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MINI-MOBILE MACHINE WITH ELECTRIC CONTROL

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Abstract

The article discusses a mini-mobile machine of hybrid type designed in the Raphael Dvali Institute of Machine Mechanics. Mini-mobile machine is an intermediate link between two-wheel tractor and mini-tractor. The machine uses an electric system of control, which enables smoothly starting and stopping of machine, its maneuverability with independent changing rotation frequency and rotation direction of wheels, machine movement in forward and backward direction and braking. The machine is controlled by an operator with electrical panel both remotely and as well as sitting on the machine, which frees the operator from doing the hard work. Placing the operator directly on the machine increases adhesion power, allowing the machine to perform heavy agricultural operations. The construction of the machine provides for its operation with one or two active axels and is designed to perform various agricultural works. The represented construction of mini-mobile machine by simple alteration enables to work with one or two axles, to change the location of aggregates and units placed in the machine, and to equip it by different hanging equipment and devices. Thus, it is possible to build up the mobile machine with cross-country capability of different kind and purpose. In addition, it must be noted that the hybrid type power installation with an internal combustion engine, generators and electric drives was used for the first time for mobile vehicles of small mechanization in agriculture.

Keywords: Mobile machine, two-wheel tractor, mini-tractor

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INTRODUCTION

Following from specificity of agriculture (very many technological processes), all types of agricultural works need corresponding machinery. All these problems are found on small farms where ground areas do not exceed 4-5 hectare and manufacturers aim to produce different agricultural products, which demand a realization of many technological operations. Such demands can be met by using universal and mechanized two-wheel tractors, which are equipped with low-powered internal combustion engines and have a replaceable hanging equipment of different kinds.

Two-wheel tractors with their functions and possibilities keep an intermediate position between motor cultivators and mini-tractors. Distinction between the two-wheel tractor and the mini-tractor is that the two-wheel tractor is monoaxial, foot-operated and the seat for the operator and the steering mechanism for maneuvering is provided on the mini-tractor. As for a motor cultivator, it performs one kind of operation – ground loosening only. Two-wheel tractors are classified by engine power. Two-wheel tractors with engine power 5,5 – 6.5 hp. belong to the light class, and two-wheel tractors with engine power 7 hp. and above belong to the heavy one. Two-wheel tractors of light class because of their low weight and accordingly small adhesion of wheels cannot perform heavy and complex agricultural works, their driving is very tiring and it demands great physical overloads from operator. Users of light two-wheel tractors try to fasten additional weight to the wheel disks or use wheels with iron spikes for increasing the adhesion of wheels and grasping of tires with the ground that is not a solution of the problem. Solving this question requires the mini-mobile machine of intermediate class between two-wheel tractors and mini-tractors in which the correction of mentioned negative moments will be taken into consideration. But there is a definite effort to have the two-wheel tractors with third, additional passive wheel, which only provides a transportation of the operator and has no influence on the adhesion of wheels. With such construction solution, there is an increased longitudinal dimension of two-wheel tractors that influence negatively the maneuverability of the machine.

MAIN PART

The figure 1 represents the basic diagram of hybrid type mobile machine of original construction and the figure 2 shows an acting physical model of the machine designed on the basis of the same diagram in the Raphael Dvali Institute of Machine Mechanics.

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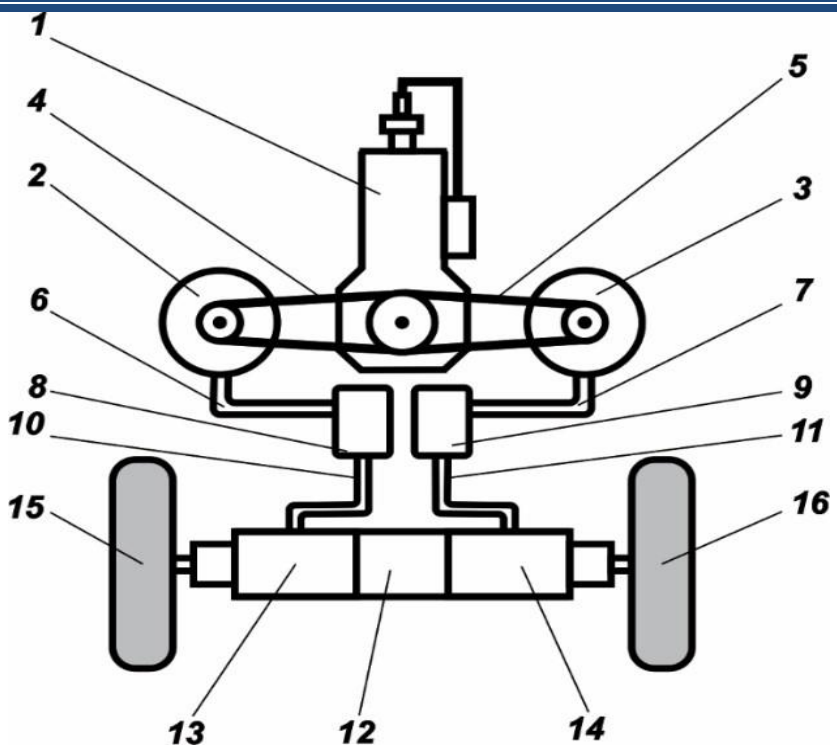

Fig. 1. Basic diagram of the hybrid type mobile machine.
1 – internal combustion engine; 2, 3 – direct current automobile generators;
4, 5 – belts for driving of generators; 6, 7, 10, 11 – electrical conductors; 8, 9 – electronic control blocks; 12 – axle; 13, 14 – direct
current motors with planetary reduction gears; 15, 16 – wheels.

The basic power installation of the mobile machine is air cooling internal combustion engine with power 7,5 hp, working on the petrol, n = 3600 rpm, which activates two automobile generators type MD31395 with parameters: N = 1777 W., n = 6000 rpm., I = 132 A., U = 14,4 V., and as a drive, direct current motor-reducers of Italian firm “TRANSTECNO” are used, model ES350 with following parameters: N = 500 W., N = 500 rpm., U = 12 V., I = 58,5 A., planetary reduction gear with transmission ratio i = 64, axial load P = 2000 N.

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Fig. 2. Acting physical model of the hybrid type mini-mobile machine.

Construction of mobile machine allows working with one or two axles. Axles are identical and they represent two independent direct current motors with planetary reduction gears located in the longitudinal tube (frame). The wheels are mounted on the axes outgoing from reduction gears (Fig.3).

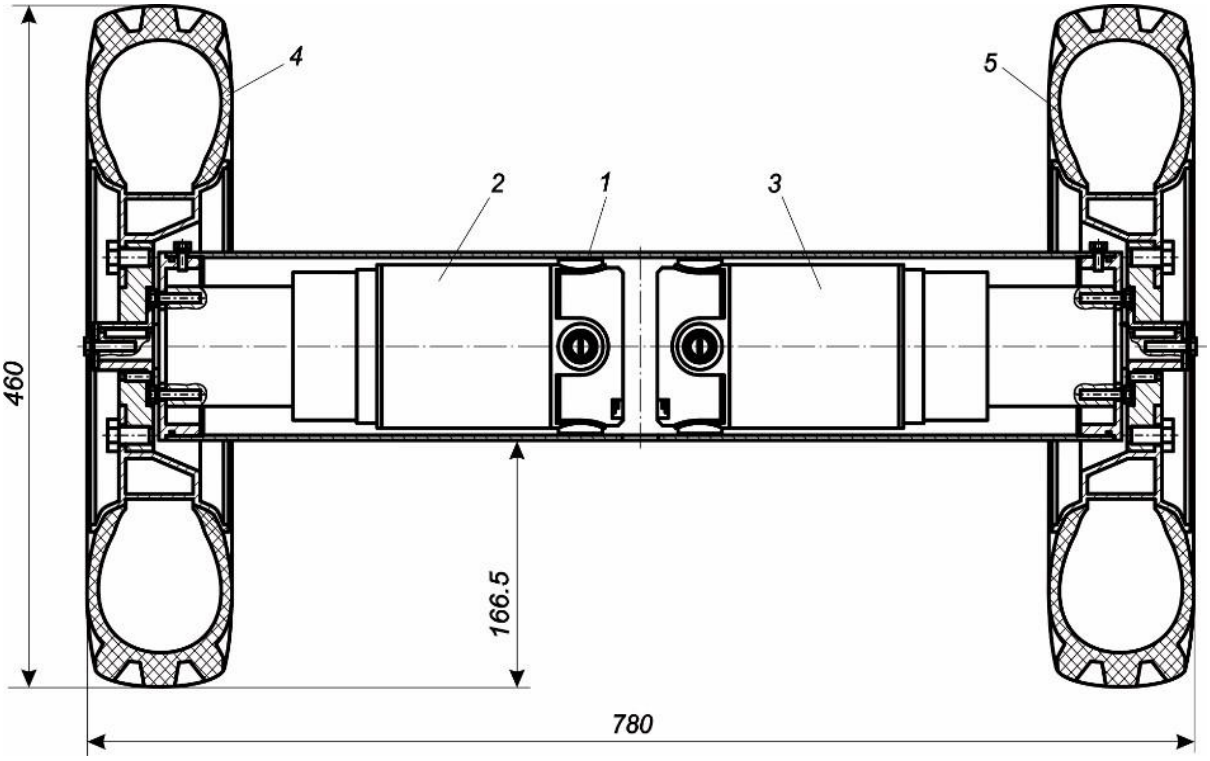

Fig. 3. Assemblage drawing of mobile machine axle.
1 – frame; 2 – DC motor-reducers; 4, 5 – wheels.

The classical differential mechanism not provided in the axles. Its existence was excluded by electric system for independent starting and control of direct current motors, which are placed in the axle. In terms of maneuverability and cross-country capability of the machine, the mentioned system, as compared with classical differential model, has great advantages, particularly: firstly, the machine cannot slide on one wheel, as it happens in case of simple type differential drive, and it significantly increases the cross-country capability that is very important for such type of machines, and secondly, while maneuvering the machine, an independent control of electric motors allows us to change speed as well as the direction of rotation of the wheels. This last condition provides a high maneuverability of the machine and while using one axle, the machine can make u-turn with minimal radius around the center of the axle.

By increasing the adhesion of wheels, performing the heavy agricultural works by machine is provided by the aggregates and units located on the driving axle as well as the gravity force of the

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operator placed on the same axle. The hanging equipment (fig.4) or special simple support compensates the reactive moment arising on the axle when using only one axle in the machine. The operator can drive the machine both in a sitting position and by remote control, which makes his heavy physical work easier.

Fig. 4. Mobile machine with hanging equipment.

The purpose of the control system is to change the rotation frequency and rotational moment brought on the tire casing as a result of road condition and movement regime. Mobile machines with classical working scheme, whose basic power installation is internal combustion engine and force installation - gear box and axle with differential, have an independent steering and breaking system. Unlike them, the represented machine is equipped with electrical control system, two independent generators and driving gears. Electrical control system supposes: smooth start of machine, its driving with independent changing rotation frequency and rotation direction of wheels, remote control of machine, machine movement in forward and backward direction, braking of machine, and protection of the generators from overload.

The figure 5 represents an electrical scheme of machine feeding, control and moving start on the example of one driving gear, where number 1 is the 3-phase alternating current generator with rectifier, number 2 is a voltage regulator (provides uninterrupted voltage on board system at the different rotation of the generator); number 3 is a control block with operator control; number 4 is a direct current motor; number 5 is a double-pole switch (provides the switching of control block and drive of machine); number 6 is a double-pole switch of current phase inverter (provides the control of forward and backward movement of machine); and number 7 is changeable, regulated resistance (provides the rotational frequency of electrical motor i.e. to regulate the speed of machine).

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Conditionally, control block can be divided in two parts. First is the electrical scheme of PWM-regulator, which provides the regulation of rotation frequency of motors; second is a current phase inverter, which inverts the current incoming to the electrical motors. Those operations are realized by two electrical relay.

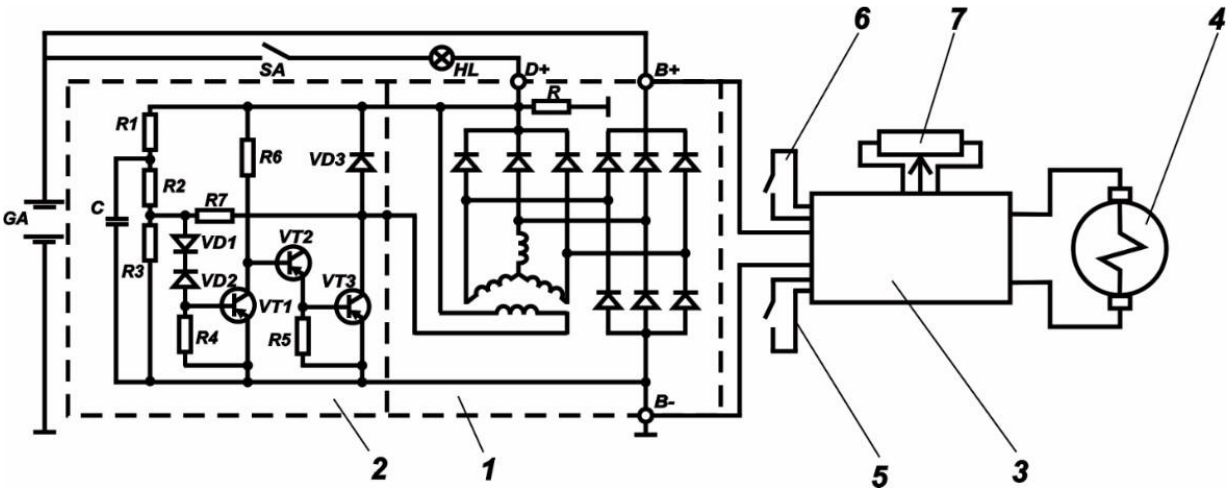

Fig. 5. The scheme of electrical feeding and control of machine

When the machine is equipped by one axle, two such devices are necessary, but when the machine is equipped by two axles, in this case one drive is added (fig. 6). Application of mentioned control blocks enables to realize an electrical feed of motor from one generator with corresponding power. The figure 7 shows a block scheme of control of feeding from one generator of mobile machine

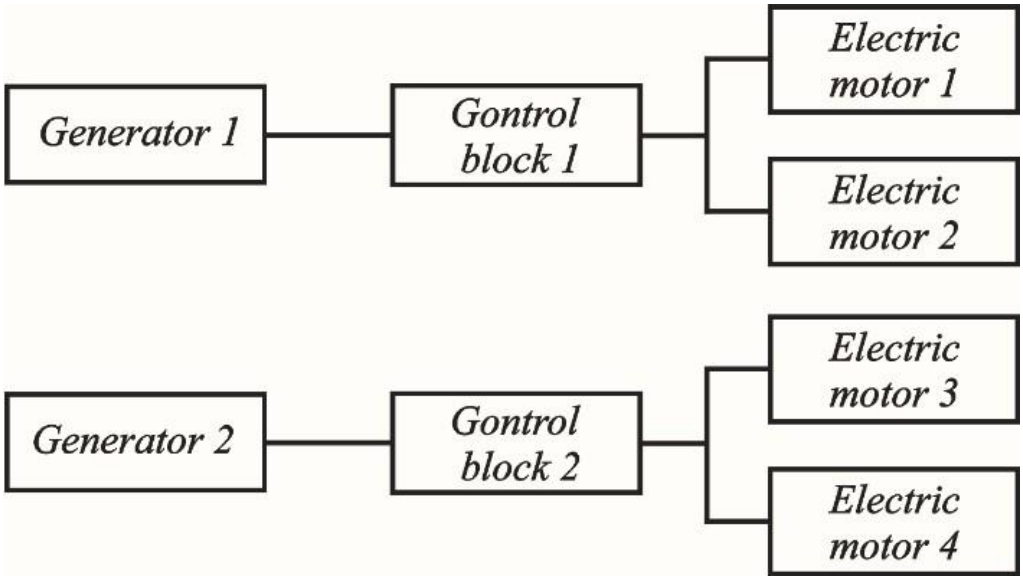

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Fig. 6. Block scheme of control of machine with two generators and two axles.

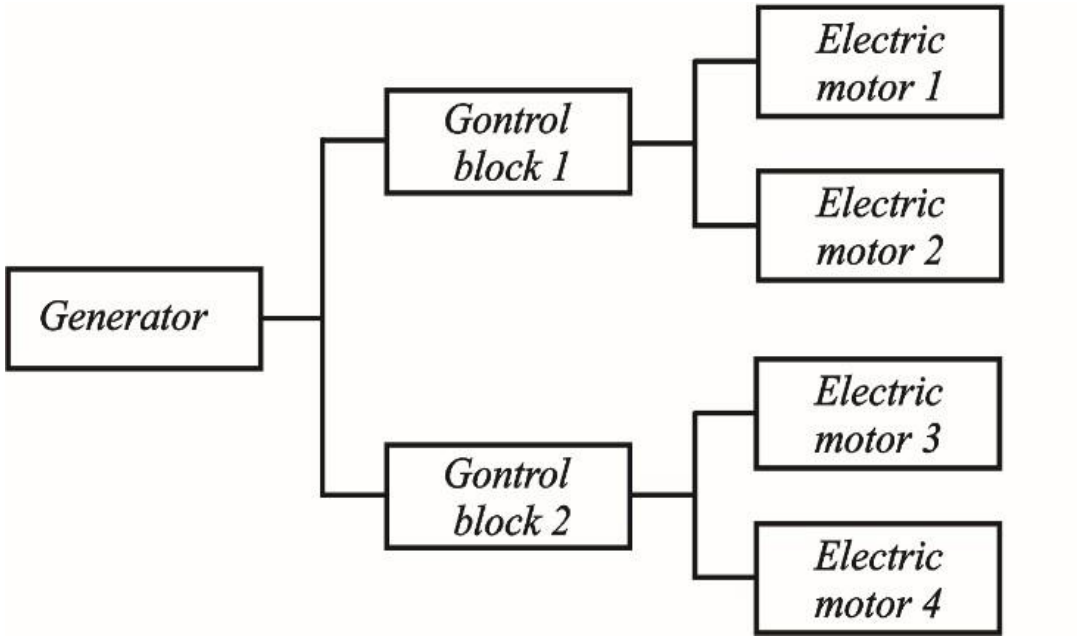

Fig. 7. Block scheme of control of machine with one generator and two axles.

The figure 8 shows the placing of control blocks on the mobile machine.

Fig.8. Placing of control blocks on the mobile machine.

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The parameters of the represented mini-mobile machine are:

- Full weight – 400 kg;
- Effective power of the engine – 7.5 hp; - Maximum speed – 4 km/h; - Radius of wheel – 0,23 m.

As it is known, the power balance of mobile machine is expressed by the following equation:[1]

$$N_e \cdot \eta_m = N_f + N_\omega + N_i + N_j \quad (1)$$

Here, is output power of the power unit, hp;

- transmission efficiency;
- consumption power for overcoming the rolling resistance, hp;
- consumption power for overcoming the air resistance, hp;
- consumption power for overcoming the road inclination resistance, hp; - consumption power for overcoming the machine acceleration, hp.

Due to the small size and weight and low movement speed, the powers spent for overcoming the air resistance and acceleration can be ignored, so the power balance equation (1) can be written like this:

$$N_f = \frac{G \cdot f \cdot v \cdot \cos\alpha}{270} \quad (3)$$

$$N_i = \frac{G \cdot v \cdot \sin\alpha}{270} \quad (4)$$

$$N_e \cdot \eta_m = N_f + N_i \quad (2)$$

for its side[2] and

in the last expression: is a full weight of the mobile machine, kg.

– a speed of machine, km/h.

– wheel rolling resistance coefficient.

– an inclination angle of the road.

Substituting (3) and (4) in (2) power balance equation assumes the view:

$$N_e \cdot \eta_m = \frac{G \cdot v(f \cdot \cos\alpha + \sin\alpha)}{270} \quad (5)$$

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The meaning of wheel rolling resistance coefficient depends on the kind of road covering and machine speed. As

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the machine speed does not exceed 70 km/h, f = f_0, its meaning can be taken from the handbooks:[5,6]

- The road with asphalt concrete covering =0.014 0.0181;
- The miry soil =0.05 0.10; • Snowy road =0.025 0.03;
- Dry sand =0.080,1.

Meaning of transmission efficiency is [9].[5]

According to the data of mini-mobile machine and 5th expression, we can calculate the theoretical meaning of eventual complete weight of the machine by different covering and inclination angle of the road. The results obtained by calculation are given in Table 1.

Theoretical meaning of eventual complete weight of the mobile machine by different covering and inclination angle of the road

Kind of road covering	Coefficient of rolling resistance (f_0)	Inclination angle of the road (^{0})					
		0	10	20	30	40	45
Asphalt concrete	0,018	7555	715	377	264	209	189
Miry soil	0,1	1360	503	309	234	192	176
Snowy road	0,03	4533	680	367	259	205	186
Dry sand	0,1	453	295	219	181	155	151

CONCLUSION

The represented construction of mini-mobile machine by simple alteration enables to work with one or two axles, to change the location of aggregates and units placed in the machine, and to equip it with different hanging equipment. Thus, it is possible to build up the mobile machine with cross-country capability of different kind and purpose. In addition, it must be noted that the hybrid type power installation with internal combustion engine, generators and electric drives was used for the first time for mobile machines of small mechanization in agriculture.

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