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LABORATORY STAND FOR RESEARCH OF THE WORKFLOW IN HYDROSTATIC MECHANICAL TRANSMISSIONS

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Abstract

The work of the laboratory stand as a whole as well as its particular elements is described. The effect of laws of parameters change of hydrostatic transmission fluid machines regulation and the laws of the braking torque change on the basic parameters of hydrostatic mechanical transmissions of different structures (two schemes were discussed: the first one with an inlet differential, the second - with an output differential) at implementation of both acceleration and deceleration processes is determined. The phenomenon of non-simultaneous translation of operating regimes of fluid machines being a part of the hydrostatic mechanical transmission with an "output" differential in the areas of zero speed and power modes is studied.

Key words: experimental study, hydrostatic mechanical transmission, hydrostatic mechanical transmission, input differential, output differential, mathematical model, acceleration, braking, special area.

1. Laboratory stand

To determine the effect of laws of parameters change for regulating hydrostatic transmission fluid machines and the laws of braking torque change on the basic parameters of hydrostatic mechanical transmissions of different structures at implementation of both acceleration and deceleration processes, as well as to study the phenomena of non-simultaneous translation of operating regimes of fluid machines being a part of the hydrostatic mechanical transmission with an "output" differential in the areas of zero speed and power modes there were developed two laboratory stands - one with an input differential, the second - with an output differential. The simplified block diagrams of laboratory stands of HSMT are shown in Fig. 1, the scheme of the HSMT stand with an "output" differential, as an example is shown in Fig. 2; a general view of the stand is presented in Figure 3.

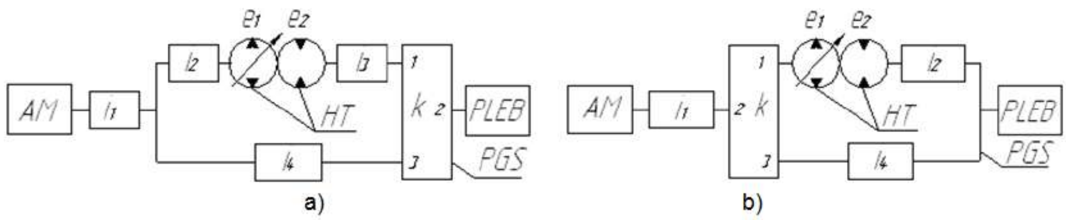

Fig. 1. Simplified block diagrams of HSMT stands:

a - with an output differential; b - with an input differential; AM - asynchronous motor; PLEB - powder loading electromagnetic brake; HT - hydrostatic transmission; PGS – planetary gear set; *k* - internal gear ratio of the planetary series [1]; i_j - gear ratio of the gearbox.

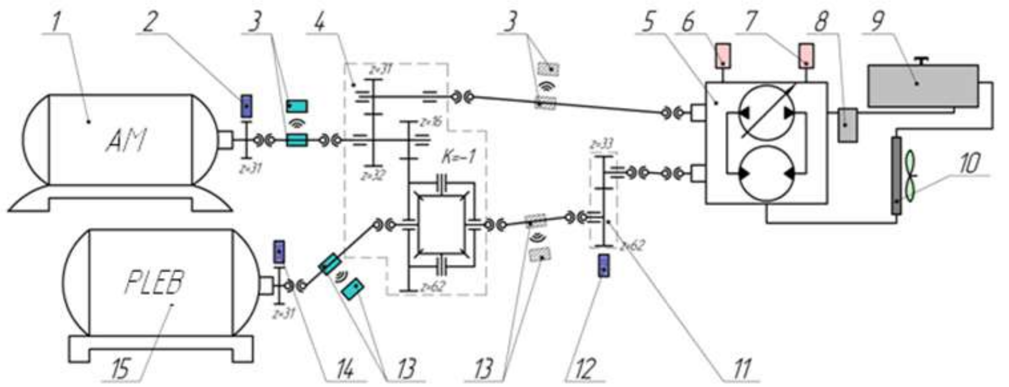

Fig. 2. The kinematic diagram of the stand of HSMT with an "output" differential:

1 - asynchronous motor; 2, 12, 14 - speed sensors; 3, 13 - torque sensors; 4 – reduction gear assembly with planetary drive; 5 - HSMT; 6, 7 - excess pressure sensors; 8 - final filter; 9 - tank; 10 - fan radiator; 11 - matching gear; 15 - powder loading electromagnetic brake.

Fig. 3. General view of the stand of HSMT with an output differential

2 Equipment and outfit of the laboratory stand

As an energy source in the stands they used the asynchronous motor A2-72-4 with the following parameters: power 30 kW, shaft revolutions - 1450 rev/min, efficiency - 90.5 (pos. 1, fig. 2).

The law of hydraulic pump parameter adjustment was set by means of computer via FL86STH80-4208A stepper motor (torque 4.5 Nm) with CNC 4.5A driver (Fig. 4) [2].

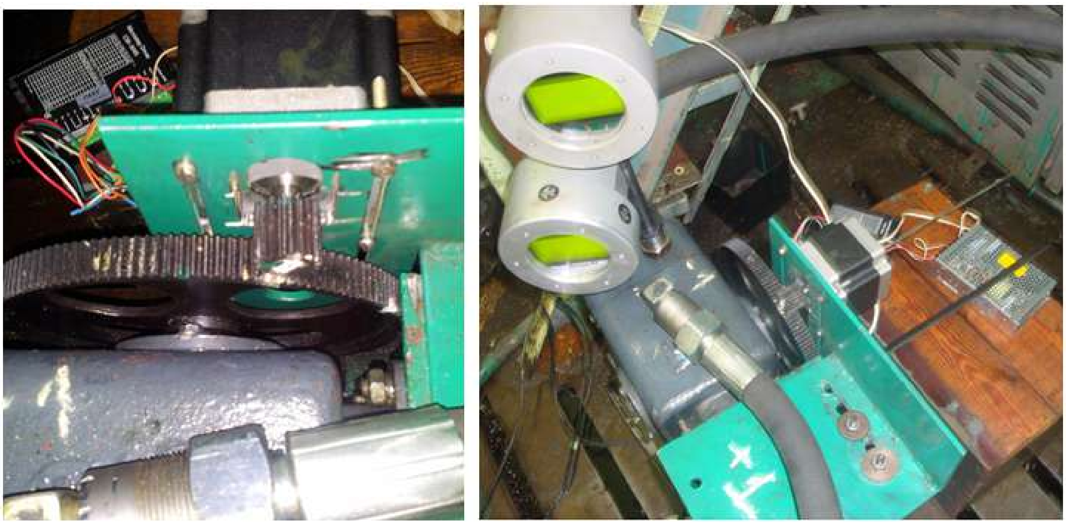

Fig.4. Stepper motor with a driver and power supply

To measure the excess pressure there were used "Arcturus-03" sensors (pos. 6, 7, Fig. 2, Fig. 5), which are designed for continuous directly-proportional pressure transformation into the DC signal. The sensor is based on piezoconverter "silicon-on-sapphire" and a microprocessor. To ensure long-term stability the piezoconverter, that is screwed into the sleeve, is placed in a chamber of heat and cold for up to two months, where constant change of temperature modes removes all the stresses in the metal membrane and the piezoconverter.

Fig. 5. "Arktur-03" overpressure sensors

The sensor allows for the choice of measurement units, the display format, digital interface parameters, a built-in self-diagnosis system, a calendar, a clock, internal memory for 7000 readings, etc. The upper limit of pressure measurement by the sensor that was used in the study is 25 MPa.

During the investigations the output current signal varied in the range of 0 - 20 mA. After adjustment to the analog-to-digital converter L-Card E14-140M, which detects only volt signals, the change of the output signal by "Arktur-03"sensor was performed in the range of 0-4 V, which corresponds to the variation of pressure in the range of 0 - 25 MPa; the dependence is linear, i.e. 1 V corresponds to the pressure of 6.25 MPa, the value 2B - 12.5 MPa, etc.

Determination of angular velocity of shafts was carried out using inductive speed sensors (Fig. 6) - ISS (sensors are made in accordance with GOST 15150-69 and meet the specifications TUUZ.58-14310589-117-2001).

Fig. 6. Inductive speed sensor mounted on the shaft of the powder brake mechanism

The output signal presents a square signal, similar to a sinusoid in form; whose parameters are largely determined by geometric parameters of the ring gear and a working gap between the face of the sensor and the gearing.

The largest amplitude of the output signal occurs at the minimum working gap between the face of the sensor and the gearing. Therefore, the gap in the course of research was selected as a minimum from the recommended range (according to specifications the clearance should be in the range of 1.5 - 2.25 mm).

During the investigations the torque was determined by means of strain sensors. The measuring set consists of two units (Fig. 7), placed in plastic radio transparent housings. The first one is a unit of tensor bridge signals amplification, analog-to-digital conversion and transmission over the radio circuit, is mounted on the shaft near the tensor bridge, the second one is the signal receive unit over the radio circuit, processing and digital-to-analog signals conversion received from the tensor bridge, which is set at a distance of 10 meters from the first one within the service area, as evidenced by a uniform steady LED-indicator light. The second unit is connected to the contact pad of the analog-to-digital L-Card E14-140M converter module by a cable, thanks to the latter the results in the form of volt signals are recorded and displayed on the laptop.

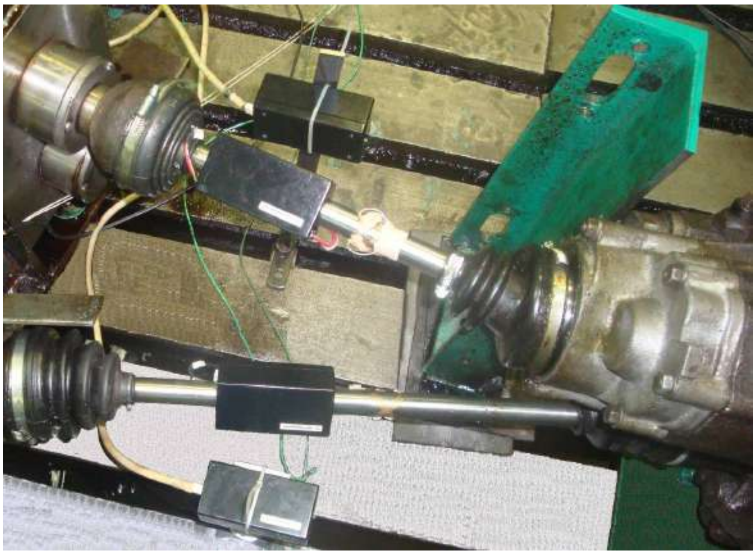

Fig. 7. Scheme of torque measuring devises arrangement

The described device is easy to manufacture, the units, transmitting and receiving signals can be placed at a sufficient distance from each other, which is very suitable for practical research in the tractor industry. That is why the given device was used during the experimental studies.

3. Processing of research results

The main stage of excess pressure and torque processing, namely volt signals obtained in the course of experimental studies, is the choice of the filtering method [3 - 5].

A filter is a frequency-selective device that transmits signals of certain frequencies, delaying or weakening signals of other frequencies. In view of the amplitude-frequency characteristics they are divided into low-pass filters, high-pass filters, band-pass filters, notch and phase filters. In practice they widely use the filtering methods of Chebyshev, Butterworth, Bessel, and the filtering methods of critical damping. In works [3 - 5] there is recommended the following protocol of filtering for all channels (except the rotation angle of the steering wheel and the angular velocity of the steering wheel) - the use of Butterworth low-pass filter. To automate the processing of the data obtained it is practical to use the free software "Butterworth filter."

4. The results of the study

During the study of the phenomena of simultaneous translation of fluid machines operating modes being a part of HSMT with an “output” differential in the areas of zero speed and power modes there was revealed the following.

Except the pump and motor modes of fluid machines operation there are intermediate modes, when the flow of the mechanical and hydraulic power is opposing, and their algebraic sum is equal to zero. Let’s consider the basic characteristic segments of the oscillogram shown in Fig. 8. On the segment *a-b,* the linear change of the output shaft speed *ntor* corresponds to the linear change of the parameter adjustment *e*, the adjustable hydraulic machine 1 (HM1) works in the pumping mode, the unregulated hydraulic machine 2 (HM2) - in the engine mode. Point *b* corresponds to the beginning of the dead zone in the regulating characteristic of HM1, segment *b-c* corresponds to zero of the actual adjustment parameter *e′= 0* associated with the valve flow that controls $e' = k \cdot Q_{valve}$, where *k* is the permanent structural factor.

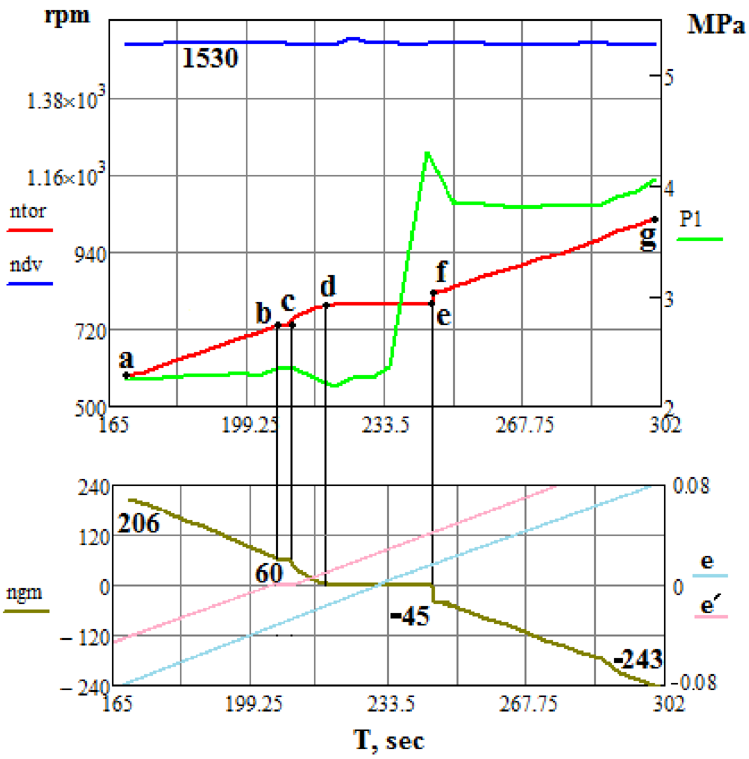

Fig. 8. Experimental mechanical and hydraulic properties of HSMT in the area of operation modes translation:

rpm - speed of shafts; *ntor* - speed of the output shaft; *ndv* - speed of the asynchronous motor shaft; *ngm* - speed of the hydraulic motor shaft; *P*1 - pressure in the pumping line of HSMT; *e* - measured value of the relative adjustment parameter; *e′*- the actual value of the relative adjustment parameter; *T* - time of measurement

On the segment *c-d* there occurrs a quick stop of HM2, due to the falling characteristic of friction forces in HM1the pressure decreases, the total leakage reduces. On the segment *d-e* the friction torque direction changes, in HM2 there also occurs a differential lock, as a result the beginning of the hydraulic machine movement is accompanied by a pressure jump.

In the course of the study there were experimentally acquired the values of adjustment parameters corresponding to the power and speed translation of hydraulic machines; there was built a graph of the actual adjustment parameter, and the dead zone of the adjustable hydraulic machine was determined.

During the research of the acceleration and braking process in order to maintain the efficiency of stands, the maximum braking point was set at 40 nm. Increase of the braking torque results in reducing the time from the start of braking to the full stop of the powder loading electro-magnetic brake shaft and a significant increase in the operating pressure drop in HSMT.

The lower the intensity of the adjustment parameter of the hydraulic machine, and slower the increase of the braking torque is, the lower the operating pressure drop in the HSMT will be, the other parameters of considered HSMT were not considerably affected by the laws of parameters change for controlling the hydraulic machines of HSMT and the laws of the braking torque change during the acceleration process.

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PSEUDOCEPSTRAL METHODS THE TIME-FREQUENCY LOCALIZATION ULTRASHORT PULSE SIGNALS IN THE RADIOWAVE SYSTEMS OF PHASE-DEVIAMETRY ASSESSMENT MECHANICAL VIBRATIONS

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Abstract

It is shown that phase-deviametry assessment reflected ultra short radiopulses can be interpreted as a time-resolved by the method of indirect conversion radiosignal in diagram intensity mechanical vibration (vibration velocity) probing the surface, generating its own mechanical vibrations or acoustic disturbances modulated by external environment. Numerical methods for finding phase-deviametry assessment estimation by the time-frequency localization USP-signal by pseudocepstral methods of analysis: wavelet-cepstral processing and Hilbert-Huang transform are proposed.

Keyword: radiowave vibrometry, USP-signal, phase-deviametry, time-frequency localization, pseudocepstral transform, wavelet-cepstral processing, Hilbert-Huang transform.