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THE ASSESSMENT OF THE LOAD DISTRIBUTION AT THE INDIVIDUAL CIRCULATION WHEELS IN THE PLANETARY GEAR WHICH ARE WORKING IN THE DRIVE SYSTEMS OF MINING MACHINES

Summary. The investigation method which allows to estimate the load distribution at the individual circulation wheels in a planetary gear is presented. The investigations by statistical load were made. For the measurement of the tooth deformation the strain gauge were applied. This method to investigation the prototype planetary gear is recommended.

1. INTRODUCTION

In the paper the method which allows to estimate the load distribution at the individual circulation wheels in a planetary gear is presented.

The propose investigations have static character and can be made in the laboratory. The present method can help by the correctness estimate of the constructive solution of planetary gear. In particular it can be useful to the prototype investigations. Moreover by using this method the load distribution on the width of gear can be assessed. It is synonymous with the estimate of technological errors and deformations, which are made by load the elements of the investigated gear.

The verification of the propose method was made in the laboratory of The Institute of Mining Mechanization, Silesian Technikal University. As the object of investigation there were the prototype planetary, gear of the type 2K-H and with the power rating 55 kW.

2. THE AIM AND THE METHOD OF INVESTIGATION

It is known, that in the correct constructed planetary gear the load distribution on the individual circulation wheels should be uniform. It can be assure by the correct constructive solution. The easiest way to obtain the uniform load distribution is in the gears with three ways (three planetary wheels). Therefore such gears are the most often applied and they are the subject of the further consideration. The uniform load distribution on the three ways can be obtained by the freedom assurance of theradial movement of the one unit 1, what can be realized by several means:

- the sun gear is not bearing, has the freedom of the radial movement, so the forces which proceed from the collaboration with three circulation wheels are self - acting equalized,
- the great wheel with internal gearing can radial displace, to this moment, when the load from the three circulation wheels are equalized,
- the planet wheels are bearing in the mechanism which malce possible the displacement of this wheels in the adequate direction, so the load is equalized,
- the internal gearing wheel and the sun gear have the possibility of simultaneous displacement with regard to planet wheels, this shortened the time of wheels relative setting and decreased in such way the walue of dynamical forces,
- the fix planet wheel shackle has the freedom of radial displacement, which effects the equalization of the walue of forces which are acting at the three planet wheels.

The constructional solutions are applied, in which the mutual position of wheels axies is constant, which can be the reason of great overloads the planet wheels. It should be remembered that in each case, independent of the constructional solution it can be expected the overload of the one planet wheels. In the strength calculations the overload is taking into consideration by introduce the non - uniform distribution coefficient of the planet wheels,load, which is a ratio between real maximum load on the wheel and the nominal value which results from the assumption, that the wheels are uniform loaded

$$K_o = \frac{P_{max}}{P_{nom}}$$

On the non - uniform distribution of load in the planet gear have influences: the execute errors (the class of exactness), the assembly errors, the constructional solutions. If it will be assess the global in-

fluence of these factors it is proposed to make statical investigations on the stand. The diagram of the stand is presented in fig. 1.

It is shown that the propose stand is composed from the investigate and auxiliary gears, the driving motor, the brake and the measuring - registration apparatus.

The investigate and auxiliary gears must be connected with coupling, which halves are settled at the output shafts. The driving system with the brake have to be such choosen, that the wheels of the investigated gear are quassistatic loaded. At the teeth with internal gearing on the parimeter the resistance strain gauge converters are uniform sticked. On this same tooth they are sticked two strain gauges at the two sides of the face in the place, where it is hoped the greatest deformation (fig. 2).

It is proposed at least to stick six strain gauges from one side. The compensation strain gauge has to be sticked at a separate steel plate, which in the measure time should to be in the direct neighbourhood of the investigated gear. The system to the measurement of the tooth deformation is presented in fig. 3.

The output signals which are obtained by using Wheatstone's bridge, are called out through the tooth deformation, are amplified through the amplifier and are carried off to the measuring - registration - apparatus. For the "fundamental" measure it should be made the marking of the sticked strain gauges. It can be such done, that the teeth with sticked strain gauges are loaded with a known load which is uniform distributed on the tooth length. In the time of marking the signal value called by known load is every time read and is attribute to definite strain gauge.

When the investigation stand, the measuring apparatus are prepared and it has been given the "model" signal values from each strain gauge, then the measure which allows to define the load distribution at the separate planet wheels can be made. When the investigated gear is loaded by the nominal load (it can be used load with other value), the position of planet wheels which teeth in turn gearing with the teeth of internal gearing, also with these on which the strain gauge are sticked, is changed.

In such means in turn from each strain gauge they are obtained signals, which inform us about the loading of the meshing pair of teeth.

Attribute to each planet wheel and each strain gauge the adequate symbol, it can be subordinate the registrated signals to the adequate pairs (fig. 4). By this, from the same pair it can be obtained two signals, which make possible by the results interpretation to take into consideration the errors of the adheison of the collaboration teeth.

It is known, that for the one case it has to be done so many measurements, that the results could be statistically treated. The obtained by the measurement and statistically treated signal values have to be treated as a loading measure of the tooth gear with internal meshing, through

each planet wheel of the gear. It means that the obtained signals inform us about, which load transfers the determinate planet wheel in the determinate position. From this it can be inferenced about the load distribution on respective planet wheels in their different position with regard to the wheel with internal meshing.

In fig..5 it is presented as an example the course of signals from the strain gauge which are obtained in the meshing time of the meshing of the teeth from three planet wheels with determine tooth of internal gearing wheel. The results from revision experiments and their interpretation are presented in paper 2.

3. CONCLUSION

- The propose method in sufficient means allows to define which load distribution is at the separate planet wheels in the planetary gear, when it is statical loading.
- Using this method it is additional obtained the information about the load distribution along the tooth line.
- The measuring - registration apparatus, which have to been used in this propose investigation method is general accessible and easy to service.
- The present results did not present the dynamical phenomenon which are treated in the work of a gear. But it must be underlined, that this method can be adopted to the dynamical investigations.
- In particular the prototype gears should be investigated by using this method.

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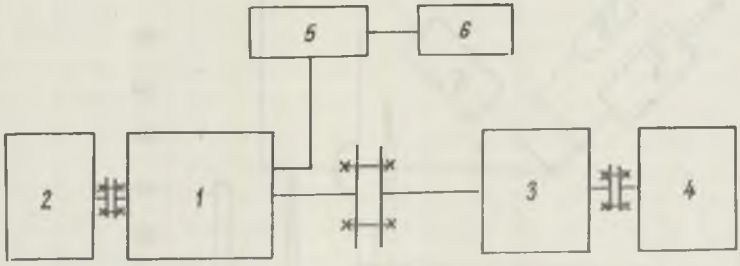

Fig. 1. The scheme of investigated stand

1 - the investigate planetary gear, 2 - the brake, 3 - the auxiliary gear, 4 - the driving system, 5 - the measuring apparatus, 6 - the registration apparatus

Rys. 1. Schemat stanowiska badawczego

1 - badana przekładnia planetarna, 2 - hamulec, 3 - przekładnia pomocnicza, 4 - układ napędowy, 5 - aparatura pomiarowa, 6 - aparatura rejestrująca

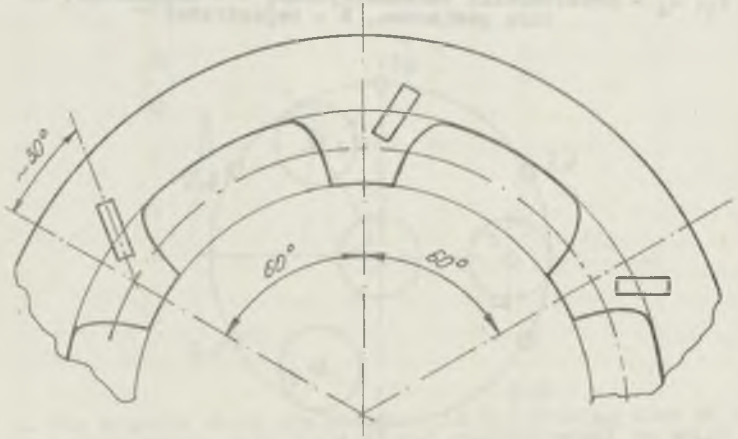

Fig. 2. The distribution of the strain gauge converters on the internal meshing wheel

Rys. 2. Rozmieszczenie przetworników tensometrycznych na kole o zazębieniu wewnętrznym

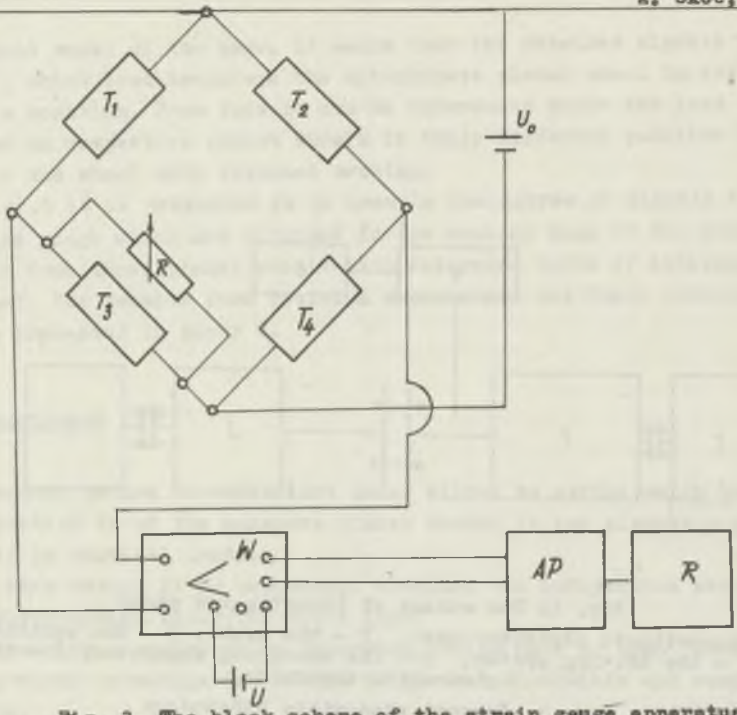

Fig. 3. The block scheme of the strain gauge apparatus

T_1, T_2, T_3, T_4 - the strain gauge convertors, W - amplifier, AP - measuring apparatus, R - registration apparatus

Rys. 3. Schemat blokowy aparatury tensometrycznej

T_1, T_2, T_3, T_4 - przetworniki tensometryczne, W - wzmacniacz, AP - aparatura pomiarowa, R - rejestrator

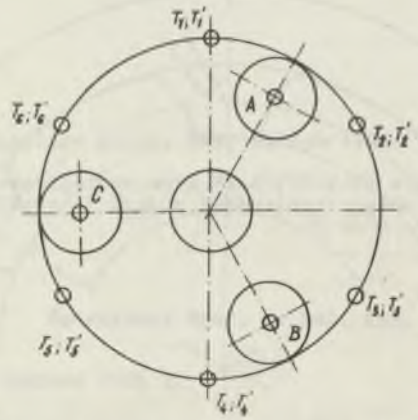

Fig. 4. The scheme of the position of the planetary wheels with regard to the sticked strain gauges

Rys. 4. Schemat przedstawiający kolejne położenie kół obiegowych względem naklejonych tensometrów

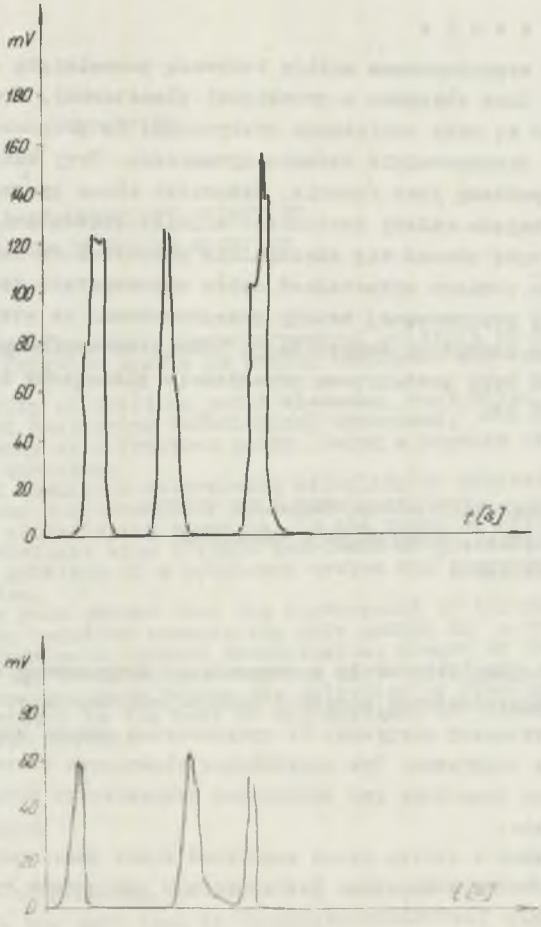

Fig. 5. The signals which are obtained in the meshing time of the successive planetary wheels with the internal mashing wheel on which strain quages T_1 and T_1' were placed

Rys. 5. Sygnały otrzymane w trakcie zazębiania się kolejnych kół obiegowych z zębami koła o zazębieniu wewnętrznym, na których naklejone są tensometry T_1 i T_1'

OCENA ROZDZIAŁU OBCIĄŻENIA NA POSZCZEGÓLNE KOŁA OBIEGOWE W PRZEKŁADNIACH PLANETARNYCH PRACUJĄCYCH W UKŁADACH NAPĘDOWYCH MASZYN GÓRNICZYCH

S t r e s z c z e n i e

W artykule zaproponowano metodę badawczą pozwalającą ocenić rozdział obciążenia na koła obiegowe w przekładni planetarnej. Proponowane badania przeprowadzone są przy obciążeniu statycznym. Na proponowanym stanowisku można również przeprowadzić badania dynamiczne. Przy badaniach statycznych układ napędzany jest ręcznie, natomiast chcąc prowadzić badania dynamiczne, do napędu należy zastosować silnik. Przedstawiona w artykule metoda badań może okazać się szczególnie przydatna do badań prototypów przekładni. Do pomiaru odkształceń zębów wykorzystano tensometry.

Weryfikację proponowanej metody przeprowadzono na stanowisku badawczym w Laboratorium Instytutu Mechanizacji Górnictwa Politechniki Śląskiej. Obiektem badań były prototypowe przekładnie planetarne typu 2K-H o mocy znamionowej 55 kW.

ОЦЕНКА РАЗДЕЛЕНИЯ НАГРУЗКИ НА ОТДЕЛЬНЫЕ КОЛЕСА ПЛАНЕТАРНЫХ ПЕРЕДАЧ, РАБОТАЮЩИХ В ПРИВОДНЫХ СИСТЕМАХ ГОРНЫХ МАШИН

Р е з ю м е

В статье предлагается метод исследования, позволяющий оценить разделение нагрузки на циркуляционные колеса в планетарной передаче. Испытания проводятся при статической нагрузке. На предлагаемом стенде можно также проводить и динамические испытания. При статических испытаниях система приводится в движение ручным способом; при проведении динамических испытаний следует применить двигатель.

Представленный в статье метод испытаний может быть особенно полезным при испытаниях прототипов передач. Для измерения деформации зубьев использовались тензометры.

Верификация предлагаемого метода проведена на испытательном стенде в лаборатории НИИ механизации горного дела Силезского политехнического института. Объектом испытаний были первоначальные образцы планетарных передач типа 2К-Х с номинальной мощностью 55 кВ.