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THE ANALYSIS OF A FIELD OF WORK OF A SYSTEM, I.C. ENGINE - HYDROSTATIC TRANSMISSION

1. Introduction

The task of a hydrostatic drive system and the assembled mechanical transmissions is to match propulsion engine/driving motor characteristics with the load characteristics. Then, the process of designing energy-saving driving systems requires conducting the full analysis of the energy process running in the components of the system and their interaction. Due to that it is necessary to build a mechanical model of a driving system in the possible general form, establishing mathematical apparatus (programming) used for establishing static energy characteristics and determining working parameters.

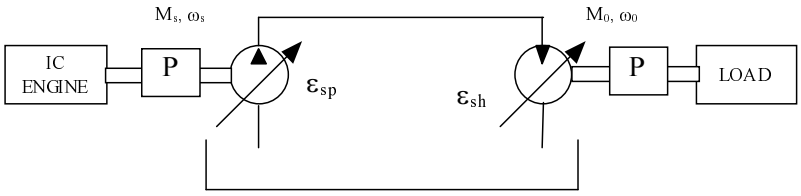

Fig. 1. Block scheme of a driving system

The important issue is the possibility of estimation of the energy efficiency of different solutions of the driving system working in the same load conditions. The global efficiency of the system described by the dependency [1,2,4] can be the indicator:

$$\eta_g = \frac{\int_S M_o \cdot n_o \cdot f(M_o, n_o) ds}{\int_S N_{sp}(M_o, n_o) \cdot f(M_o, n_o) ds} \tag{1}$$

where: $f(M_0, n_o)$ - density function of probability of occurring load state described by the coordinates (M_0, n_o) included in the area/zone of the characteristics S, $N_{sp}(M_0, n_o)$ - power distribution function of the primary

energy source (propulsion engine/driving motor) including the efficiency distribution (losses) of a driving system referred to the area of the load S characteristics.

For the practical reasons it is more convenient to use the dependency establishing the global efficiency for the load spectrum presented in the discrete form:

$$\eta_g = \frac{\int\limits_{i,j} M_{oi} \cdot n_{oj} \cdot p_{ij}\left(M_{oi}, n_{oj}\right)}{\int\limits_{i,j} N_{spij}\left(M_{oi}, n_{oj}\right) \cdot p_{ij}\left(M_{oi}, n_{oj}\right)} \tag{2}$$

2. Model of Drive System

Due to the huge variability of load characteristics general model of load was accepted/assumed in the form of rectangular area of load characteristics $M_0=f(n_0)$, which was discreted by butting on/overlay uniform 400-point net constructed by division of moment and turning velocity.

The mathematical model, presented in this paper, of the hydrostatic driving system together with the programming used for its solving [1] enables establishing full energy static characteristics. The characteristics involve the information about the distribution of the hydrostatic transmission efficiency and working/performance and controlling parameters against and working points on the universal characteristics of fuel consumption [g/kWh], carbon monoxide content, (CO%), nitrogen oxide (NO_x) and level of smoke emission (Bosch) in the exhaust gasses of the IC Engine a background of the load characteristics.

The aim of the examinations was to establish the influence of pump redimensioning and the way of matching its characteristics to the combustion engine on the efficiency distribution, working and controlling parameters of the hydrostatic system realising the function of minimising energy losses.

3. The Analysis of the Results of the Modelling Investigations

The presented under efficiency distributions are obtained for the ideal controlling system indicated for an optional working point, situated in the field of the load characteristics, optimal settings of both the hydrostatic machines. The

full characteristics , gained as the result of investigating the model, have a form of the report including information about the engine load parameters (M_{sh} i n_{sh}) and the corresponding values: total - global efficiency of the hydrostatic system η_g, the controlling parameter of the pump ε_p, controlling parameter of the hydrostatic engine ε_{sh}, pressure in the outlet of the pump p_p, turning velocity of the pump shaft n_p, turning moment in the pump shaft M_p.

The even division of the load of the hydrostatic engine, assumed in the discrete model, allows the working point of the combustion engine to be treated as its load spectrum. Controlling the driving system according to the function of the minimal losses does not allow the working/performance points of the combustion engine to be distributed evenly in the whole field of its driving characteristics, but it creates the band of the increased concentration, as well as the totally unused areas.

The presented below graphs Fig. 2 of the efficiency distribution of the hydrostatic transmission PV21-MV22 can be used for the optimisation of energy properties of the hydrostatic transmissions, if the load spectrum of the system is known, which describes the time contributions occurring for each point or restricted zones of working parameters. There was the analysis conducted, within this work, for the uniform distribution of the load characteristics. It means even time contribution occurring for each of the 400 points of the working zone.

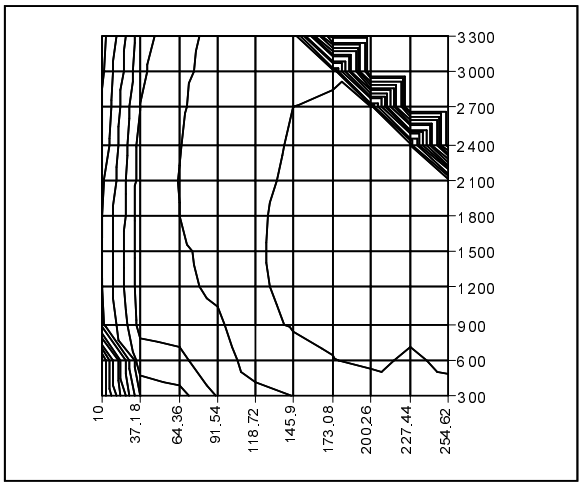

Fig. 2. The efficiency distribution of the PV21-MV22 hydraulic transmission, global efficiency η 62%

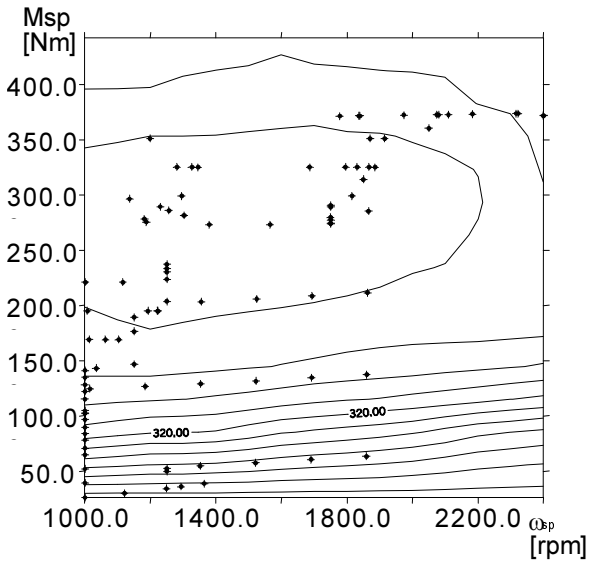

Fig. 3. Distribution of working points of universal chnaracteristics of the fuel consumption (g/kWh) in the exhaust of the SW 400 engine driving transmission PV21-MV22, general efficiency 12%

In the pictures 3 and 4 the distribution of the working points of the combustion engine was plotted on its universal characteristics areas: unitary fuel consumption, carbon monoxide content in the exhaust gasses. Only this type of analysis, although qualitative, of the distribution of the load characteristics shows the importance and possibilities of the assumed procedure of the energy analysis of the system.

Comparison of the hydrostatic transmission's efficiency, combustion engine's efficiency and the global efficiency of the whole drive system seems to be interesting.