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APPLICATION OF TECHNO - ECONOMIC CRITERION FOR ADOPTION SHAFT - HUB GEAR JOINT

SUMMARY. Gear modelling is being carried out in three stages: hub gear modelling, body gear modelling and footed rim modelling. In the paper is given segment in the process of gear modelling - hub gear modelling which is applied in the program modulus ZPS4. The shaft - hub gear joint can be carried out in different ways. Shaft - hub gear adoption is very important designers decision. In the paper is given the adoption of techno - economic criterion for adoption shaft - hub gear joint.

1. INTRODUCTION

The hub dimensions, width and diameter don't depend on the rim gear dimensions, but depend on the support shaft diameter dv. The hub shape depends on hub gear - shaft connection. Adoption, shaping and shaft - hub gear designer's everyday assignment. Calculation and shaping of shaft - hub gear joint can be found in many papers, in the structure of gears hub gear - shaft joint is to provide transmission of torque and axial load which exists between shaft and gear. The construction of this zone modelling can be carried out in different ways by appropriate technical and geometric requirements.

Considering the aim of each producer to manufacture gear for transformation mechanical energy i.e. in adaptation of motor energy to the working machine needs but production expenditure to be less as possible, because of that the adoption of shaft - hub gear joint is carried out on the basis of techno -economic criterion.

Techno - economic optimum means:

- technical requirements (torque, built - in area etc.) are at least fulfilled,

- economic expenditure (production expenditure) are minimum at appropriate technical requirement fulfilment.

By means of shaft - hub gear joints mechanical elements - gears perform the function as transmission of torque, transmission of turning movement or transmission of axial and radial loads. Shaft - hub gear joint renders impossible relative movements in radial direction and in peripheral velocity direction. Relative axial movement between shaft and the hub gear by means of special solutions can be made possible or impossible. More comply problem is transmission of torque from the shaft to the gear and opposite.

Torque transmission is carried out in three mays as follows:

1. By means of sliding resistance between shaft and hub gear
- cylindrical press fit
- conic press fit carried out in classical way - by hub gear heating, shaft cooling respectively
- conic press fit carried out by means of oil under the pressure.

2. By means of shape of connected surfaces
- groove joint

3. By means of special element
- key joint.

2. TECHNO - ECONOMIC CRITERION FOR SHAFT - HUB GEAR JOINT ADOPTION

The research results [1] built in the programme modulus ZPS4 for shaft - hub gear joint adoption are valid depending on the way of connection, for the shaft diameter that is hub gear d_v = 20...500 mm, quantity of production n_i = 1...100, shaft - hub gear joint (SHG) and shaft - hub gear width, diameter ratio b_g/d_v = 0.1...1.5.

In the figure 1, is given the sphere of application the following shaft - hub gear joints in the function of shaft - hub diameters which were put in programme modulus:

1. joint performed by key
2. groove joint
3. joint performed by cylindrical press fit
4. joint performed by conical press fit (classical way)
5. joint performed by press fit (oil under pressure).

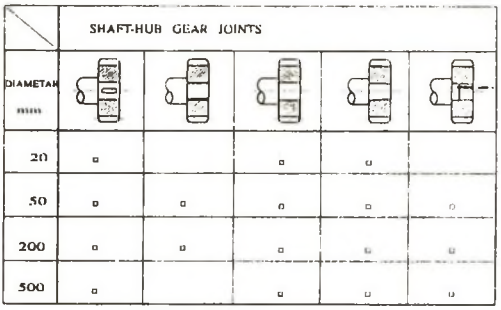

Fig. 1

In the figure 2 is shown algorithm of the programme modulus ZPS4 which refers to the adoption of shaft - hub gear joint.

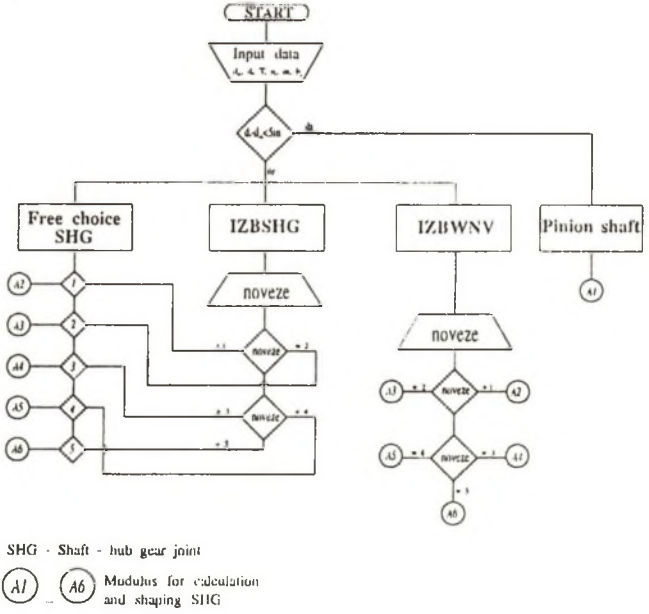

Fig. 2

The torque transmitted by shaft - hub gear joint is not limited. Any value of the torque can be transmitted by any above mentioned shaft - hub gear joint. From the other hand the customer's requirement for shaft - hub gear joint to be performed by key is absolutely limited. Because of that

in the modulus for adoption of shaft - hub gear joint is given free choice possibility and techno - economic criterion is excluded.

If programme adopts the shaft - hub gear joint the customer is supposed to have two possibilities:

- adoption of joint for determined shaft diameter, hub gear diameter d_v, width of hub b_g and the number of joints n_i on the basis of minimum cost for shaft - hub gear performance,
- adoption of joint for determined torque which is transmitted by means of shaft - hub gear joint on the basis of minimum cost.

The first case of shaft - hub gear joint adoption with known geometric characteristics (hub gear diameter d_v and hub gear width b_g) with the number of joints that should performed n_i, by expression (1), it is possible to calculate costs UK_i, is valid $b_g/d_v = 1$, $d_{v0} = 50$ mm, $d_{vi} = 20...$ 500 mm (max.) depending on performed joint and $n_i = 1...100$ joints.

$$UK_i = UK_0 \cdot \left\{ A_0 + A_1 \cdot \left(\frac{d_{vi}}{d_{v0}} \right)^{E_1} + \left[A_2 + A_3 \cdot \left(\frac{d_{vi}}{d_{v0}} \right)^{E_2} \right] / n_i \right\} \qquad (1)$$

Expression (1) valid for $b_g/d_v = 1$, d_{v0}=50 mm, $d_{vi} = 20...500$ mm, $n_i = 1...100$ joints. The values of the constant A_0, A_1, A_2, A_3 and exponents E_1, E_2 are given in [1]. In case $b_g/ d_v \neq 1$, the cost of shaft - hub gear joint performance UK_i should be multiplied by the factor of the relative cost RK_i calculated by the expression (2)

$$RK_i = 1 + \left(\frac{b_{gi}}{d_{vi}} - 1 \right) \cdot \left[\left(C_1 \cdot \frac{d_{vi}}{d_{v0}} \right)^{F_1} + C_2 \cdot n_i^{F_2} \right] / \left(C_3 \cdot n_i^{F_3} \right) \qquad (2)$$

$$UKT_i = UK_i \cdot RK_i \qquad (3)$$

Expression (2) is for $d_{vi} = 20...500$ mm depending on the type performed joint, b_{gi}/d_{vi} =0.1...1.5, $n_i = 1...100$. The values of constants C_1, C_2, C_3, and exponents F_1, F_2, F_3, are given in [1]. Criterion for adoption is that performed joint is less expensive UKT_i and fulfilment all above mentioned limits.

The second possibility that program gives to the user is adoption of shaft - hub gear joint on the basis of relative cost in the function of torque transmitted by this joint . In the figure 3. is given the change of relative costs in the function of torque for above mentioned shaft - hub gear joint covered by program.

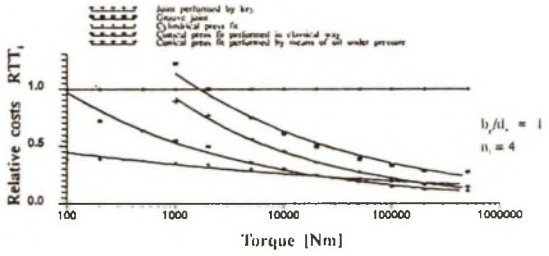

Fig. 3

The shaft - hub gear joint, very often requires fulfilment some particular requirements as follows:

-easy disassembling

-minimum costs VG

-minimum assembly costs

-selfcentering

-possibility of torque transmission

-little concentration of tension of shaft - hub gear joint.

Having introduced the disassembling factor (f_d), factor of costs (f_{tr}), factor of assembly costs (f_m), selfcentering factor (f_s), torque transmuting factor (f_t) and tension concentration factor (f_z) relative costs of shaft - hub gear joint can be calculated according to expression (4)

$$RT_i = \frac{RTT_i}{f_d(i) \cdot f_{tr}(i) \cdot f_m(i) \cdot f_s(i) \cdot f_t(i) \cdot f_z(i)} \qquad (4)$$

where: RTT_i - relative costs in the function of torque.

The values of above mentioned factors are given in the chart 1 and are in valid for $b_g/d_v = 1$, $n_i = 4$ and $d_v = 50$ mm.

The shaft - hub gear joint is suppose to fulfil all features, someone or none. In the case of not taking in consideration some of the features of shaft - hub gears joint, appropriate factor has value 1. For ratio $b_g/d_v \neq 1$, $n_i \neq 4$ and $d_v \neq 50$ mm, relative costs RT_i should be multiplied by relative costs factor RK_i, according to expression (5)

$$RTR_i = RT_i \cdot RK_i \qquad (5)$$

Chart 1

	SHAFT-HUB GEAR JOINTS				
					
f_1	1.0	1.0	0.2	0.2	0.9
f_2	0.5	0.2	1.0	0.7	0.5
f_3	0.5	0.75	0.3	0.3	0.7
f_4	1.0	0.75	1.0	1.0	1.0
f_5	0.3	0.75	0.5	0.75	0.75
f_6	0.5	0.2	0.75	0.8	0.8

Criterion for adaptation is that foreseen shaft - hub gear joint provides minimum relative costs RTR_i by fulfilment all above mentioned limitations.

In the figure 4 is given algorithm for adoption of shaft - hub gear joint for the case of the least costs taking into consideration torque that should be transmitted by given joint and features which should comprise that joint.

3. THE RESULTS OF APPLICATION TECHNO - ECONOMIC CRITERION FOR SHAFT - HUB GEAR JOINT ADOPTION

All mentioned ways chapter for shaft - hub gear joint performance have certain shortages which affect on quality of gear transmission as well as its price. These shortages are particularly apparent at the large gear power of special application (roto - excavator driver wheel, ship gears, gears in metallurgy, in chemical industry etc.) where the mass gear is rather big (over 5000 kg). The hub machining for key as mounting of gear is very difficult as because of big mass as big dimensions.

Besides heating of hub needs special tools and makes this procedure to be more expensive. The application of techno - economic criterion for shaft - hub gear joint at the huge power gears as a result is conic press fit which is carried out by the oil under pressure.

In that case the new procedure of rigid joint performance by conic press fit by means of oil under pressures is implemented. This procedure is convenient for fitting the gear because beside providing futile joint enables easy assembly and disassembly which is very important with these gears. On the basis of this procedure in MIN has been manufactured larger number of gears and

shafts where is the joint between hub gear and shaft carried out by conic press fit oil under pressure.

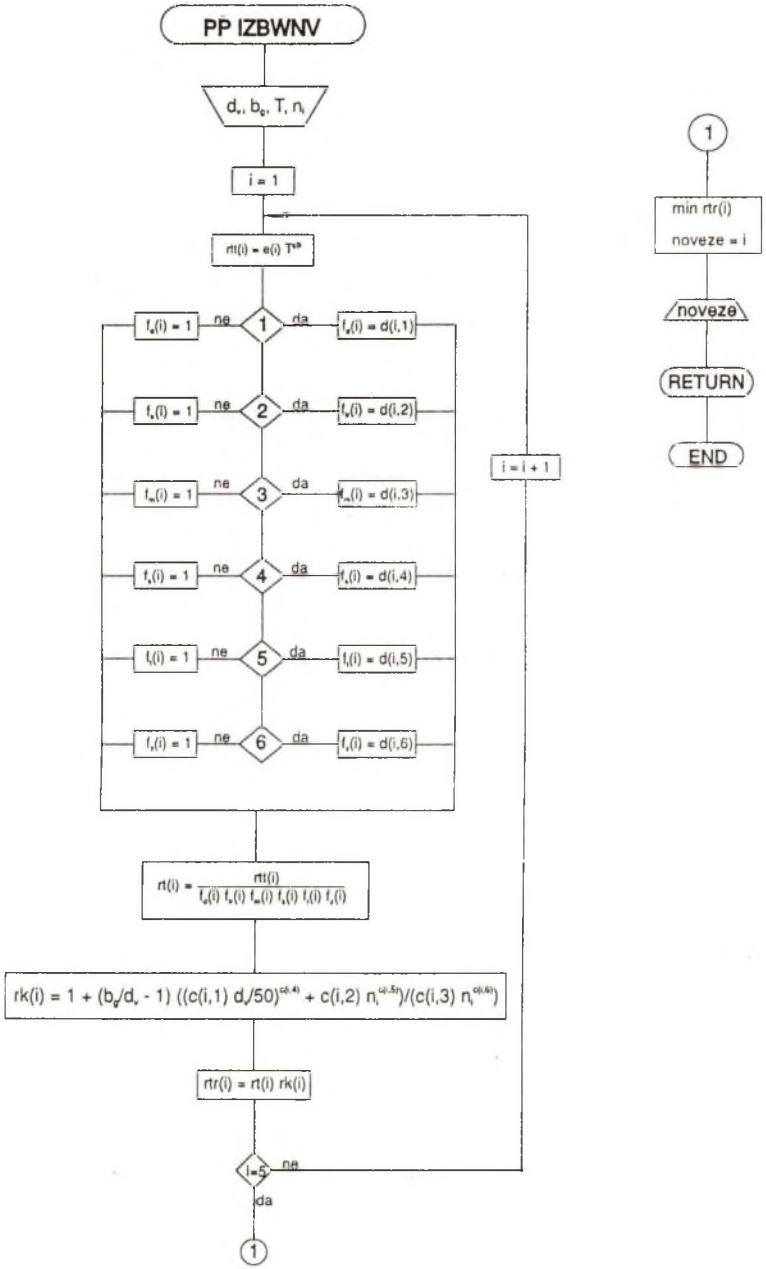

Fig. 4

The most important gears are:

- gears for shipyard crane motions
- gears for rolling mills
- gears in chemical industry
- gears for roto - excavator and stackers

On the basis of this procedure in MIN has been manufactured a larger numbers of gears fitted on the cranes for drive travelling and showed good results. Beside them larger number of gears has been manufactured for conveyer, different mine equipment (roto - excavator, stocker...).

4. CONCLUSION

The shaft - hub gear joint can be performed diferently. At modelling process of hub gear very important decision is adoption of shaft - hub gear joint. In the paper has been given application of techno - economic criterion for shaft - hub gear joint adoption.

On the basis of such performed analysis on the huge number of gears which have been manufactured in MIN the shaft - hub gear joint accomplished by means of conic press fit using the oil under the pressure.

5. REFERENCES

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Revised by: Jan Kaźmierczak