DEVELOPMENT, MANUFACTURING AND INTRODUCTION OF NEW CONSTRUCTIVE SOLUTION OF TRANSMISSION MECHANISM

РАЗРАБОТКА, ИЗГОТОВЛЕНИЕ И ВНЕДРЕНИЕ НОВОГО КОНСТРУКТИВНОГО РЕШЕНИЯ ПЕРЕДАТОЧНОГО МЕХАНИЗМА.

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Abstract: *It was developed, studied, manufactured and tested new designs of multistage gearboxes on the two shafts with cylindrical gears, providing virtually unlimited value ratios. This reduces metal consumption, improved reliability and efficiency by the eliminating in the mechanical system of the intermediate shafts and their support units, to provide a set of agreed most effective technical solutions and create new machines and units at the level of the best world samples*
KEYWORDS*: TRANSMISSION MECHANISM, PACKET GEAR, SCHAFT SPEED*

1. Introduction.

Gear reducers are widely used in machines and units in almost all branches of modern engineering.

The use of low-power and high speed electric motor drives, allowing to reduce energy consumption as a whole, and by the extreme operating conditions of machines and units depends on the number of stages and gear ratio value of gear reducers.

Therefore it is very important to finding the most efficient kinematic scheme of multi-gear reducers, taking into account not only the external (consumer) characteristics, but also its cost [1-3].

The department "Machine parts" of Azerbaijan Technical University developed, studied, manufactured and tested new designs of multistage gearboxes on the two shafts with cylindrical gears, providing virtually unlimited value ratios, which originality was confirmed by the Eurasian patent. This reduces metal consumption, improved reliability and efficiency by the eliminating in the mechanical system of the intermediate shafts and their support units, to provide a set of agreed most effective technical solutions and create new machines and units at the level of the best world samples [4-7]

To confirm the theoretical assumptions were made laboratory working model of a new constructive solution to single-threaded five-step gearbox with a total transmission ratio $U_{\Sigma}=243$ (Fig. 1)

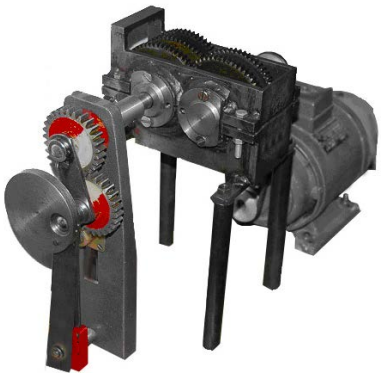

Fig. 1. *Laboratory sample of the new constructive solutions of three-stage cylindrical gear reducer with a gear ratio $U_{\Sigma}=243$*

A distinctive feature of the proposed gear is that all the intermediate shafts are eliminated in this mechanical system, in all stages drive and driven gears are the same size, that it provides increased reliability and manufacturability. The structure of the gear working as a coaxial transmission mechanisms includes, freely rotated on the driving and driven shafts, one three and two double corona gears, mounted in the form of a "packet". The rotation direction of three and double corona gears wherein respectively coincide with the rotation direction of the driving and driven shafts. Due to the specific useful direction of the friction force of lubricating fluids on the cylindrical and side surfaces of the structural pars of “packet” gear its efficiency is increased up to 8%, and thus achieved a reduction of electricity consumption.

The proposed transmission gears in the future called "packet reducers" that has been recognized in several international conferences [8, 9].

Further, according to initial data of the drive rod pumps and based on normative requirements for water wells depth of 40 m and an oil well to a depth of 1,500 m (for sucker-rod pump SKD3-1,5-710) have been designed, manufactured and successfully industrially tested two double-flow three-stage cylindrical gear reducers on two shafts, with the transmission ratio $U_{\Sigma}=64$ (Fig. 2, 3).

Fig. 2. *Mechanical drive rod pumps for water wells depth of 40 meters with a new constructive solution double-flow three-stage cylindrical gear reducer with a gear ratio $U_{\Sigma}=64$.*

Fig.3. *Mechanical drive rod pumps for oil well depth of 720 meters in relation to the SKD 3-1,5-710 with the new double-flow constructive three-stage cylindrical gear reducer $U_{\Sigma}=64$.*

2. Methods

For the using in mechanical drives of machines and units of relatively high-speed and low power consumption electric motors significant practical importance has the evaluation of critical rotational speed of the drive shaft of the new constructive solutions of three-stage double-flow "packet gear".

We consider the drive shaft gear batch on two bearings with a rotating speed $n_1^{"}$. The drive shaft is represented as a stage rotor with a fixed gear and symmetrically arranged double corona gears rotating around its geometric axis and downloaded randomly distributed masses and moments of inertia [10].

Approaching of the shaft rotation frequency to the critical can be dangerous, so the rotation frequency from $0,7n_{kr}$ to $1,3n_{kr}$ not recommended for the operating modes of packet gear. In this connection, in all cases it is desirable to provide an operation of packet gear with a rigid drive shaft and $n<0,7n_{kr}$.

To check the reliability of the basic scientific statements made numerical experiment – calculation of the drive shaft of two-stage double-flow packet gear for the sucker-rod pumps SKR3 and SKDR with the following input data:

- Nominal torque at the output shaft T^{*}=7100Nm;
- Actual gear ratio of the reducer $u_{\Sigma}=64$, the gear ratio of one stage of package reducer $i_n=4$;
- Output shaft diameter $d^{'}$=90 mm;
- Based on design reasons the diameter of input shaft on its mid taken d_1=0,5$d^{'}$=45 mm; thereafter d_2=40 mm; d_3=40 mm; d_4=35 mm;
- Diameter of the initial circle of gear d_{w1}= 117 mm;
-Coefficient characterizing the ratio of the width of the respective stages of the output shaft ν=0,5;
- Torsion stress of the output shaft $[\tau]_k$=40 Mpa.

The first approximation for the critical speed of the drive shaft is determined according to the formula

$$n_{kp}=C\left(\frac{y_{(0)}}{K_{y(0)}}\right)^{\frac{1}{2}}\Bigg|_{x=\frac{1}{2}}=9,55\left(\frac{1}{367,2773}\right)^{\frac{1}{2}}10^4=4983,18,\quad rpm$$

Recommended rotation frequency of the drive shaft of packet reducer

$$n<0,7n_{kr}=3488,23\ rpm$$

Where

$$y(0)=-\frac{1}{L}\int_0^L\int_0^{x_1}\frac{M(x_2)}{EJ(x_2)}dx_2dx_1-\frac{x}{L}\int_0^L\int_0^{x_1}\frac{M(x_2)}{EJ(x_2)}dx_2dx_1$$

$$K_y=\left|\int_0^L\int_0^{x_1}\frac{A_y(x_2)}{EJ(x_2)}dx_2dx_1-\frac{x}{L}\int_0^L\int_0^{x_1}\frac{A_y(x_2)}{EJ(x_2)}dx_2dx_1\right|$$

M(x)- discrete mass, *EJ(x)*- stiffness of the shaft section in bending.

3. Conclusion and results

1. Compared with the existing multi-stage cylindrical gears classical performance in the proposed new designs of multi-stage packet gearboxes operational and technological parameters (reliability level increased up to 8%, efficiency - up to 9%, metal content reduced up to 30%) are improved.

2. A new analytical expression to determine of critical rotational speed of the drive shaft of the new constructive solutions of three-stage double-flow "packet gear" have been improved, which has undoubted practical value by the using of low-power motor with high rotational speed of the drive shaft *n*=3000 rpm.

3. Kinematic and design features of packet gear boxes allow to obtain the minimum value of the output shaft speed (n=1 rev/day), which enabled their widespread use in the mechanical drives of monitoring systems and radars.

References

1. Bolotin V.V. Recourse of machines and structures. – M, Engineering, 1990, 446 p.

2. Adonin A.N. Oil extraction with sucker rod pumps.- M., Nedra, 1979, 213 p.

3. Molchanov G.V., Molchanova A.G. Machines and equipment for oil and gas extraction. - M, Nedra, 1984, 464 p.

4. Abdullayev A.I., Najafov A.M., Qasimov R.M. «Mechanical drive of sucker rod pumps». Patent of Eurasian Patent Organization № 012103, F04B 47/02, Moscow, 2009.

5. Abdullayev A.I., Najafov A.M. «Three-stage double – flow gear reducer». Patent of Eurasian Patent Organization № 07053, F04B 47/02, Moscow, 2012.

6. Abdullayev A.I., Najafov A.M. «Qualitative assessment of technical level of packet gears» // Journal of Engineering, Moscow, №12, 2008, pp. 6-9.

7. A.M. Najafov, A.I. Abdullayev. "Optimizing Modular Gears in the Mechanical Drive of Beam Pumps". / Russian Engineering Research, New-York, USA, 2009, Vol. 29, №1, pp.7-9, ISSN 1068-798 X.

8. Abdullayev A.I., Davidov G.Sh., Najafov A.M., Hamidov N.R. Establishment and evaluation of technical level of packet gear. Сбор. докл. Межд. Конгр. «Mechanics and tribology of traffic systems 2003», Rostov on Don, 2003, pp. 14-17.

9. A.M. Najafov, A.I. Abdullayev. "The new constructive decision of a mechanical drive of sucker-rod pumps". / Int. Symp. on Engineering & Architectural Sciences of Balkan, Caucasus & Turkish Republic, 22.-24.10.2009, Isparta/Turkey, Vol.2, pp.88-93.

10. Birger I.A., Shorr B.F., Iosilevitch G.B. Calculation of the strength of machine parts. – M, Engineering, 1990, 446 p.