FISITA 2004
World Automotive Congress
23 - 27 May, Barcelona, Spain

Fundació Politècnica de Catalunya: la formació contínua
UNIVERSITAT POLITÈCNICA DE CATALUNYA

TECHNICAL PAPER FOR STUDENTS AND YOUNG ENGINEERS

- FISITA WORLD AUTOMOTIVE CONGRESS, BARCELONA 2004 -

TITLE:

RESEARCH OF DYNAMICAL LOADING FOR VEHICLE'S HYDRAULIC DRIVES BY UNSTEADY MOTION REGIME

Topic:

- ● FUTURE AUTOMOTIVE TECHNOLOGY
- ○ INTELLIGENT TRANSPORTATION SYSTEMS
- ○ USER FRIENDLY AUTOMOBILE
- ○ ADVANCED PRODUCTION AND LOGISTICS
- ○ VEHICLES & THE ENVIRONMENT

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National Society: ● YES ○ NO

Name of the National Society: Academic Automotive Association

Abstract:

In this work the dynamical load of vehicle's hydraulic gear during disperse was analyzed. There were regarded peculiarities of piston's speed changing depending on time in presence of influence of mechanically immovable elements masses of vehicles and strengths conducting on a piston.

Solution of mathematical equations for modelling of hydraulic gear dynamics has been made. In this case dynamical calculation has a control nature and allows evaluation if calculated parameters of a gear provide given dynamical characteristics of the system.

Place / Date: Minsk, 11 / 02 / 2004

INTRODUCTION

Hydraulic drives are widely applied in various engineering branches: vehicles, technological machines, automatic devices. So, hydraulic systems of metallurgical machines, hydraulic systems of machine tools, systems of vehicle hydraulic automatics are widely known. The need for these devices is explained by not only simplicity of a design and their rather low price, but also high speed with significant target capacity.

The analysis of researches on dynamics of hydraulic drives for vehicles shows complexity of the processes occurring in a liquid stream at its interaction with firm bodies. As a rule the equations of transients in hydraulic drives are not linear.

The physical processes proceeding in a hydraulic drive may be described with the help of mathematical model which reflects the real phenomena arising in hydraulic system with a high degree of approximation. Generally the system of equations describing dynamics of a hydraulic drive includes two types of the equations which correspond to physical processes in these drives:

- The differential equation of movement of mobile details of system;
- The equation of balance of instant mass charges of liquid.

There is a dependence of the generalized coordinate on time from the differential equation. The balance equation of instant volumetric charges of the liquid represents the algebraic sum of the input and output charges. The various variants of piston’s speed change from weight of mobile mechanical elements and forces of technological resistance were considered in the result of reduction mechanism’s decision differential equation of movement and the equation of balance of instant mass charges. The dependence of speed of the piston on time on a site of dispersal of the vehicle is received on the combination of mass-vectorial and force characteristics.

STATEMENT OF RESEARCH PROBLEM OF HYDRAULIC DRIVE DYNAMICS

The dynamical load of a volumetric piston hydraulic drive of the vehicle on a site of dispersal was investigated in the work. The volumetric piston hydraulic drive, Fig. 1, consists of the hydraulic cylinder 1, the pump 2, the allocator 3, the brake device 4, the relief valve 5, connecting pipelines and a drain tank.

The on-off four-linear allocator 3 is shown in the position appropriate to the movement of the piston from the left to the right (the working course of the machine 7). Switching of the allocator from one position into another occurs from electromagnets 6. The brake device 4 (an adjustable throttle) is included in a line which at a working course is drain.

The simplest dynamic model, which is adequate to researched processes (1, 2), is chosen as the mathematical description of dynamic processes in a hydraulic drive. The piston serves as a link of reduction in which the weight of a working liquid on an examined site and weight of the given mechanically mobile elements of the machine is given is taken. A number of assumptions is entered in this model: the liquid is considered incompressible and concentrated in same volume, only one mode of current is taken into account.

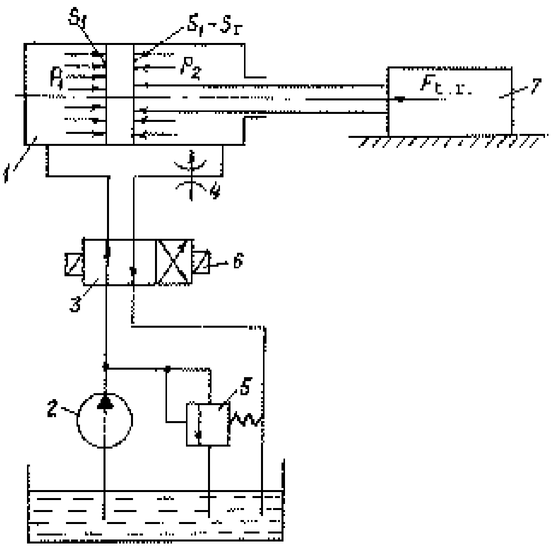

Figure 1. Circuit of a piston hydraulic drive

CALCULATION OF DYNAMICS OF HYDRAULIC DRIVE

The differential equation of the movement of a link of reduction looks like

$$m_n \frac{dv}{dt} = F_g - F_r \qquad (1)$$

The driving force given in the piston and the force of resistance

$$F_g = p_1 S_1; \qquad F_r = F_{t.r.} + p_2 (S_1 - S_r).$$

The pressure $\mathbf{p_1}$ in the pressure head cavity depends on the pressure upon the output from the pump $\mathbf{p_p}$ and from losses of pressure in a pressure head line $\mathbf{\Delta p_1}$:

$$p_1 = p_p - \Delta p_1$$

The pressure $\mathbf{p_2}$ in a drain cavity depends on losses of the pressure in a drain line $\mathbf{\Delta p_2}$ and losses of pressure in the brake device:

$$p_2 = \Delta p_2 + \Delta p_{br}$$

Losses of pressure $\mathbf{\Delta p_1}$ and $\mathbf{\Delta p_2}$ depend on the speed of current of liquid which at the constant charge is proportional to the value of the piston's speed $\mathbf{V}$:

$$\Delta p_1 = A_1 V + B_1 V^2$$

$$\Delta p_2 = A_2 V + B_2 V^2,$$

Where **A1, A2, B1** and **B2** are constant factors.

Losses of pressure in the brake device:

$$\Delta p_{br} = B_{br} \frac{V^2}{f_{br}^2},$$

Where $\mathbf{B_{br}}$ is experimental factor, $\mathbf{f_{br}}$ is the area of through passage section in the brake device.

The general given weight $\mathbf{m_n}$ is found from a condition of equality kinetic energies weights of mechanical parts of the piston **m** and weights of the liquid $\mathbf{m_1}$ in the pressure head and drain pipelines

$$m_n = m + m_1 \frac{V_l^2}{V^2} \qquad (2)$$

The equation of the balance of the instant volumetric charges of the liquid represents the algebraic sum of the input $\mathbf{Q_{in}}$ and output $\mathbf{Q_{out}}$ charges. The charge on an output from the pump for the working course of the piston is connected to the speed of the piston by parity:

$$Q_{out} = VS_1,$$

and the charge on the input is connected to speed of the liquid in pipelines:

$$Q_{in} = V_l f \cdot$$

Whence

$$\frac{V_l}{V} = \frac{S_1}{f} \cdot$$

Where

$$S_1 = \frac{\pi d_1^2}{4},$$

$\mathbf{d_1}$ is the piston's diameter; **f** is the area of through passage section of the pipeline.

The initial data to the calculation (for drive in heavy-duty truck):

$$d_1 = 0{,}065m, \ d_r = 0{,}02m, \ \ f = 0{,}785cm^2 \ , \ f_{br} = 0{,}1cm^2$$

$m_1 = 0{,}02 kg$, $A_1 = 2 \cdot 10^6 \dfrac{H \cdot s}{m^3}$, $A_2 = 17 \cdot 10^6 \dfrac{H \cdot s}{m^3}$, $B_1 = 4 \cdot 10^6 \dfrac{H \cdot s}{m^4}$,

$B_2 = 15 \cdot 10^6 \dfrac{H \cdot s}{m^4}$ $B_{br} = 4{,}8 10^{-4}\ H \cdot s^2$, $P_p = 4{,}7 10^6 Pa$.

Taking into account the accepted initial data it is received:

$$m_n = m + m_1 \frac{V_l^2}{V^2} = m + m_1 \frac{S_{1.}^2}{f^2} = m + 0{,}02 \left(\frac{33{,}16}{0{,}785} \right)^2 = m + 35{,}687,$$

$$F_g = (p_p - A_1 V - B_1 V^2) S_1 = (4{,}7 \cdot 10^6 - 2 \cdot 10^6 V - 4 \cdot 10^6 V^2) 3316 \cdot 10^{-6} =$$

$$= 15582 - 6632V - 13264V^2$$

$$F_r = F_{t.r.} + \left(A_2 V + B_2 V^2 + B_{br} \frac{V^2}{f_{br}^2} \right) (S_1 - S_r) = F_{t.r.} +$$

$$\left((17 \cdot 10^6 V + 15 \cdot 10^6 V^2 + 4{,}8 \cdot 10^{-4} \frac{V^2}{0{,}1^2 (10^{-4})^2} \right) (3316 - 314) \cdot 10^{-6} .$$

$$= F_{t.r.} + 51034V + 59439V^2$$

After the substitution of values $\mathbf{m_n}$, $\mathbf{F_g}$ and $\mathbf{F_c}$ in the equation (1) finally we have:

$$(m + 35{,}687) \frac{dV}{dt} = 15582 - 57666\, V - 72703\, V^2 - F_{t.r.} \qquad (3)$$

On the basis of the equation (3) various variants of piston speed change from time, i.e. speed of the machine are designed, at separate influence of weight of mechanically mobile elements of the machine **m** and forces of technological resistance $\mathbf{F_{t.r.}}$. The program is made on the computer; the constructions are submitted on the basis of the calculations and are executed on the Fig. 2, 3.

CONCLUSIONS

Analysis of the researches on dynamics of a hydraulic drive of the vehicle shows the complexity of the processes occurring in the system. At drawing up the mathematical model of a hydraulic drive the real drive is replaced by the dynamic model the complexity of which depends on the accepted assumptions. Thus it is supposed, that the liquid is considered incompressible and concentrated in one volume, only one mode of current is taken into account. Besides liquid is homogeneous and its cavitations and outflow are excluded. In this case the dynamic calculation is verifying and allows to estimate, whether the designed parameters of a drive provide the given dynamic characteristics of system (for example, speed).

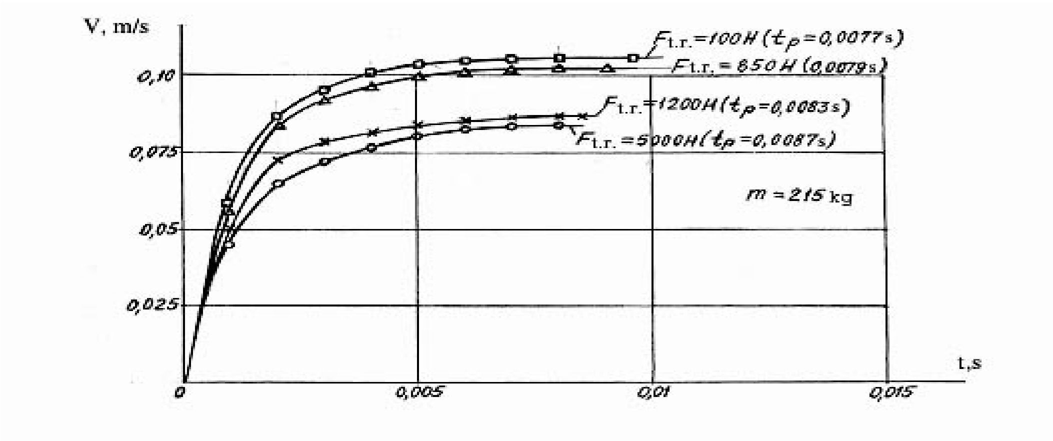

Figure 2. Dependence V (t) at F t.r. = 850 N

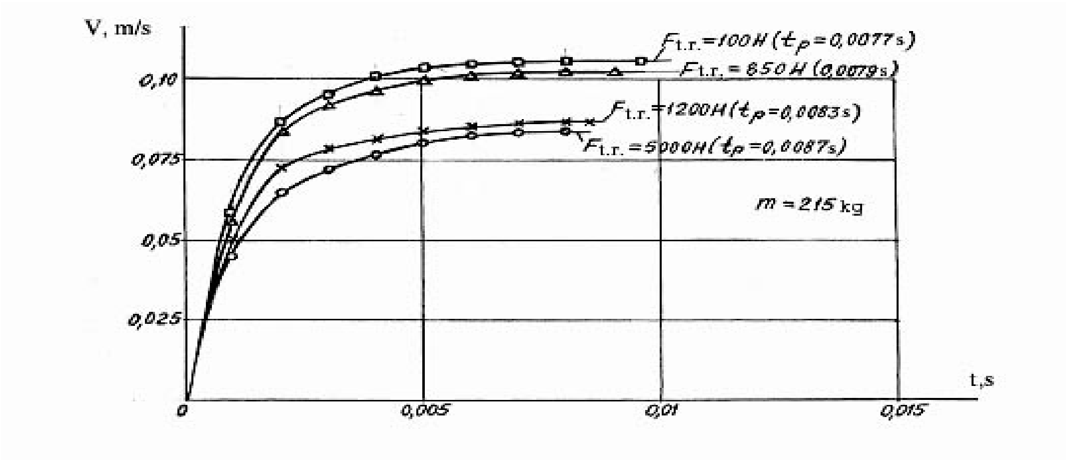

Figure 3. Dependence V (t) at m = 215 kg

The decision of differential equations modeling dynamics of a hydraulic drive is carried out with the use of a computer. The results of the calculations are submitted in the figures 2, 3. As the calculation on a site of dispersal shows, it is possible to draw the following conclusions:

1. At constant force of technological resistance and variable weight the speed of the piston with growth of weight decreases (Fig. 2). And, the reduction of speed is observed up to the certain limits, i.e. up to the moment of time which corresponds to the end of time dispersal's time $\mathbf{t_d}$.

2. At constant weight and variable force the speed of the piston in process of increase of force decreases (Fig. 3). If for each experience of research the speed of the piston in the beginning of the time of dispersal sharply grows, these fluctuations decrease by the end of the time of dispersal.

ACKNOWLEDGEMENT

I would like to thank Dr. V.I. Zinkevich, Associated Professor at Belarusian National Technical University, for his help and consultations.