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Experimental Research Focused on Yields of Linear Hydraulic Engines Used to Drive the Deep Pumps

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Abstract

This paper presents the authors's concerns for determining the functional parameters and its yields for a linear hydraulic engine with double effect. Functional parameters are determined both at unloaded running and loaded running of the liniar hydraulic motor. The yields was determined on loaded running.

Key words: *yields, hydraulic engine*.

Introduction

Based both on the presenting data on [1; 2] and on the experience [3; 4], in some conditions of controlled drilling or as a result of some sensitive deviations during wells drilling or on the situation of exploration of oil at high deep, clasical pumping units use it became irational because of the huge energetic consum or of the imposibility to use them at deeps more than 3000 m. On these situations are used oil extraction units with hydraulic action. These units include the extraction pump and a hyrdaulic motor on which the reversing movement is autocontrolled. By all these reasons the author of this work has designed and realised a lineare hydraulic engine to do the experiments for registing both the functional parameters and the its yeld. The laboratory test allow to establish some mesures which can not be registed in the field because of the construction of the deep hydraulic unit and because of the high deep of laying. The author also has realised two desplacement transducers boath to regists the desplacement of dispenser distributor and of piston rod displacement of the linear hydraulic engine In such cases are used for oil extraction units with hydraulic action. These are consisting of the extraction pump and a hydraulic motor which is an autocontrolled reversal movement one. For these reasons, the author of this work, conceived, designed and built a linear hydraulic motor for conducting experimental research to determine both functional parameters and its return. Experimental research in laboratory conditions, allowing the establishment of the sizes that can not be determined on the field conditions, because of the depth hydraulic unit buunloaded running and of its location at hight deep. Also the author has made and second displacement transducers, both for recording the movement of the distributor drawer and of displacement of motor piston rod of linear hydraulic engine.

Experimental Test Results

The general bench view on which are doing the tests is presented by figure 1.

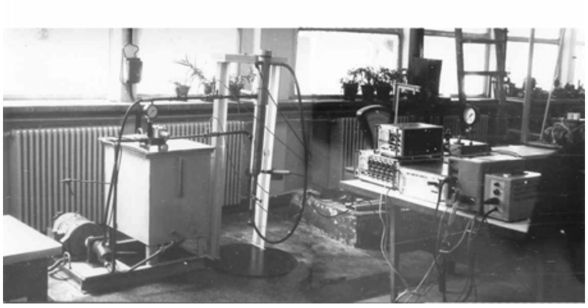

Fig. 1. The general stand view

The simultaneous registered of seven parameters (two displacements, three tenssions and two flows as function of time) at diferent pump functional regimes alows to put on evidence diferent quqntitative and calitative aspects. The reading of oscilograph was done by direct mesuring and then the results were analized by the help of EXCEL program. To record the displacement of the draw of lineare hydraulic engine it was realised a inductive transducer, transformer type, which was introduced in the balanced hydraulic tube which is presented in figure 2. Figure 3 presents the functional diagrame of lineare hydraulic engine unloaded running, at an angular speed of pump by ω_p=157rad/s. The run on duty it was realised by using a vane with a nail on the exit pipe. The functional diagrame is presented in figure 4.

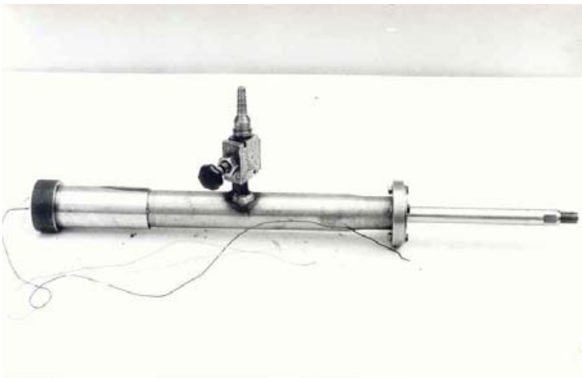

Fig. 2. Displacement transducer and balanced hydraulic tube system .

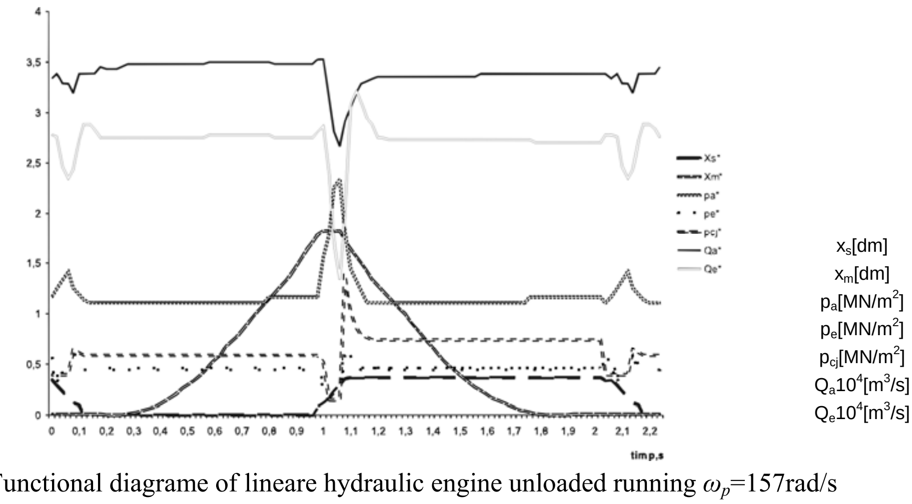

Fig. 3. Functional diagrame of lineare hydraulic engine unloaded running ω_p=157rad/s

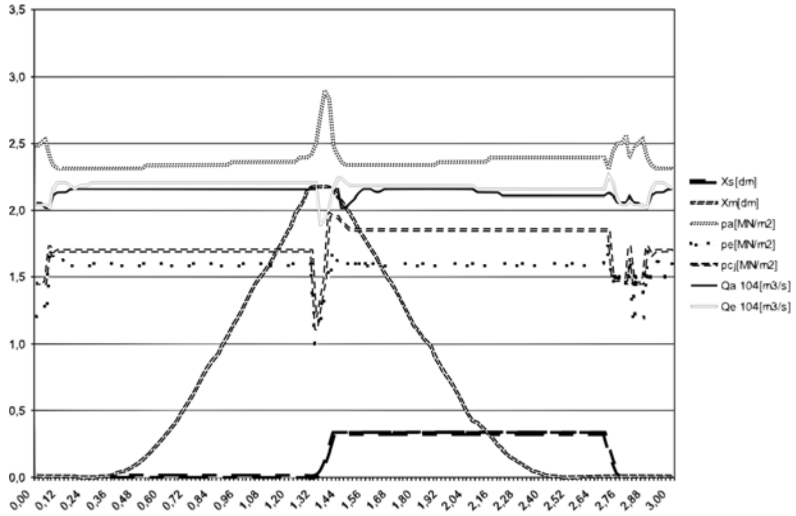

Fig. 4. Operation diagram of linear hydraulic engine loaded running , ω_p=157rad/s

Stroke capacity of lineare hydraulic engine

$$V_m = A_m S = 0{,}318 \cdot 10^{-3}\,\mathrm{m}^3, \tag{1}$$

where:
A_m is the area of piston transversal section;
S – stroke size .
Theoretical frequency of MHL function is:

$$f_{m,t} = \frac{Q_p}{V_m}, \tag{2}$$

where Q_p is the debit realised by pump.

The real operating frequency of the linear hydraulic motor can be determined experimentally by the help of operating charts, resulted on an operating cycle time (Tc).

Given this observation it can be written:

$$f_{m,e} = \frac{120}{T_c}, \tag{3}$$

where T_c is:

$$T_c = t_a + t_d + 2t_{cd}\ , \tag{4}$$

where:
t_a is time for making the upward stroke;
t_d – time for making the downward stroke;
t_{cd}–swiching time of distributor drewer .

Theoretical values and experimental values of lineare hydraulic engine are presented in table 1.

The dependence between the run frequency of the linear hydraulic motor and pump flow is shown in Figure 5. Is apparent that there is a constant difference (10-11%) between actual working frequency and theoretical one for linear hydraulic motor. This is explained by the fact that a part of the flow is used for switching flow distributor drawer at the head race and because of dead space existence.

Table 1. Frequency values of lineare hydraulic engine unloaded running

Crt. no	ω_p [rad/s]	Q_p[10^4m^3/s]	$f_{m,t}$ [strokes/min]	$f_{m,e}$ [strokes/min]
1.	115	2.54	47.9	42.8
2.	125	2.77	52.2	46.5
3.	136	3.00	56.6	52.2
4.	146	3.22	60.7	53.5
5.	157	3.46	65.3	58.8
6.	167	3.69	69.6	61.8

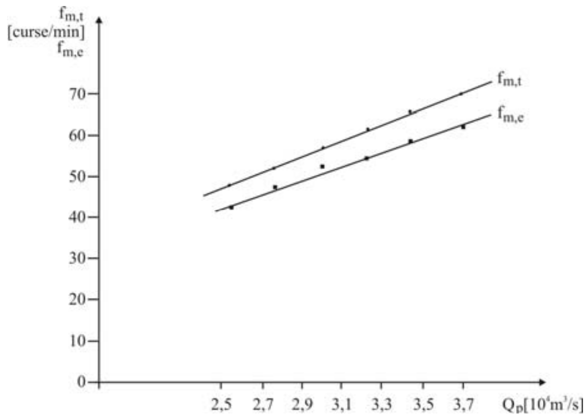

Fig. 5.The dependence between the run frequency of the linear hydraulic motor and pump flow: $f_{m,t}$ – theoretical frecvency on unloaded running run; $f_{m,e}$ – experimental frecvency unloaded running .

When operating under loading run (the pressure on exhaust of hydraulic linear engine ($p_e \cong 1{,}5$MN/m^2), the frequency of operation loaded running ($f_{m,s}$) of hydraulic linear motor shows a decrease, compared with the unload run. This is shown in Figure 6.

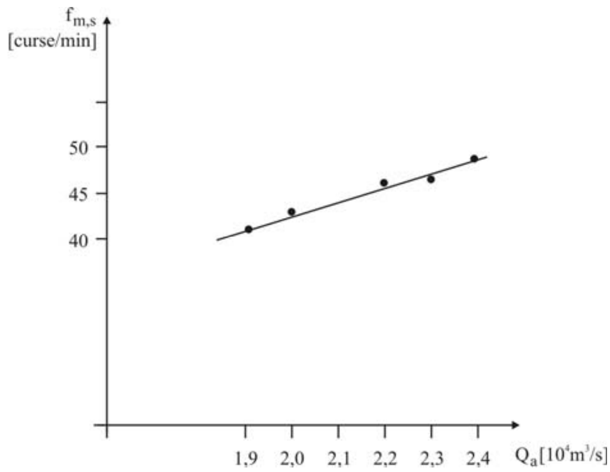

Fig. 6. Operating frequency of the linear hydraulic motor loaded running (p_e=1,5 MN/m^2).

By examining the diagrams of linear hydraulic motor operating at different angular speeds of the pump it can made some observations. It will further examine the operating diagrams of the linear hydraulic motor at ω_p=157 rad/s.

Operation of linear hydraulic motor unloaded running

It can be observed that the switching time of drewer distributor is t_{cd}=0,10 s. The upward stroke is done in 0.72 s and the downward one in 0.70 s, the two races runing time being about the same. Standing time of piston between upward stroke and downward one is 0.08 s. The feed power (p_a) between the two races has an increasing from 1.167 MN/m^2 to 2.33 MN/m^2, which can be explained by the the suddenly change of direction of movement of the piston of linear hydraulic engine.

Operation of linear hydraulic motor loaded running

From the begining it is observed that the realization time of races is higher. The distributor's switching time is t_{cd}=0.08s. Time to achieve the upward race is t_a=1.02 s, while the downward race t_d=0.98s. It results a difference for the two races of 0.04 s. Parking between the ascending and descending flight is 0.10s. At the changing of direction of movement, the feed pressure increased from 2.39 to 2.89 MN/m^2. It follows an increase of 20% above the working pressure, an increase that can be taken into account in setting the safety valve.The acceleration of the piston for upward race is a_{ma}=0.38 m/s^2 and for the downward race is a_{md}=0.41m/s^2 From the analyse of charts at upload run and load run of linear hydraulic motor is can be noted that the duration of an operating cycle decreases in the same time with the increasing of angular velocity from the pump. The operating time cycle loaded running run is higher than the unload operation at the same angular speed of the pump. This is shown in Figure 7.

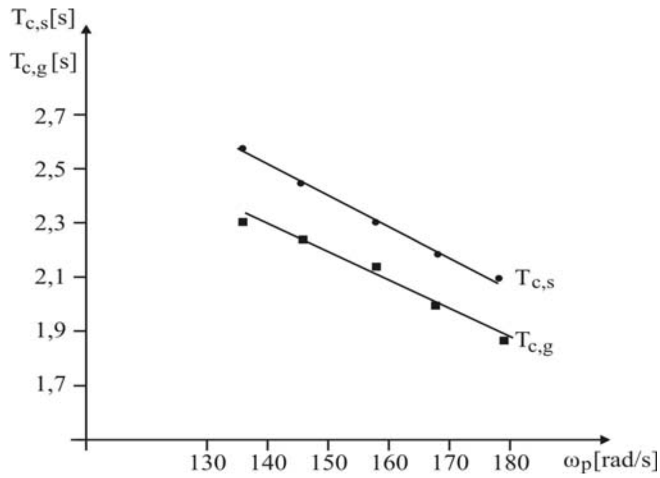

Fig. 7. Operating cycle according to the angular speed of the pump (ω_p):
$T_{c,g}$ – time of operation cycle unloaded running ; $T_{c,s}$ – time of operation cycle loaded running .

The yield of linear hydraulic engine

The yield of linerae hydraulic engine (η_m) can be established by the following relation:

$$\eta_m = \frac{P_m}{P_h} = \frac{F_m \cdot v_m}{p_a \cdot Q_a}, \quad (5)$$

where:
P_m is the mechanical power;
P_h – hydraulic power;
F_m – the power realised by the lineare hydraulic engine;
v_m – the medium displacement speed of the piston ;
p_a – feed presure;
Q_a – feed flow.

The power realised by lineare hydraulic engine as a function of feed pressure is presented in figure 8.

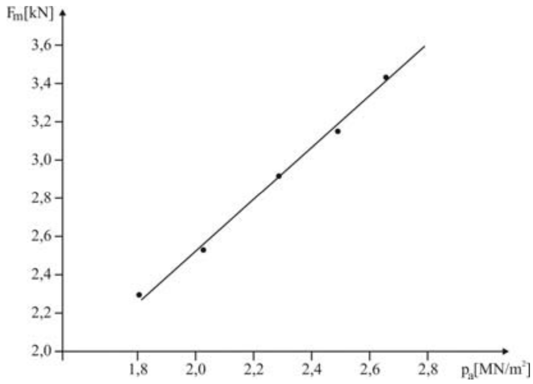

Fig. 8. The power realised by linear hydraulic engine as a function of feed pressure

To evaluate the mechanic power it is calculed a medium speed of piston displacement which is presented in figure 9.

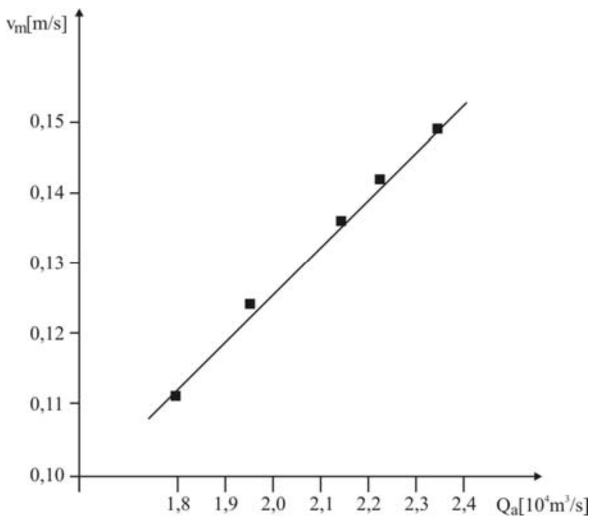

Fig. 9. Medium speed of piston displacement as a function of feed debit (Q_a)

The engine yield is calculated by relation (3.1) an it is presented in figure 10.

It is noted that the overall efficiency of linear hydraulic motor is placed at around 0.8, a value that can be considered good.

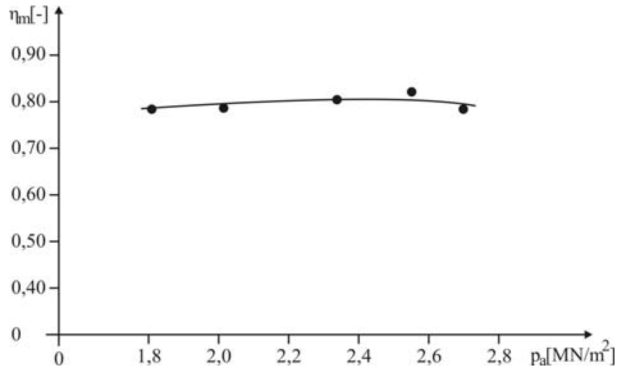

Fig. 10. Yield of linerare hydraulic engine variation as a function of feed pressure (p_a)

Conclusions

The experimental research focused on linear engine which are using to drive hydraulic pumps for deep extraction of oil, led to a number of conclusions, as follows:

- linear hydraulic motor hydraulic balanced led to a leveling of supply pressure on the two strokes (up and down);
- watching the drawer movement and the movement of piston distributor engine requires to carry out two displacement transducers (inductive type);
- inductive displacement transducers made by the author have proved to be reliable in operation of linear hydraulic motor (under pressure, the working environment being an oil H30);
- simultaneous register boath of distributor drawer movement, of the piston displacement and the flow and pressure values showed a proper operation of the linear hydraulic motor;
- up and down trips operation time is insignificant different (difference 0.02 to 0.04 s)
- switching time of supply purpose (traveling time of the drawer distributor), is in the range 0.08 to 0.10 s;
- operating frequency of linear hydraulic engine, experimentally determined, is with 10-11% less than the operating frequency theoretically determined;
- an operating cycle period (T_c), is decreasing with the ungular velocity growth on pump and is smaller on unload operation of linear hydraulic engine;
- yield value of linear hydraulic engine t is approximately constant and lies around 0.8.

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Cercetări experimentale privind randamentul motoarelor hidraulice liniare utilizate la acționarea pompelor de adâncime

Rezumat

Lucrarea prezintă preocupările autorului privind determinarea parametrilor funcționali şi a randamentului pentru un motor hidraulic liniar cu dublu efectiv. Parametrii funcționali au fost determinați atât la funcționarea în gol, cât şi în sarcină a motorului hidraulic liniar. Randamentul motorului hidraulic liniar s-a determinat la funcționarea în sarcină.