A NEW KINEMATIC SCHEME OF THE MULTILINE QUASI-DIFFERENTIAL MULTITURNAROUND ELECTRIC DRIVE OF PIPELINE GATE VALVES

Kukhar V.D., Pashin A.A.**, Raspopov V.Y.***, Sabo Y.I.****, Sidorov P.G.******

ABSTRACT

The main disadvantage of power transmission based on single and multiline planetary gears with an output to the carrier is a narrow range of reproducible transfer function in a single step, which is limiting their application area and requires the use of other technical solutions to the multiline transmission. The above drawback is completely eliminated in the new two-stepped indivisible multiline transmission {Patent RU №2402707 from 08.10.2008} with an input to the carrier via high-speed gear and output to a large central wheel. The aim of this work – to show the possibility of new technical solutions for power transmissions, to show the pecularity of its kinematics, power transmission and reducer implementation, including the shut-off mechanisms of pipeline gate valves.

Kinematic scheme of the combined multiline electric gear based on quasi-differential gear " 3*k*—2*g*—*h*"

Kinematic scheme of the combined transmission includes a new two-stepped quasi-differential gear "3*k*—2*g*—*h*" (3 central wheels, 2 satellites, one carrier) with an input to the carrier *h* and an output to a large central wheel b_2 and high-speed gear " z_1-z_2" {1,2}. The latter is necessary because the electric motor is located not coaxially but parallel to the axis of the gearbox to allow passage of the screw bolts. Fig. 1 shows a scheme with internal tooth gearing. Range of ratio in such transmissions is extended to the limits: 5…45, the most common in drive technology, and the most loaded elements are the internal tooth gearings "b_1-g_{1i}" of satellites g_{1i} at the entrance to the group and tooth gearings "g_{2i}- b_2" of satellites g_{2i} at its output. Moreover, the satellite g_{2i} acts as a gear in the internal tooth gearings "b_1-g_{1i}" (accelereting gear), and satellite g_{2i} has the function of pinion gear in the toth gearing "g_{2i}-b_2" (decelerating transmission).

Transmission provides a convex—concave contact in its most loaded gearings, high rate of overlap that characterises the smoothness of the gearings and, if gearings are not linked in phase in the kinematic flows, it increases power multi-streaming $K_F = a_c \varepsilon_\alpha$ and unloads conjugate profiles both internal "b-g_i" and external "a-g_i" gearings.

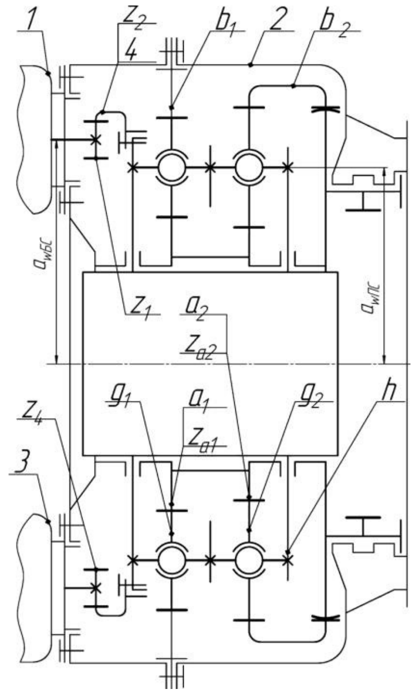

Fig.1. Kinematic scheme of the combined power transmission with an internal high-speed gearing transmission of a new multiturnaround drive:
1- drive motor,
2- reducer of quasi-differencial type,
3- control unit ,
4- speed gear "z_1-z_2"

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Analysis of power flows in transmission

The carrier serves as the input level and at the same time gives the mechanical energy transmitted to the two rows of satellites g_{1i} and g_{2i} set parallel and kinematically linked by central small double wheel gear a_{12} in a single planetary gear of tooth gearings " b_1- g_{1i} – a_{12} – g_{2i} – b_2" connected in series with four active working gearings " b_1 –g_{1i}", "g_{1i} – a_1 ", " a_2 – g_{2i} " and " g_{2i} – b_2" .

And the two active gearings " b_1 –g_{1i}" and "g_{1i} – a_1 " act as a planetary gear and convert the parameters of force ($F_{hg_1}V_{O_g}$), incoming at the satellite g_{1i} , into new parameters ($T_a\omega_{a_{12}}$) to pass it on to the satellites of second row g_{2i} along with the power coming from the carrier on these satellites ($F_{hg_2}V_{O_g}$). The flows of power on the satellites g_{2i} are summarize with the help of active gearing " a_2 – g_{2i} " and through the active gearing " g_{2i} – b_2" are transmitted to the output wheel b_2.

The power transmission from input to output is realized on the input speed ω_h, while the changes of speed and moment are performed on the output gear ($T_{b_2}\omega_{b_2}$). Transmission perfectly meets the requirements of the multiple-stream admission conception {3}.

Thereby, a quasy-differential principle of distribution and summation of energy is presented here. On such a principle dose not work, none of those known to modern technology transmissions. Due to the closure of the lever-gear transmission chains in the flow works as the whole.

Visualization of the working gearings

On the Fig. 2 a visualization of the working gearings of second planetary stage is displayed. It is evident that, as opposed to well-known schemes of planetary mechanisms, the central wheels do not differ much from each other in size that allows you to mount five satellites (or even more). In the classical transfer "2k—g—h" it would inevitably lead to a gear ratio reduction. In the new transfer "3k—2g—h" it is not happening.

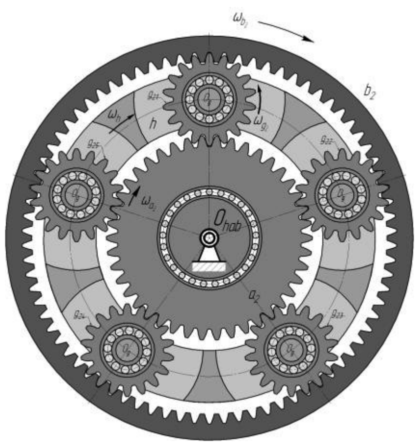

Fig. 2. Visualization of the working gearings of second planetary stage

Synthesis of multiline transfer

The gear ratio of multiline transfer as a part of a drive determined in accordance with the formula Willis

$$5 \le u_{hb_2}^{b_1} = \frac{1}{u_{b_2h}^{b_1}} = \frac{1}{1-u_{b_2b_1}^{h}} = \frac{z_{b_2}z_{a_1}}{z_{b_2}z_{a_1}-z_{b_1}z_{a_2}} \le 45 . \quad (1)$$

The main condition for the kinematic synthesis of the considered power transmission is the reproduction of the desired gear ratio $u_{hb_2}^{b_1}$

Taking into incount the interconnection of teeth numbers of the planetary gear units in the group "3k—2g" the formula (1) for the gear ratio is reduced to the following view

$$u_{hb_2}^{b_1} = \frac{z_{b_2}z_{a_1}}{\Delta z(z_{a_1}+z_{b_1})}, \quad (2)$$

where $\Delta z = z_{b_2} - z_{b_1} = 1,2,...,10; \quad 20 < z_{a_1} < 75; \quad 60 < z_{b_2} < 125.$

For the reproduction of the gear ratio of the power transmission, demanded by the forecast, it is necessary to perform the number of certain additional synthesis restriction:

– embedding of power transmission to the limited dimensions of the cylindrical body reducer with the socket in the diametrical plane {4}:

$$D_{\text{p}} \le m\left(\frac{3z_{b_2} - z_{a_2}}{2}\right) = m(z_{b_2} + z_{g_2}); \quad (3)$$

– the vicinity condition of the satellites

$$z_{g_2} + 2 < (z_{a_2} + z_{g_2})\sin\frac{\pi}{a_c}; \quad (4)$$

– coaxiality

$$z_{a_1} + z_{g_1} = z_{b_1} - z_{g_1} = z_{a_2} + z_{g_2} = z_{b_2} - z_{g_2}; \quad (5)$$

– simple assembly transmission at the number of kinematic flows a_c >1, which is guaranteed, if a_c =3, 5, 7

$$\frac{z_{a_1}+z_{b_1}}{a_{c_1}} = C_1^{'}; \quad \frac{z_{a_2}+z_{b_2}}{a_{c_2}} = C_2^{'}, \quad (6)$$

where $C_1^{'}$; $C_2^{'}$ are particular even numbers;

– phase asynchronism of movements in kinematic flows, which is provided for appointment of numbers of teeth of expressions

$$\left.\begin{aligned} z_{a_1} &= a_c C_1 + (a_c - 1); \\ z_{b_1} &= a_c C_2 + (a_c - 1); \\ z_{a_2} &= z_{a_1} - \Delta z; \\ z_{b_2} &= z_{b_1} + \Delta z; \end{aligned}\right\} \quad (7)$$

– the sums equality of teeth numbers of the central wheels in the two planes of their motions

$$z_{a_1} + z_{b_1} = z_{a_2} + z_{b_2} . \quad (8)$$

Condition (8) makes it possible to build a parametric number of output parameters in a single overall dimension. Conditions (5) and (8) guarantee the absence of constructional redundant relationships and equality surplus of link angles in four active working gearing among themselves that can be imposed within the following ranges: $18^\circ \le \alpha_{w_{a_1g_1}} = \alpha_{w_{g_1b_1}} = \alpha_{w_{a_2g_2}} = \alpha_{w_{g_2b_2}} \le 30^\circ$.

Joint consideration of equations (1)...(8) allows to set the number of teeth of gear transmission units, with a glance of the all main and additional conditions of their kinematic synthesis.

Geared implementation

The gear specification is that the satellites should always be smaller size ($z_{g_1} = z_{\min} = 25...28$), especially in the range of gear ratios $8 \le u_{hb_2}^{b_1} \le 45$. Therefore, the size of the transfer is determined by the satellites and the output central wheel.The numbers of teeth of all four central wheels a_1 ; a_2; b_1 and b_2 possess the values for which the requirement of placing them on the hollow shafts is constructively easily implemented, that constrain on the intermediate shaft and the carrier. The teeth number of the satellites will be appointed from the condition of their placement in the ring gear of the spherical double-row ball or roller bearings of the needed load-carrying ability.

With the possibility of producing a rotor of the electric motor with the hollow rotor (for the rod passage of the slide valve) the transmission does not need extra ordinary transmission and installs coaxially to the gate valve (Fig. 3).

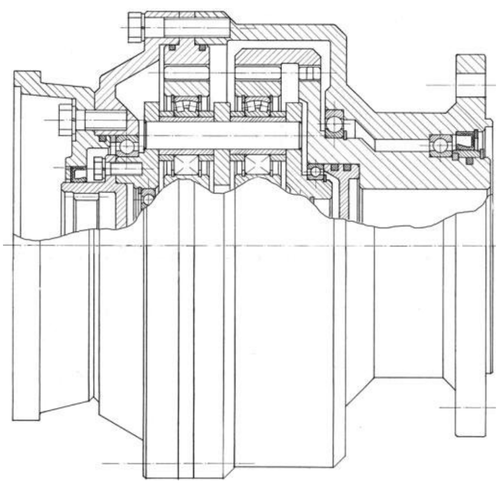

Fig. 3. The design of coaxial gear based on a multiline transmission "3k—2g—h" with the entrance to the carrier and output to the large central wheel with the internal teeth

Conclusions

The usage of quasi-differential planetary gear as the basic design of multiline multiturnaround electric drive let us to extend the range of gear ratio, and help the most loaded elements in the planetary group to make the internal links of satellites with a large central wheel/ The transmission provides a convex-concave contact in the most loaded links of transmission.

The dimensions of the transmission are determined by satellites and the output central wheel. The reduction gear turns out to be compact, with the low weight. Constructively easily the implementation inside the hollow shaft gear of the free placement of the output unit valves realizes. Another elements are also conveniently arranged: manual transmission, pressure sensors, position sensors, etc.

Literature

1. Two-stepped planetary transmission. Sidorov P.G., Pashin A.A., Plyasov A.V., Smelov J.E., Shiryaev I.A. patent for invention № 2402707 from 08.10.2008. Publ. 27.10.2010, bull. № 30.
2. Sidorov P.G., Pashin A.A., Plyasov A.V. The method of structural formation and addition of the classification of simple planetary mechasms.//TSU News. Technical sciences. Vol. 2: in 2 parts. Tula: Tula State Univ., 2010. Part I. P. 39-48.
3. Sidorov P.G., Pashin A.A., Plyasov A.V. Multi-streamed teeth transmission: structure, formation kinematic and power relationships, classification and prospect of usage.// Driving technology, 2010, № 4. P. 25-30.
4. Shiryaev I.A., Pashin A.A., Sidorov P.G. Relationships of the planetary drive dimensions with the parameters of gear units. // TSU News. Technical sciences. Vol. 2: in 2 parts. Tula: Tula State Univ., 2009. Part II. P. 37-41.

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Dear Reader,

The number of applicants for the 27th Seminary of Machine Designers and Product Developers is more than it was in the previous years and the areas of subject of the papers are growing wealthier. Beside the traditional examples of machine structures there are more and more papers dealing with sanitary and surgical instruments and products, and the product pallet of supply industry becomes wider, too. All of these suggest that the tasks of mechanical engineers – together with the electrical engineers, engineers of information technology, engineers of material science, physicians and biologists – are multiplied, gradually renewed. They find their way to the automobile and transport industry as well as to the small and large producing and consuming units of the agriculture, environment and energy production. This also means the easier and more successful recruitment of the engineers but the employment, the recognition of value of work and often the recovery of monetary value represent new tasks. The rapidly changing environment of economy and legal-financial regulation require a new and more violent market practices from the private engineers.

In parallel, the preliminary knowledge of applicants to the technical higher education is improving and major requirements can be laid claim to. There are more and more Master students and at last – if very slowly – the number of Ph.D students is increasing independently of the "hunting", both in homeland and abroad, for talented trainee engineers having knowledge of languages.

The generational renewal is coming slowly to the end at the universities educating engineering students. There has been grown already up a new young or middle-aged teaching staff, who takes over the tasks of the "warrior emeritus" predecessors. But we are considering always respectfully to these predecessors who educated all of us during the no less diversified second half of the 20th century, whether as professors, lecturers or as practicing engineers.

One of the great predecessors is the lately deceased Professor Dr. József Magyar, head of department, whose worth is commemorated also at this Seminary. In January 2012 an exhibition will be organized to the memory of Professor Dr. Zénó Terplán who has left for ten years.

The preserve of the memory of our professors, lecturers, our engineers graduated at one of the Hungarian technical universities and has been already honoured with golden jubilee certificate can give extra power to the multitude of successors.

Dr. Ádám Döbröczöni

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