RESEARCH OF PROPERTIES OF THE DIESEL ENGINE UNIVERSAL REGULATOR OF A TRACTOR

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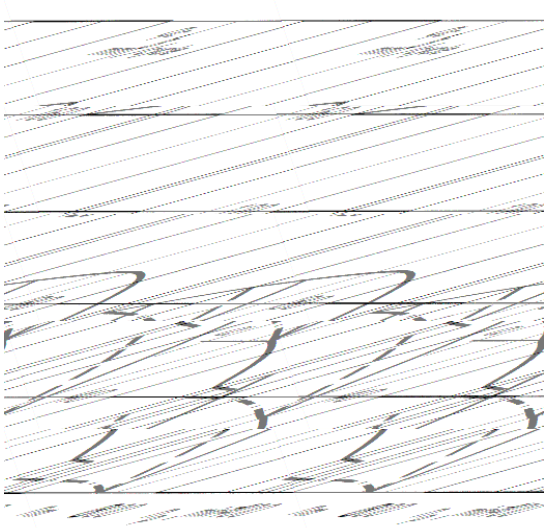
The necessity of an economical petroleum fuel expenditure and reduction of harmful emissions with exhaust gases is becoming a more and more acute problem with each year. The optimization of the system of fuel supply regulation is an effective means of improvement of economic and ecological parameters of diesel engines. The design is developed in our university and the research sample of the universal all – regime – one – regime regulator of diesel engine D-240 of the wheel tractor MTZ – 80 have been made. The carried out researches showed that the application of one – regime regulation at performance of transport works by a tractor allows to reduce an expense of fuel essentially and to lower emissions of harmful substances with exhaust gases. It is due to the fact that at one – regime regulation on any changes of loadings a diesel engine reacts precisely by the change of rotation frequency on any changes of loadings, which allows to dose out the submission of fuel more precisely, depending on movement conditions not permitting its excessive increase. At the same time the universal regulator enables to use all – regime regulation at the performance of field works by a tractor [2].

While examining the universal regulator an interesting property was revealed: at one – regime regulation, a corner of inclination of partial high – speed characteristics of fuel supply on a site from the starting frequency of rotation to the frequency which corresponds to the maximum rotation movement n_m may be different and depends on the rigidity of an auxiliary corrector spring which works on the specified site of the characteristics and serves for the maintenance of the characteristics declivity. With the help of a regulator calculation, which was done by the method of imitating modeling, it was established that the rigidity of an auxiliary spring 8.3 H/mm corresponds to an inclination corner of characteristics to an x – coordinate 43°, rigidity of 13.0 H/mm corresponds to the inclination corner 33°, and rigidity 25.2 H/mm corresponds to the inclination corner 15°. (Fig. 1).



The calculated data were confirmed by experimental researches of the fuel pump with a universal regulator on the engineless stand KI-22205: springs of different rigidity 8 H/mm and 25 H/mm were inserted into the regulator corrector and high – speed characteristics of fuel with corners of an inclination to the horizontal which are close to the calculated ones. It is natural, that there was a question, what corner of characteristics inclination is the optimum one from the point of view of operational properties.

Researches in this field had not been carried out earlier and consequently we did the experimental researches which included motor tests on the diesel engine D-240 and road tests of the tractor MTZ-80 with a trailer. As the regulator of rotation frequency of the diesel engine most significantly influences its work on the unsteady modes, it was decided to fulfil the tests on the most typical of these modes – on the mode of acceleration. In the first kind of tests, for the comparison of the main indices of the diesel engine during operation with a universal regulator at one – regime regulation acceleration of a diesel engine, trials were carried out on the brake stand KI-4893. Thus auxiliary springs of different rigidity (8 H/mm and 25H/mm) were inserted in turn into the corrector of regulator. The values of torqne moment M_e, frequencies of the crancshaft rotation, transference of the regulator control lever Wr, transference of the fuel pump rack h_p, and also the time of acceleration t_a of the diesel engine were continuously written down on a tape of the electro – magnetic oscillograph K12-22. Accelerations were carried out by the transference of the control lever by the regulator from 10° up 50° with constant speed in all cases of oscillographic testing.

The analysis of oscillograph records has shown that the change of rigidity of an auxiliary spring does not result in the essential influence on the indices of acceleration, including the period of acceleration t_a to the final rotation frequency.

During road researches the acceleration of the tractor MTZ-80 with a trailer were carried out.The records of the control lever W_r position by the regulator, transference of the fuel pump rach h_p, frequency of the tractor driving wheel n_k rotation and the time of tractor acceleration t_a up to maximum speed at different rigidities of the corrector auxiliary spring were carried out. The results of oscillograph records testify that the indices of tractor acceleration at different rigidity of auxiliary springs are practically identical. The only difference is that the time of the tractor acceleration at rigidity 8 H/mm 0.5 second is shorter, that at rigidity 25 H/mm. Thus the results of experimental researches have shown that the inclination corner of partial high –speed characteristics does not significantly influence the indices of a diesel engine.

Researches on the influence of the inclination corner of partial high – speed characteristics on fuel and harmful emissions of tractor might be of significant interest. Comparative tests on the toxicity of transport machines in working conditions represent a complex organizational and technical problem. It is considerably easier to use mathematical models. We have worked out such mathematical model, in which the diesel engine, the regulator of rotation frequency, the conducted part of clutch and the movement of the tractor train are described by systems of differential equations.

The equation of a diesel engine at acceleration in the condition of idling from the minimum frequency of rotation $n_{\min}$ to the frequency at which the operator releases the clutch pedal.

$$\frac{dn_e}{dt} = \left[Mi\left(q_c, n_e\right) - M_M\left(n_e\right)\frac{30}{J_e} \right], \tag{1}$$

where:

M_i – the indicated rotation moment of a diesel engine;
M_M – the moment of mechanical losses;
g_c – cycle fuel supply;
n_e – frequency of crankshaft rotation;
J_e – the moment of inertia of diesel engine rotation weights which is connected with crankshaft and machine joined to it.

The equation of the mechanical regulator of direct action

$$\frac{dZ}{dt} = \frac{1}{v}\left[P_c\left(Z, n_p\right) - E\left(W_r, Z\right) \right], \tag{2}$$

where:

v – factor of connected friction in connections;
P_c – centrifugal force of cargoes which is defined by the position of coupling Z and frequency of cargoes rotation n_p;
E – supported force which is determined by deformation of springs, used in the regulator;
W_r – position of the control lever by the fuel supply.

The solution of this system of equations will be carried out by a diesel engine up to the achievement of a given rotation frequency. Then the operator releases the pedal of coupling, continuing to move the lever of fuel supply and the first stage of the tractor train movement begins from the place with towage couplings.

This stage is described by a system of the equations:

Diesel engine

$$\frac{dn_e}{dt} = \left[Mi\left(q_c, n_e\right) - M_M\left(n_e\right) - M_c \frac{30}{J_e \pi} \right], \tag{3}$$

where:

M_c – the moment of coupling.

Conducted frequency of coupling:

$$\frac{dn_e}{dt} = \frac{30\left(M_c - M_t\right)}{J\pi}, \tag{3}$$

where:

$\frac{dn_e}{dt}$ – acceleration of conducted frequency of coupling;

M_t – the moment of resistance of a tractor train movement.

J – the moment of inertia of the conducted part coupling taking into consideration the mobile weights of a tractor train.

After alignment of freguency of a diesel engine's rotation and conducted part of coupling the second period of tractor train movement takes place – with blocked coupling. The movement of a tractor train is described by the equation:

$$\frac{dV}{dt} = \frac{1}{\delta\left(G_t + G_{tr} + G_w\right)} \left\{ \frac{\left[Mi\left(q_c, n_e\right) - M_M\left(n_e\right) \right] U_i U_p U_w}{2g} - P_t \pm P_i - P_w - P_{tr} \right\}, \tag{5}$$

where:

δ – the factor which takes into consideration the weights rotation of the tractor train.

G_t, G_{tr}, C_w – tractor, trailor, cargo weights;

P_t, P_i, P_w – resistance of swinging, rise, air;

P_{tr} – force of draft on a hook;

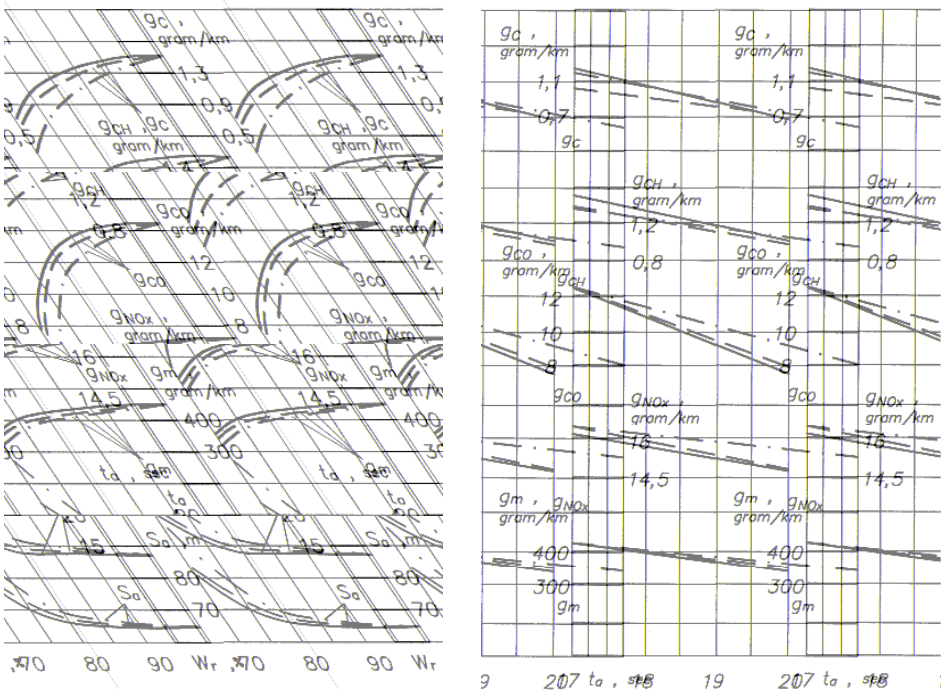
r_d – dynamic radius of a wheel;

U_i, U_p, $U_к$ – transference numbers of gear – box, main transference, wheel transference.

All other component models are described by the algebraic equations. The expense of fuel and air, emissions of harmful substances are described by polynomials of the second order. For the definition of polynomials, factors of the loading characteristics of a diesel engine in different high – speed conditions were removed. The algorithm and the program of calculation on the personal computor of the ecological and economic indices of the tractor in the conditions of acceleration were developed. Other unsteady conditions were not examined, as the regulator does not significantly influence the indices of the diesel engine operation in these conditions. The program of calculation includes the main modulus, four subroutines of the kind SUBROUTINE and one of the type

FUNCTION. In the main modulus the unsteady conditions of tractor operation conditions of transition from one regime to another are described, operators of subroutines calls are shown, the initial data for calculation are given. The verification of the mathematical model's adequacy has confirmed an opportunity of the developed model use for the calculation of the fuel expense and harmful emissions by the transport machine in the operational conditions.

In Fig. 2 the results of calculation and theoretical investigations on the mathematical model of the influence of inclination corner of the partial high – speed characteristics on the indices of the tractor MTZ-80 are shown, that is the dependence of acceleration time t_a, ways S_a, acceleration, emissions of harmful substances (g_c, g_{ch}, g_{co}, g_{nox}) expenses of fuel g_m at the acceleration from the control lever position by the fuel supply W_r at one – regime regulation. In figure two the following designations are accepted: g_c, g_{ch}, g_{co}, g_{nox} – according to the running of soot, hydrocarbons, carbon oxide and nitric oxide emissions.



The corner of inclination of partial high – speed characteristics on a site from starting frequency to the frequency of rotation which corresponds to the maximum rotation moment was set by a change of rigidity of the corrector auxiliary spring and factor which designates the compression of the auxiliary spring at the individual movement of the control lever by the fuel supply. And it was determined for each concrete case by a static calculation of a regulator. Due to

separate results of calculations it is possible to draw a conclusion that the inclination of partial high – speed characteristics at one – regime regulation influences a range of possible change of acceleration indices of a tractor train. Besides, with the increase of rigidity of the corrector auxiliary spring this range is increased. In operational conditions, especially when the tractor train moves in a transport stream or the possible intensity of its acceleration is defined by other factors, more objective estimation of the inclination corner's influence on particularly high – speed characteristics of fuel supply will be values of indices at identical intensity of acceleration as, basically, at practically any inclination of characteristics, one – regime regulation allows to operate by the intensity of acceleration of a tractor train. Comparative indices at such approach are shown in Fig. 3 where the time of acceleration of a tractor train to the speed of 35 km/h is marked on the axis of absciss. From the given dependencies it can be seen that the inclination corner of partial high–speed characteristics has practically no significant influence on the amount of harmful substances emissions and the expense of fuel. That is why by the development of one – regime regulators for wheel tractors and other transport machines the inclination of partial high – speed characteristics may be different, taking into consideration the stable diesel engine operation on partial and high–speed conditions.

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SUMMARY

The work is directed at raising of fuel economy and lowering of harmful rejections of a wheeled tractor when performing transport work by using universal regulator and optimal partial high – speed characteristics under one – mode regulation.