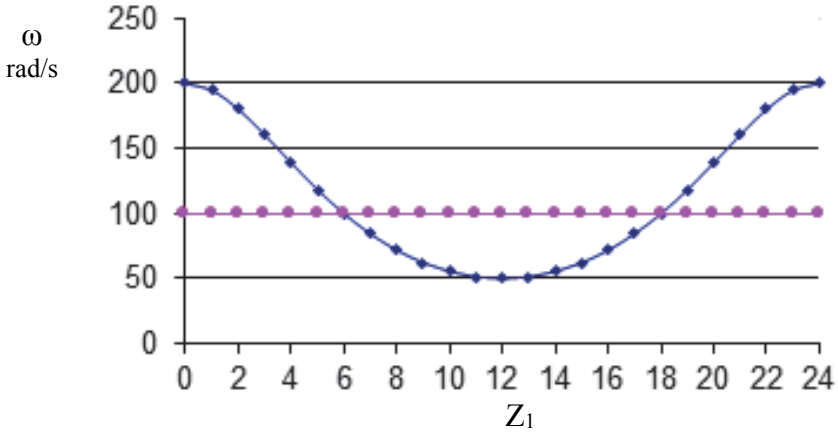

Fig. 4. Illustration of courses of angular velocities ω_1 and ω_2
Rys. 4. Ilustracja przebiegu prędkości kątowej ω_1 i ω_2

Fig. 4 shows the course of the angular velocities for teeth of the created gear, which are numbered by following Fig. 2. An input angular velocity is constant, with a value $\omega_1 = 100$rad/s. Output angular velocity varies according to the continuously changing transmission ratio.

4. MANUFACTURE OF ECCENTRIC GEAR

Technical preparation stage production is secured by company IPSO Košice, which specializes in the development and distribution of CAM systems and NC programming automation and CNC machines. Selecting the optimum mode of production was limited of conditions, such as the number of units produced (was produced only one pair of gears), production should be ensured by technology commonly available in the area and without any expensive products and the costs of development of production and the production function model should be as small as possible.

Based on the above conditions, has been chosen NC EDM machine for cutting (the wire cutter) EIR 005 B management RS-ER5. Although this is older machine manufacturing equipment, machine in question allows the creation of constructed-shaped gears and assure the estimated necessary precision 0.01 mm and roughness of Ra 1.6 μm.

The basic problem was to generate NC code complex shape gear. This code does not allow a common approach when creating NC programs for gears, when is describing the shape of one tooth, which is repeated by the required number of teeth. Answer the purpose 3 methods of preparing NC code.

The first way is programming in the NC machine code. Given the complexity of the shape that requires about 300 blocks this process is complicated and confusing, for this machine is this option practically proves impossible.

The second method was based on the use of existing software support machine. Description of manufactured elliptical wheel contains 48 part rectilinear and circular arcs 192. These elements in this process, it was necessary we define (the circle center, radius, start and end point of the circular arc, etc.), therefore, this method is time-consuming to prepare.

The last method is based on creating postprocessor (Compiler) for the machine in the CAM2000 system, which is designed to automate the programming of NC machines. This option has clearly been the most effective and technically most spectacular way. It was created postprocessor for EDM cutting EIR005B with a control system RS-ER5. His task was to automatically generate NC code for the designed shape gears. In this way it is possible for

a few minutes to create a very comfortable way NC program for any shape of desired profile.

Because the cut length of each sprocket is approximately 532 mm, making of each piece lasted 8 hours at the cutting wire thickness 0.02 mm and a thickness 3 mm of wheel gears. Provided that the thickness of the gear is 15 mm, the production time is increased to 40 hours. Such a method of re-registration (either piece or series) of course is not sufficiently productive. For greater number of gear wheels produced will be necessary to choose a more suitable production technology.

For the production of the elliptical gear may be application of method of powder metallurgy. Powder metallurgy products are currently called. "Economically efficient" products because of their price compared to parts produced for example cutting operation can be up to 25-50% lower. Powder metallurgy is characterized by the use of the material up to 95% in the manufacture of components "on - done" no cost to tool machine. Powder metallurgy is one of non-waste technology. She has the character of a closed cycle. Its output is already a finished product ready for installation. For it is characterized by up to 50% energy savings and up to 75% saving on wages. This method is suitable for series huge and large-scale production.

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5. CONCLUSION

Gears for specified gearing with time - change of gear ratio was to be designed as elliptical, so that the conditions correct image. In program AutoCAD was created by one elliptical gear. This gear was the basis for making us the gear designed for the specified parameters.

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