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A METHOD USED TO DETERMIN THE POWER NECESSARY FOR HYDRAULIC EXCAVATORS

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ABSTRACT

This paper presents a method of verification in the design phase, the mechanical power necessary involvement hydraulic pumps for excavators with bucket reverse.Because, in the design phase the digging forces are not known, for a considered forces limit the equipment is capable for each simulated position.

KEYWORDS: hydraulic, excavators, hydraulic cylinders

1. Introduction

The heat engine power used is chosen from a design experience or other excavators that have similar characteristics. The known power diagram is assumed - heat engine speed drive. The diagram is shown in Figure 1.

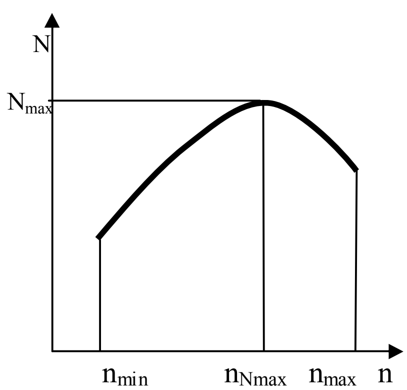

Fig 1. Power diagram of heat engine.

Interested in maximum power N_{max} that is obtained at speed $n_{N_{max}}$.

As a hydraulic pump, usually are used pumps with a variable flow, the maximum power constant, having flow diagram - pressure as that shown in Figure 2. p_b is the pressure above which the pump adjustment system reduces the maximum power flow $p \cdot Q_{VG} = N_{max}$.

Parameter Q_{VG} is the flow that the hydraulic pump would make if the pressure used would be zero. Otherwise internal flow losses occur, considered proportional to the pressure, estimated with hydraulic efficiency that for a certain pressure has the expression

$$\eta_{HP(p)} = \eta_{HP\,min} + \left(1 - \eta_{HP\,min}\right)\left(1 - \frac{p}{p_n}\right) \quad (1)$$

where $\eta_{HP\,min}$ is the minimum efficiency that is registered at nominal pressure.

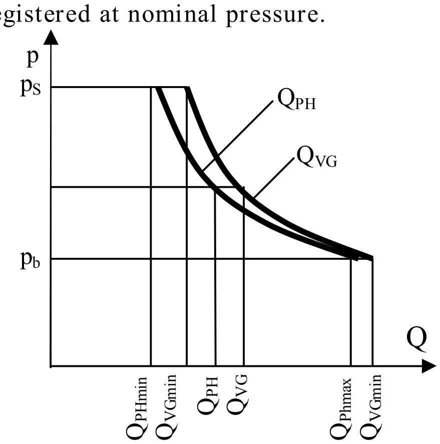

Fig. 2. Diagram of operation of the hydraulic pump

Consequently the flow produced in the hydraulic pump coupling and reaching the consumer is:

$$Q_{PH} = Q_{VG} \cdot [1 - \frac{p_{PH}}{p_n}(1 - \eta_{HP\,min})] \quad (2)$$

In digging, the elements of power generators, differential hydraulic cylinders are used. If the chamber that is corresponding to the large surface of the piston is feedid, the chamber corresponding lower surface of piston flow evacuates

$$Q_E = Q_{PH} \cdot \frac{D_c^2}{D_c^2 - D_t^2} \qquad (3)$$

From out of the pump until the reservoir containing hydraulic agent pressure drops occur:

- On admission

$$p_{PH} - \Delta p_A = p_1 \qquad (4)$$

- On disposal

$$p_2 - \Delta p_E = 0 \qquad (5)$$

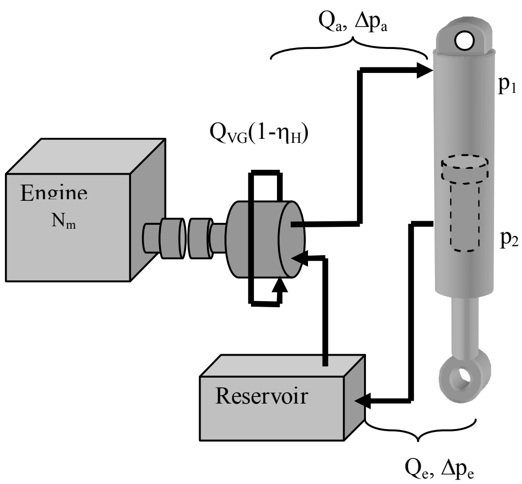

Fig. 3. The principle hydraulic scheme

The size of the pressure drops depends on the force that appears in the hydraulic cylinder, which depends on working pressure of the pump and the default flow instantly.

2. The loss of power adopted

It is considered that over the piston are working forces of Figure 4.

$$Fp_1 - Fp_2 = F_f + F_u \qquad (6)$$

The value of forces act requiring all forces are:
- Force on active surface

$$Fp_1 = p_1 \cdot \frac{\pi \cdot D_c^2}{4} F_p \qquad (7)$$

- Force on passive surface of the piston

$$Fp_2 = \frac{\pi \cdot \left(D_c^2 - D_t^2\right)}{4} \qquad (8)$$

- Friction force in packing

$$F_f = p_c \cdot \pi \cdot D_c \cdot l \cdot \mu \cdot n = 1.5 \cdot p_n \cdot \pi \cdot D_c \cdot l \cdot \mu \cdot n \qquad (9)$$

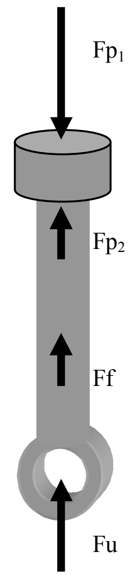

Fig. 4. Forces that are working over the piston

As the circuit is composed of numerous staff of local hydraulic resistance, linked by pipelines of small length, is considered the flow regime is turbulent (if verified in several numerical simulations). Following pressure drop are:

$$\Delta p_A = \sum_{i=1}^{n} \lambda_i \frac{L_i}{d_{hi}} \cdot \frac{\rho * W_{Ai}^2}{2} + \sum_{j=1}^{n} \zeta_j \cdot \frac{\rho * W_{Aj}^2}{2} \qquad (10)$$

$$\Delta p_E = \frac{\rho * W_E^2}{2} \cdot \left(\frac{\lambda(W_e)}{d_h} \sum_{p=1}^{g} L_p + \sum_{t=1}^{v} \zeta_t \right) \qquad (11)$$

and speed hydraulic inlet agent can be calculated with

$$W_A = \frac{4 \cdot Q_{VG}}{\pi \cdot d_h^2} [1 - \frac{p_{PH}}{p_n} (1 - \eta_{H\,min})] \qquad (12)$$

These parameters could be calculated if the pressure was known to the hydraulic pump.

3. Procedures and results

Determination of digging forces, especially in the design phase,is difficult to achieve. We considered in this case that the maximum forces on the mechanism of hydraulic excavator and the facility can develop. It took into account the interdependency of hydraulic cylinders to reduce the forces of digging in one of the cylinders if the pressure reaches the value adjustment passive overload valves.

Table 1

C2	P1 (MPa)	P2 (MPa)	P3 (MPa)	PPH (MPa)	DPA (MPa)	DPE (MPa)	FP 1(kN)	FP2 (kN)	FU (kN)	Qvg (l/s)
0	34.02	25.74	17.66	27.19	0.38	0.12	825.22	1.92	808	1.78
28.7	34.03	24.08	18.13	25.58	0.43	0.13	774.27	2.15	756.81	1.9
55.6	34.02	23.1	18.62	24.63	0.46	0.14	744.21	2.31	7226.5	1.97
83.3	34.02	22.55	19.15	24.1	0.48	0.14	727.21	2.41	709.5	2.01
111.1	34.02	22.28	19.71	23.05	0.49	0.15	719.07	2.46	701.31	2.03
166.6	34.02	22.23	20.31	23.8	0.49	0.15	717.55	2.47	699.77	2.04
194.4	34.02	22.35	20.96	23.92	0.49	0.15	721.34	2.44	703..59	2.03
222.2	34.03	22.63	21.65	24.18	0.48	0.14	729.86	2.39	712.16	2
245	34.03	23.04	22.39	24.57	0.46	0.14	742.26	2.32	724.64	1.97
277.8	34.02	23.57	23.19	25.08	0.45	0.13	758.53	2.23	741.00	1.93
305.6	34.03	24.23	24.06	25.72	0.43	0.13	778.82	2.13	761.39	1.88
333.3	34.02	25.01	25.00	26.48	0.40	0.12	802.8	2.02	785.47	1.83
361.1	34.02	25.93	26.03	27.37	0.38	0.11	831.03	1.89	813.83	1.77
388.9	34.02	27	27.16	28.4	0.35	0.11	863.66	1.76	846.59	1.71
416.7	33.47	28.01	28.17	28.4	0.35	0.11	863.66	1.76	846.59	1.71
444.4	30.03	28.01	28.10	28.4	0.35	0.11	863.66	1.76	846.59	1.71
472.2	26.46	28.01	27.96	28.4	0.35	0.11	863.66	1.76	846.59	1.71
500	22.79	28.01	27.77	28,40	0.35	0.11	863.66	1.76	846.59	1.71

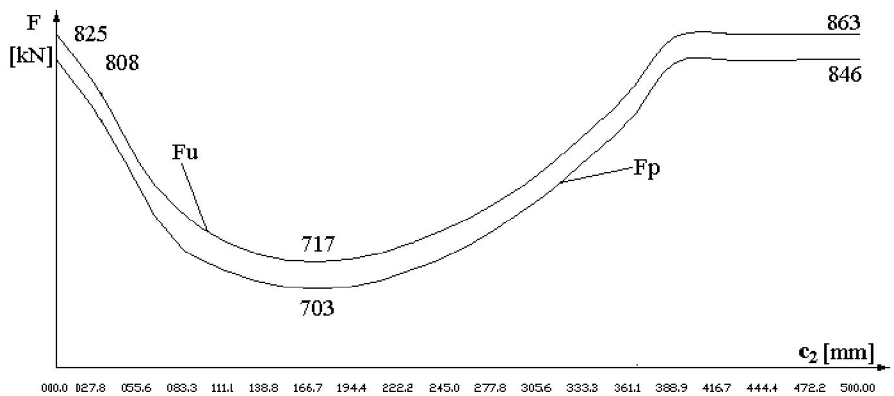

Fig. 5. Diagram of forces variation

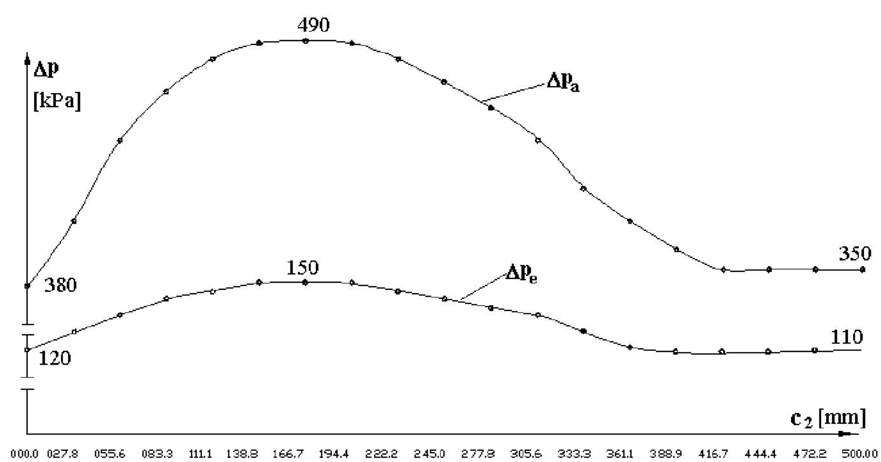

Fig. 6. Diagram of pressure variation

The problem goes from strength to reach the limit of digging, digging mechanism allowed the hydraulic scheme, the pump will be generating a higher pressure than that calculated under static conditions, to cover losses and pressure on hydraulic path. If the pump is already at maximum working pressure will generate a smaller digging force due to pressure loss in hydraulic installation. We must have not known the pressures work and no debts.
The problem is solved starting from a numerical program to calculate the limit forces in static conditions who were added a series of subroutines that take into consideration all the aspects mentioned above.
In Table 1 is shown an example of numerical simulation of the process of digging for the case in with active was considered the cylinder 2 (working data come from an excavator product by the company "PROMEX" Braila).

In Figures 5 and 6 are represented the variations of key parameters depending on the actual race of the cylinder 2.
Knowing the pressure and flow in every point of the hydraulic power we can measure the local powers and loss of power to each subsystem. This method allows a more realistic assessment of the need for power, for digging, of a hydraulic excavator.

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