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RATIONALE OF TRACTION MOTOR PARAMETERS IN THE MOTOR-BLOCK DRIVE

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Abstract: the regulating and starting properties of DC motors used as a drive of an electric soil tiller is analyzed. The method of power determination and traction motor selection of the motor-block is given as well. The recommendations on the speed of movement in the plowing of soils with different resistivity were presented.
Keywords: motor-block, plowing, electric drive, traction DC electric motor, electric motor power parameters.

An establishment of required traction motor-block characteristic with high energy performance and certain reliability is a main purposes of the traction motor. The general traction characteristic of mobile power engine is the traction force F_m dependence on movement speed V at constant power of the driving motor P.

The mechanical characteristic $M=f(\omega)$ is the regulation law of the motor-block drive. For the practical implementation of this law, both AC motors and DC motors with controlled valve converters can be used as a traction motor. However, DC motors application, and especially sequential excitation motors, has some significant advantages:

1. Mechanical characteristics of sequential excitation motors $M=f(\omega)$ (natural and artificial) for any speed control are approached close to hyperbola, it means the

angular velocity ω changes automatically when resistance torque is changed to provide power $P_1=const$, which is in good agreement with the regulation law of traction motor. However, a relatively simple, controlled semiconductor rectifier could be used to control the DC motor while being powered by AC network. In order to implement the same control law, when AC motor used as a drive, it is necessary to use an expensive three-phase valve converter.

2. DC motors, unlike asynchronous and synchronous motors, provide speed regulation in the wide range both down and up from nominal value by attenuation of the magnetic field using simple means. In this case, the change coefficient of the maximum speed is $K_\omega = \omega_{\max}/\omega_{nom}$ = 2-4 and characterize the regulating engine properties. To increase the speed in asynchronous and synchronous motors above nominal value, it is necessary to increase the supply voltage in 2-2.5 times above nominal one, which causes intensive motor and converter heating, a significant losses increase and efficiency decrease.

3. In sequential excitation motors the electromagnetic torque has a quadratic dependence on the armature current I_a, and accordingly on the load current I: $M \sim I_a^2; \quad M \sim I^2$, i.e. $M \sim I_a^2; \quad I \sim \sqrt{M}.$ It gives reason to use these motors in drive actuators where high torques are required at startup and frequent overload torques are occurred. According to mechanical character, the angular velocity of the engine is $\omega \sim 1/\sqrt{I}$, resulting in useful power is $P_2 = M\Omega = C\sqrt{M}$.

Therefore, in the case of load torque changes over a wide range, the sequential excitation motor power P_2 and current I_a changes proportionally to $\sqrt{M}$. It means that with the same load on the motor-block shaft, the serial excitation motor may have a lower installed power than other electric motors.

In addition to the advantages of traction DC motors, there are also significant disadvantages: relatively large dimensions and weight, brush-collector assembly presence. The great advantage of squirrel-cage motors used as a traction drive is its reliability, relatively low weight and dimensions. However, frequency converters applying complicates the traction drive and increases its cost significantly.

Choosing the power of the traction motor is one of the most complex and responsible tasks when creating traction electric drive of any mobile units and transport systems, including moto-blocks at the initial stage of their development.

Primary soil cultivation is the most energy-intensive technological operation, so the traction motor power has to be taken to provide the required tractive force on the motor block hook F to perform plowing heavy (F_h), medium (F_m) or light (F_l) soil.

The useful power of the traction motor is determined by the formula

$$P = \frac{K_з\left(F - f \cdot G\right) \cdot V}{\eta_р \cdot \eta_б \cdot \eta_к}, \qquad (1)$$

where $K_з$ = 1.1-1.2 – reserve factor;

F – traction force depends to soil characteristics, kN;

G – adhesive weight depends to soil characteristics, kN;

V – movement speed of the motor-block on plowing soil, m/s;

$\eta_р$ – gearbox efficiency;

$\eta_б$ = 0,93 – coefficient taking into account the losses on slip;

$\eta_к$ = 0.95 – the same thing to overcome rolling resistance.

The value $\eta_m = \eta_р \cdot \eta_б \cdot \eta_к$ is called the traction unit efficiency. In the previous calculations it is accepted η_m = 0,74-0,76 [1, p. 15].

Fig. 1 shows the graphs of useful power $P = f(V)$ under $K = const$ for traction moto-blocks according to results of calculations at η_m = 0.75; $K_з$ = 1.05 for light soils, $K_з$ = 1.1 for medium and $K_з$ = 1.2 for heavy soils [2, p. 99].

According to electrical equipment catalog [3] the motor with rated power P_{nom} closest to calculated power P should be selected. The rated motor speed n_{nom} should be higher if possible, as far as such electric motor has a higher efficiency and smaller dimensions. The maximum speed multiplicity requirement has to satisfy the relation: $K_\omega = \omega_{\max} / \omega_{nom} = n_{max}/ n_{nom}$ = 2.0-2.5.

Calculated power of the engine is determined as

$$P_p = P_{nom} \cdot K_\omega \approx M_{nom} \cdot \omega_{\max}, \qquad (2)$$

where M_{nom} is the rated engine torque, Nm.

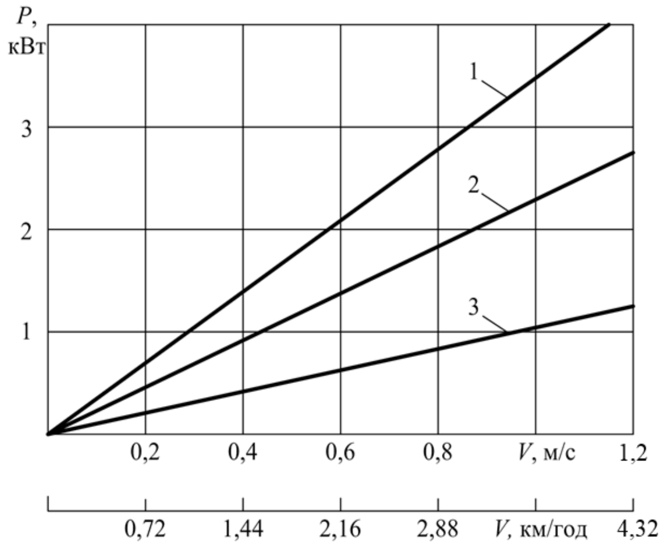

Fig. 1. Useful power graphs of the traction motor-block drive on plowing the soil: 1 - heavy, *$K_в$* = 90 kPa; 2 - average, *$K_в$* = 60 kPa; 3 - lungs, *$K_в$* = 30 kPa.

In conclusion the sequential excitation DC motors with a controlled rectifier are recommended to be applied as far as energy performance is higher than AC motors. A relatively simple and reliable method of power calculation and traction motor selection in the multi-purpose motor-block drive is proposed. The graphs of electric motor useful power in function of movement speed on soils plowing with different specific resistance are presented and could be used for practical application.

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