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DYNAMIC OF INDUSTRIAL TRACTORS WITH THM FOR CONSTRUCTION

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ABSTRACT

Traction calculus is done to determine the main parameters of the equipment's engine and transmission designed to achieve the performances imposed in exploitation [1, 2, 3].
One of the base problem of the traction calculus is to settle the engine's power and its external characteristics' stability, as well as the rates of transmission's convection that give the car the necessary for driving.
This article is intended to analyze the dynamic pattern of the hydromechanics transmission (THM) to the digging and transport when functioning the work equipments.

1 Transmission Dynamic Pattern

The transmission dynamic forms for tractors and car frames with TM or THM are shown in Fig. 1 [2, 3] .
The differential equation of TM tractor operating, reduced to the engine shaft is a function of the ω_M engine angular speed.
This is as follows:

$$M_M(\omega_M) - Ms(t) = (J_M + J_{d1} + J_{d2})\ \omega_M , \qquad (1)$$

Where:

M_M , Ms – engine moment and reduced static moment, respectively;
-ω_M , ω_M – engine angular speed and acceleration, respectively ;
-J_M – inertia moment of engine masses in rotation ;
-Jdi – aggregate inertia moment (tractor + equipment) in sliding regime, reduced to engine shaft.;

The differential equations for THM tractor operating depend on ω_M engine angular speed and TH turbine ω_T respectively. They show the operating process of the implement with such transmission:

$$M_M(\omega_H) - M_H = J_H\ \omega_H \qquad (2)$$

$$M_T - (F_{cr}+F_f)\ 1/(i_M\ \eta_t) = (J_T+J_{d1} + J_{d2})\ \omega_T \qquad (3)$$

Where:

-M_M – engine moment of twisting ;
-ω_M – engine nominal angular speed ;

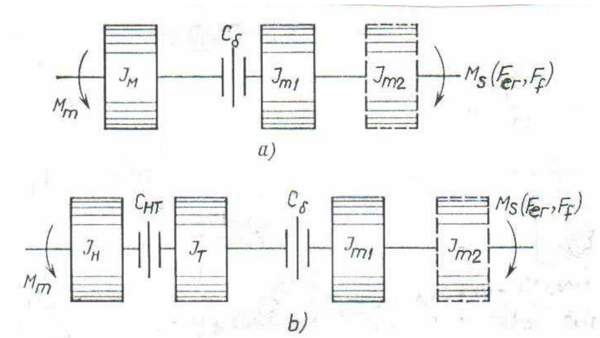

Figure 1 Working dynamic diagram of tractor transmission a) mechanical; b) hydro mechanical [2]: Cđ – friction clutch; Cht – hydraulic transformer clutch; Mm – Diesel engine moment; Ms – static moment of run resistance, of digging critic resistance (Ff + Fcr) respectively.

- M_H , M_T – moment of torsion at pump shaft and TH turbine, respectively;
- J_H , J_T – mass inertia moment at pump shaft and TH turbine shaft, respectively;
- ω_H , ω_T – angular speed at pump and TH turbine, respectively ;
-Jd1 – aggregate inertia moment, in reduced sliding at turbine shaft ;
- Jd2 – mass inertia moment of the ground digging and transported in implement sliding regime, reduced at turbine shaft ;
- i_M – transmission factor ($i_M = i_T / r_R$) ;
- ηt – transmission mechanical efficiency ;

- F_f , F_{cr} - global resistance force at running and critical force expanded at digging, respectively.

The using of mechanic clutch (see diagram in fig 1.b) at THM is done when changing the stages in gear box . To calculate the THM clutch process the dynamic scheme in Fig 1.b [3] is used.

2. Comments

1. For the digging and transport implements equipped with THM working on all operating stages (bulldozer + scarified) i_{TH} has close values between 0.76 – 0.74 according to [2].

The transmission dynamic diagram in Fig. 1.b is a general calculus diagram that may be applied both to digging and transport implements and great capacity tip lorries equipped with THM in specific working conditions.

2.The digging and transport implements sink the ground by driver sliding.

To calculate the traction force dependent on adherence wheels sliding in 20, 30, 70 or 400% regime is taking into account.

3. When changing the speed stages to eliminate the transmission shocks a mechanic clutch is mounted in the kinematics scheme after TM, that unclutch the engine from transmission.

The sliding characteristic of the mechanic clutch at speed change is done under different forms :

$$\delta = \delta[v_T , \omega_T] = \delta(\omega_T) ; \quad \delta = \delta[\omega_T , \omega_T] \qquad (4)$$

4. The running global resistance force for tractors (Ff) and the critical digging force (Fcr) for hydromechanics transmission depend on transport speed Vt.

The running global resistance force in transport regime depends on:

$$F_f = F_f [V_T(\omega_T)] = F_f(V_T) \qquad (5)$$

5. For THM tractors operating together with digging and transport implements the integral-differential equations of transmission (THM) are as follows [2]

$$\Phi_1[\omega_H, \omega_T, \omega_H, \omega_T, \delta(\omega_T, \omega_T), F_f(\omega_T, \omega_T), J_H(\omega_T, \omega_T)] = 0$$

$$\Phi_1[\omega_H, \omega_T, \dot{\omega}_H, \dot{\omega}_T, \delta(\omega_T, \omega_T), F_f(\omega_T, \omega_T), J_H(\omega_T, \omega_T)] = 0 \qquad (6)$$

The equations (6) are a non-linear equation system that can be solved as usual. To solve the equation system the integration time stage t = 0.01s is used.

The variation intervals for sliding đ of the mechanic clutch and running resistance may be between 0.005 and 0.01s.

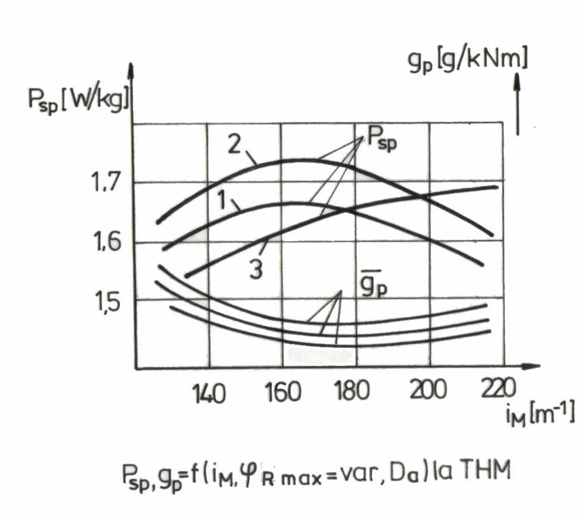

Figure 2. Variation of parameters P_{sp} , g_p , dependent on i_M , ΦRmax = Var, achieve diameter hydraulic transformer (Da) of THM; Curve (1) –Da = 0.31m; curve (2) – Da = 0.33m; curve (3) – Da = 0.35m [2].

6. The transmission dynamic system may be simplified dependent on the problems to be solved. For instance, the great capacity dumpers that use the same dynamic scheme (see Fig. 1.b), the hydro transformer working regime at i_{TH} >0.9, it is not used due to sudden reducing of the torsion moment coefficient of the TH's input shaft and due to the engine power reducing, respectively [3].

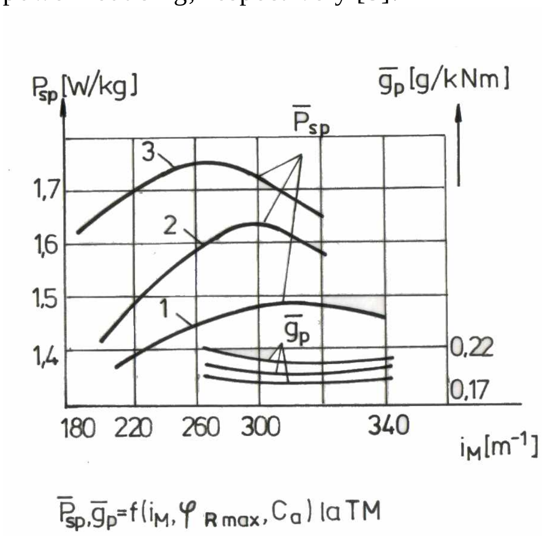

Figure 3. Variation of parameters P_{sp} , g_p, dependent on i_M , ΦRmax = 0.95, coefficient of adjusting Ca engine to a tractor with TM :

curve (1) – Ca = 1.17; curve (2) – Ca = 1.3,
curve (3) – Ca = 1.5 [2]

Some of the results of the studies done [2] about the operating performances of the digging and transport implements using Diesel engines and THM with different characteristics, are show in Fig. 2; the parameters variation (P_{sp} , g_p , C_s) = f(i_M) for TM is show in Fig. 3.

Mathematically the consumed average power of the ground , Psp , that is power in the digging and transporting critical . In [2] is introduced the function g_p as o ratio between the weight of the digging ground and the mechanical work for transporting this ground (v. Fig. 2,3, and 4)

The coefficient of the THM hydromechanics transmission stress compared to the TM mechanic on is given by the relation [2] :

$$C_S = 100\left(1 - \frac{P_{spTM}}{P_{spTMH}}\right) \qquad (7)$$

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