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THE STUDY OF HYDRO MECHANICAL PROCESSES IN HYDRO MACHINES OF POWER-INTENSIVE DRIVES

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Abstract: *The hydraulic machine with tilting disk is a very promising and widely used type of high power volumetric drives due to its production (compared with other types of volumetric drives) and regulation (*e.g. *reverse of the flow or rotation direction) easiness. Since energetic characteristic of modern drives can`t be significantly improved, the main objective of the project is to improve drive`s dynamic characteristics by reengineering the design of its core components.*
Key words: *mechatronics, hydraulics, high power drives*

1. INTRODUCTION

Nowadays the hydrostatic power drive is widely applied in machine industry, and became the integral component of modern mobile machines and the industrial equipment. Specifications of hydrostatic power drive determine the prospects of wider use of certain positive qualities of this drive in various fields of engineering.

Traditionally the hydraulic drive is used where the fast response time, sensibility, small dimensions and automated management is required. The most widely hydrostatic power drive of cars is applied in cutting machines, presses, in control systems of aircrafts, vessels, heavy machinery, mobile road-building equipment, in automatic control systems of thermal drives, hydraulic turbines (Akers et al., 2006).

The main advantages of hydraulic drives are:

- Ability to be organically integrated into the hydrostatic drive system.
- High power-intensity.
- Long-time loading mode and, consequently, high thermal regime.

However, these actuators have limitations that prevent the establishment and operation of these drives, such as:

- High volume and hydro-mechanical losses.
- Durability and reliability issues.

Two types of positive-displacement hydraulic machine should be distinguished, which now can be considered as a basis for creating power-intensive drive with long-time loading conditions (Bashta, 2009).:

- Hydraulic machine with tilting cylinder block (HMTCB).
- Hydraulic machine with tilting disc (HMTD).

Hydraulic machine with tilting cylinder block have a higher volumetric coefficient of efficiency, a smaller dead space and, consequently, a wide steady range of rpm. Hydraulic machine with tilting disc have a better weight and size parameters, and also are incomparably easier in production. Their main disadvantage is a relatively bigger volume loss, especially during the start-up process, which greatly narrows a range of stable rates and increases the zero response zones (Babaev et al., 2000).

2. SCIENTIFIC PROBLEM

Modern volumetric hydraulic machines possess high weight and size parameters. As their energetic characteristic can`t be significantly raised, the possible way of improving these machines can be in raising dynamic characteristics. Like increasing working pressure value, widening a control range at the expense of lowering the level of minimum stable rotating frequency zones (Shejpak, 2003).

Main tasks in studying and improving of power-intensive drives are:

- Researching of modern types of high-power hydraulic machines.
- Making kinematic, dynamic and force analysis of the HMTD structure.
- Creation of mathematical model of hydro mechanical processes in variable shape clearances.
- Experimentation in order to examine the results of mathematical modeling.

3. SCIENTIFIC RESEARCH

Scientific studies of problems listed above are based on the International Scientific-Educational Center BSTU-FESTO "Synergy" of the Baltic State Technical University (St.-Petersburg, Russia).

The preliminary stage was to study of the load on the piston mechanism. Among kinematic pairs in the main frame of the axial-piston HMTD - piston pair is the only kinematic pair which doesn`t have hydrostatic unloading of interfaced surfaces, because of complexity of its constructive realization The complexity is determined by indeterminacy of movement of the interfaced surfaces in relation to a loading force vector. At small rates piston pair is influenced by a huge amount of forces and friction torques (Tihonenko, 2002).

Unlike start-up conditions and conditions of unstable rates, the piston mechanism operation at stable shaft rate is characterized by essential decrease of mechanical losses, in its kinematic pairs. This is caused by transition from boundary to mixed, and, at the operation conditions close to a nominal, to a liquid friction mode. In these operation conditions, especially at a liquid friction mode, it is possible to have simultaneous relative movement of elements of the piston mechanism, depending on a ratio of friction forces in kinematic pairs. Ratio of relative rates and friction forces in kinematic pairs of the piston mechanism, in this case, are interconnected and are in dependence from such factors as values and shapes of clearances between the interfaced elements, viscosity and pressure of a working fluid in them.

4. PROPOSED SOLUTION

As a result of the load study of HMTD piston mechanism we received the generalized dependence for friction force

calculation in piston pair depending on a coefficient of friction and the geometrical sizes of piston pair. The analysis of the received dependence displays that the spherical joint offset contrariwise to a direction of the transversal force vector acting on the piston essentially reduces value of a friction coefficient in piston pair. Physically this explained by the fact that as a result of this offset, the moment from the transversal force, is partially, or completely compensated by the moment from the axial force acting on an arm equal to the offset value. This will result in absence of tipping moment on the piston. Basing on the results of the study we developed a new design of piston mechanism. This modified piston design compensates the break out force and provides mechanism with additional oil film.

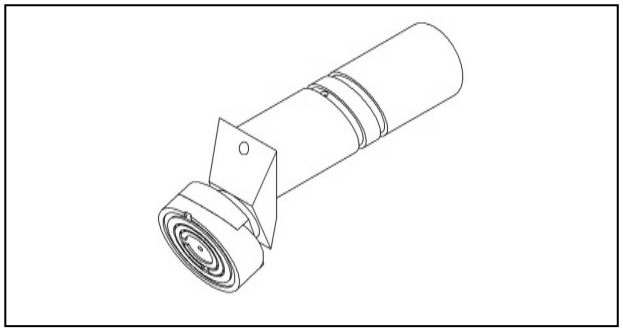

Fig. 1. Improved design of piston mechanism

For the experimentation part we made a special testing stand that simulates the work process of HMTD.

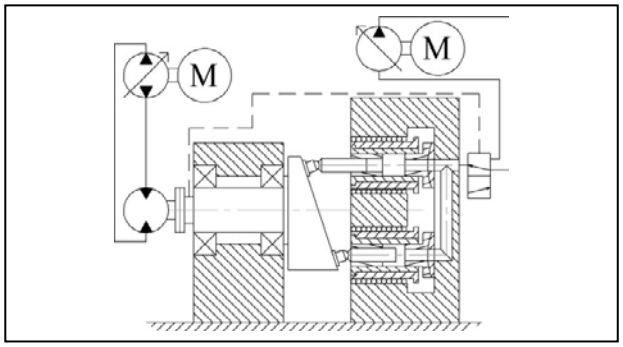

Fig. 2. Testing stand scheme

Comparative experimental researches of motor mode in a static load condition have displayed the diminished breakaway moment in advanced mechanism and higher the torque acting on a shaft within an identical range of pressure.

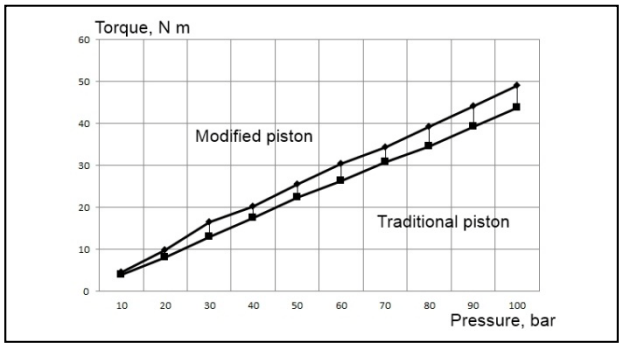

Fig. 3. Dependence of shaft torque from pressure (motor mode)

The comparative assaying of results of experimental researches of the regular and modified piston mechanism in a pump mode has displayed essential reduction of friction forces in piston pair of advanced mechanism in a wide range of rotation speeds and operating pressures.

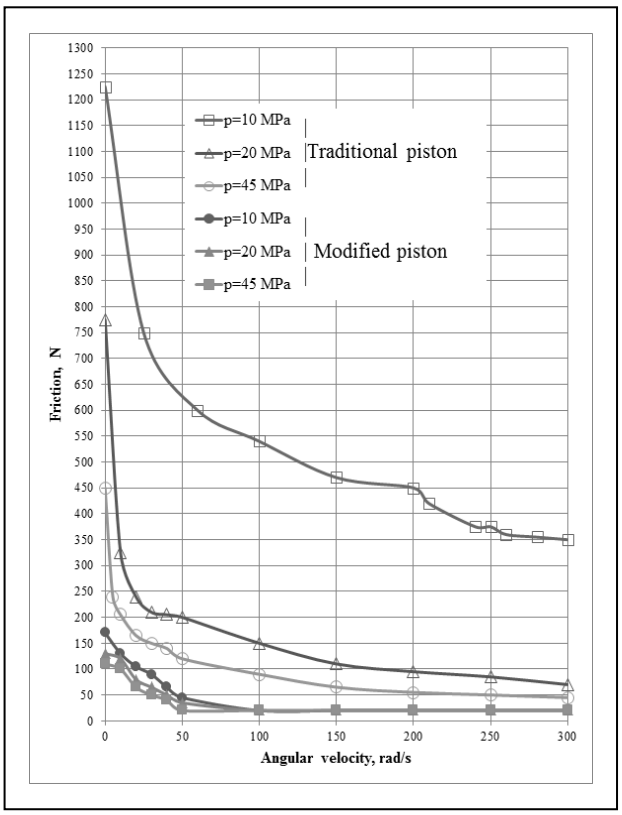

Fig. 4. Dependence of axial friction force from angular velocity (pump mode)

Using obtained results it is possible to create improved version of HMTD by only changing its piston mechanism with a modified one.

5. EXPECTED RESULTS

Developed HMTD with new piston mechanism has a high practical value. Preserving its weight and size parameters and having minor structural changes this machine may show better performance than drives of traditional design.

6. CONCLUSION

Improvement of characteristics of hydraulic machines as a widely applied component is a very urgent direction of development. In general, application of this technology may have the following results, such as an increase of efficiency, reduce of weight and size and reduce of production, installation and operation costs of hydraulic machines that will lead to cheaper production of the system it is integrated in.

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