THEORETICAL STUDIES REGARDING THE TRACTIVE EFFORTS FOR VEHICLES USING THE HYDROSTATIC TRANSMISSIONS

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Abstract: *The paper analyze the possibility to adapt the hydrostatic transmissions for automotive with a view to obtain the technological velocities. Using these hydrostatic transmissions we want to obtain some low technological velocities. We propose a hydrostatic transmission (supplementary) adaptable to the tractors on wheels with mechanical transmissions, realizing the calculus of the traction force and to the maximal travel velocity.*
Keywords*: hydrostatic transmission, traction force, technological low velocity*

1. INTRODUCTION

The transmission of the vehicles includes the total sub-assemblies that realize the power transmission from engine to the driving wheel. Through the transmission it is realized the modifying of the travel velocities and the traction forces, according to the requests and the exploitation conditions of the vehicles [2].

The transmissions utilized in the present time can be: mechanical, hydraulically, electrical or combined.

In the last time it is manifested the tendency to extend the hydraulic transmissions in the car building. There are utilized both the hydraulic transmission and hydrostatic transmissions.

2. THE TRACTION CALCULUS FOR THE HYDROSTATIC TRANSMISSIONS OF THE TRACTORS

The utilization of the hydrostatic transmission allows the constant modification of the reduction ratio without the power flux breaking. The regulation of the travel velocity and the torque transmitted to the wheels of the tractor is made varying with the resistance put up the aggregate and through different kind of automatic regulators, which realize two basic characters of service [1]:

- constant power working, P = ct;
- constant velocity working, v = ct;

The first character of service is more economical, because the tractor can work all the time at the rated capacity, with lower fuel consumption, while the traction force and the travel velocity are variables.

The second character of service is used to some kind of works that need a constant velocity, by instance to plant seedlings. This regimen is characterized by variables traction forces and constant velocity, which means that the necessary power to be variable. The tractor engine works in different partial loads characters of service characterized by specifically consumptions higher than the first character of service.

The power, forces and velocities indicators for the hydrostatic transmission are determined with four groups of parameters. These parameters characterize [2]:

a) the dimensions (the capacity of the pump and the hydraulic engine, the active surface of the force cylinder);
b) the load of force (the maximal difference or the pressure difference;
c) the load of velocity (the maximal fluid discharge);
d) the economicity (the overall efficiency).

The most important quality of the hydrostatic transmission - the progressive regulation of the velocity - limit the level of the transmitted power in some cases. It will be examined the most simple hydrostatic transmission that consist in a pump and an engine.

For the simplification, we consider that η_{1v}, η_{2v}, η_{1m}, η_{2m}, η_1,şi η_2, have constant values, $Q_1 = Q_2 = Q$ and $\Delta p_1 = \Delta p_2 = \Delta p$, where:

- η_{1v}, η_{2v}, η_{1m}, η_{2m}, η_1,şi η_2 are, respectively the volumetric efficiency of the pump, the volumetric efficiency, mechanical efficiency of the pump, mechanical efficiency, the pump efficiency and the overall efficiency of the hydraulic engine;
- Q_1 and Q_2 - the pump delivery, respectively the fluid discharge into the hydraulic engine, in cm^3/min;
- Δp_1 and Δp_2 – the differential pressure between the output and input of delivery line for the pump, respectively of the hydraulic engine, in daN/cm^2.

The work of this hydrostatic transmission is represented in fig.1

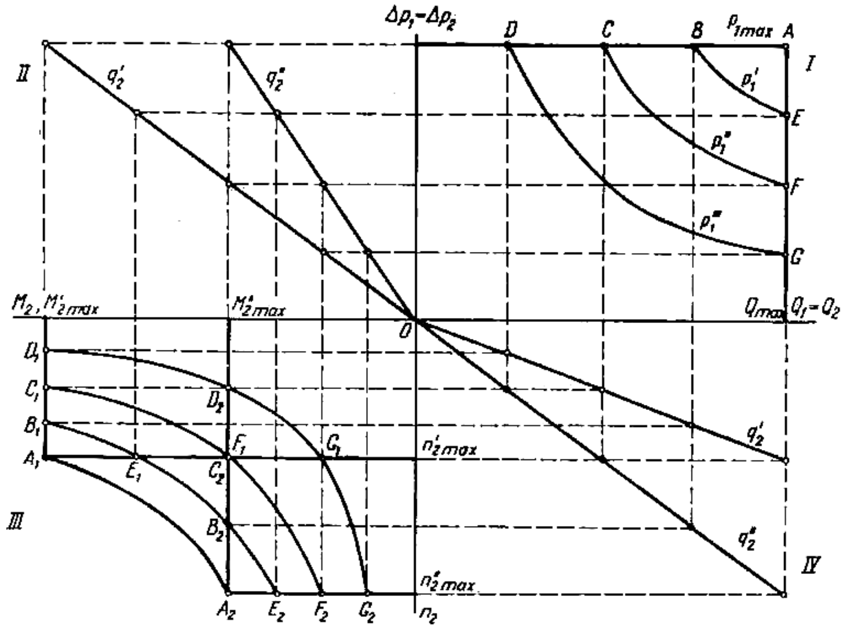

Fig.1. The working pf the hydrostatic transmission

In the first quadrant is represented the possible running of the pump working, limit by the maximal difference of the pressure p_{max} and the maximal capacity Q_{max} of fluid. For every point placed in the pump running area is correspondent a determinate power, the maximal power being in A point.

$$P_{1\max} = \frac{\Delta p_{\max} Q_{\max}}{6 \cdot 10^5 \eta_1} \text{ [kW]} \qquad (1)$$

The pumps with regulation give some constant power P_1 lower than P_{1max} into a range determinate by the fluid capacity.

The quadrant II represents M_2 varying with Δp for different values of q_2, where:

$$M_2 = \frac{\Delta p_2 q_2 \eta_{2m}}{2 \cdot 10^5 \pi} \text{ [daNm]} \qquad (2)$$

represent the torque at the output axle of the hydraulic moment, and q_2 is the capacity of the hydraulic moment, in cm^3/rot. For the regulation by steps, for each Δp value will be at least the same values for each existing step q_2.

In the III quadrant it is traced the area of the running work of the hydraulic motor and for the all hydrostatic transmission (M_2 torque varying with n_2), where n_2 is the speed at the output axle of the hydraulic motor. Running without regulation pump, the regimens area of the motor without regulation, corresponding to a constant speed, is a straight line M_{2max} = ct. In the case of the motor without regulation with regulation pump, to the maximal power P_{1max} correspond only one running work of the motor (A_1 for q'_2 and A_2 for q''_2). For lower values for the power P_1 correspond variations varying with a hyperbola in the area of running work of the motor.

In the IV quadrant is traced the variation for the speed n_2 varying with the capacity Q. Through the progressive regulation of the hydraulic motor capacity it correspond a range to the n_2 speed variation, limit by the radius q'_2 and radius q''_2.

In the figure 2 is presented the simplify traction characteristic of the tractor with hydrostatic transmission (on the abscissa is the traction force F_t, in daN and on the y-coordinate is the travel velocity of the tractor, in m^2/s).

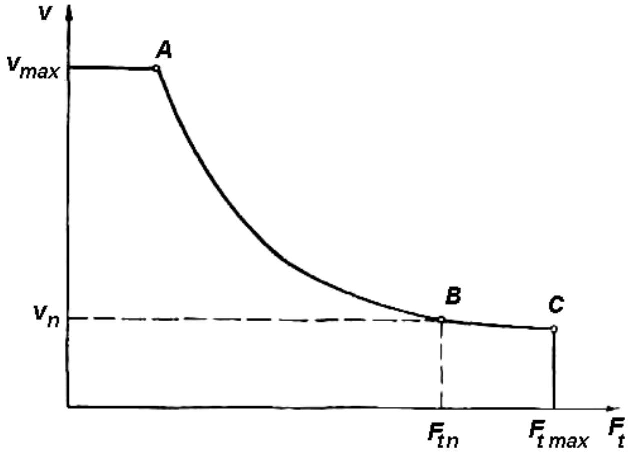

Fig. 2 The traction characteristic of the tractor with hydrostatic transmission

The running work is restricted by the right lines F_{tmax} = ct, v_{max} = ct and also by the hyperbola ABC, that correspond to the sum load of the motor.

The right line F_{tmax} = ct is determined by the maximal torque al the driving wheels, restricted up to the maximal value of the difference of the pressure p_{max}. Also the value F_{tmax} is connected to the adherence possibilities of the tractor and gives with the value F_{tn} a ratio, which characterize the traction force reserve.

3. SUPPLEMENTARY HYDROSTATIC TRANSMISSIONS FOR TRACTORS

The figure 3 presents the sheet of an hydrostatic transmission that can be adapt for the U-445 tractor [2, 4].

The circuit of the power flux is: tractor's motor - hydraulic pump P – distributor D - hydraulic motor M, fit in the coupling place of the rope pulley. The motor's power is transmitted through the wheel 12, jointed in the "synchronized power take off", to the central transmission and, from here, to the driving wheels, in the running time, the gear box being disengaged.

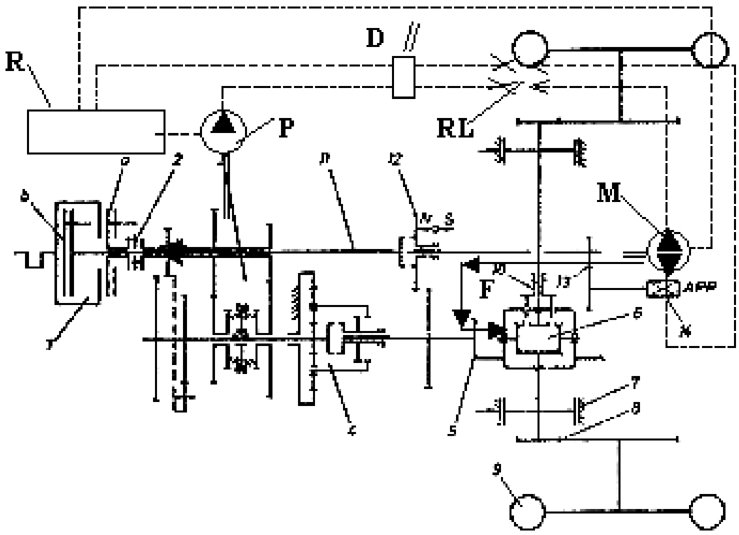

Fig. 2 The sheet of the tractor's transmission: P-hydraulic pump; M- hydraulic motor; R-oil tank; RL-coupling cock; D-distributor; F-power flow

The hydrostatic transmission can include a hydraulic motor with the following parameters:

- the volumetric capacity $V = 250$ cm^3/rot;
- the different of pressure at continuous work duty $\Delta p = 9$ MPa;
- the different of pressure at intermittent work duty $\Delta p = 10$ MPa;
- the maximal fluid pressure $p_{max} = 16$ MPa;
- the maximal speed $n_{mh} = 250$ rot/min;
- the efficiency $\eta_{mh} = 0{,}9$.

The maximal capacity of the hydraulic motor is: $Q_{\max} = \dfrac{V \cdot n_{mh}}{\eta_{mh}} \cdot 10^{-3} = 70$ l/min

The maximal power at the hydraulic motor axle is: $P_{\max} = \dfrac{Q_{\max} \Delta p}{600 \cdot \eta_{mh}} = 11.66$ kW

The tangential force will be: $F_{tg} = \dfrac{10^3 P_{\max} \eta_{tr} i_{tr}}{r \dfrac{\pi n_{mh}}{30}} = 2477.982$ daN,

where $r = 0.636$ m is the radius of the driving wheel of the tractor, $i_{tr} = 4.163$ is the reduction ratio from the hydraulic motor at the driving wheels of the tractor, end $\eta_{tr} = 0.85$ is the efficiency of the transmission [3].

The maximal road adherence force is: $F_{\max} = \mu_{ad} \dfrac{2GL + 3F_{tg} r}{3L} = 1381.333$ daN, where G = 1950 N is the heaviness of the tractor, L = 1.91 m is the axle base and μ_{ad} = 0.65 is the utilization coefficient of the adherence heaviness.

The resistance force at the travel without loads is: $F_r = f\,G$ = 175.5 daN,

where f = 0.09 is the road resistance coefficient.

Because $F_{max} < F_{tg}$ it results that the traction force will be:

$F_t = F_{max} - F_r$ = 1205.833 daN

The theoretical travel velocity can be obtained with the relation $v = \frac{\pi n r}{30}$.

Varying with the position of the hydraulic motor (in stead of the rope pulley or at the tractor's power take off), we obtain travel velocities in the range of 65 ... 1150 m/h.

4. CONCLUSIONS

Comparing to the mechanical transmissions, the hydrostatic transmission present the following advantages:

- ✓ provide a wide range of velocities and traction forces of the tractor, the slow work velocities being used mostly in vegetable growing;
- ✓ permit the disposition of the pump and the motor (motors) in any place in the transmission, because the joint between them is made through pipes;
- ✓ provide wide possibilities for automation of the work running of the tractor through automatic regulation of the travel velocity according to work resistance, in the view to the rational application of the motor power;
- ✓ simplify the tractor controls; using a distributor with lever drive the sense of rotation of the hydraulic motor axle can be stopped or changed, providing that way the stop or the reverse running of the tractor;
- ✓ the obtained traction forces are close to the ones obtained with the mechanical transmission.

5. REFERENCES

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