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Production of motor-wheels for prototypes of mini-electric vehicles based on new soft magnetic materials

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Abstract. This article discusses the issue of production a motor-wheel for prototypes of mini-electric vehicles based on new soft magnetic materials. The structure and morphology of the surface obtained composite materials have studied. The density value calculated from the X-ray diffraction data is about 3% higher than the directly measured values, which are 7.7 g/cm3. Technologies and create new technical means and their effective use, the results of development and research of magnetic materials and complex technology for constructing electric motors based on them are disparate and do not allow the creation of new approaches for their mass implementation. Tests of the electromagnetic characteristics of magnetic circuits based on the materials obtained for constructing an electric drive were carried out using an express magnetometer.

1 Introduction

Currently, it is quite obvious that electric transport, thanks to the enormous scientific and technological development in the field of highly efficient electromagnetic motors and batteries, is conquering the world market, and is the embodiment of innovative development [1-5]. The world's leading manufacturers have begun serial production of electric modifications of their electric vehicles. Total sales of electric vehicles will grow from 2.5 million in 2020 to 11.2 million in 2025, and will reach 31.1 million by 2030, electric vehicles will account for approximately 32% of the total market share of new vehicle sales, and the trend is to increase their share will be maintained [5-6].

For the effective operation of autonomous electrical devices, including electric vehicles, it is necessary to maintain a balance between the energy stored in batteries and the consumed power of electric motors. Naturally, electric vehicles use electromagnetic motors, and in addition to traction motors, a large number of executive motors are used in rotation systems, control of scanning mirrors and cameras, climate comfort dampers, ergonomic positioning of seats and others. That is, for use in electric transport, a range of various engines is required,

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the energy costs of which will be consistent and optimized in relation to the function performed [2-3]. The adopted programs for the development of electric transport in Belarus and Uzbekistan [4,6-11] and the action strategy for the further development of the Republic of Uzbekistan for 2021-2025 define the development and use of high-performance equipment, the creation and implementation of new technologies and production capacities, etc. [12-16].

Purpose of research: Improvement and justification of the type of technical means that reduce costs and their parameters. Creation of an experimental small-sized electric vehicle based on new soft magnetic materials, testing and implementation of it into production [4,6].

2 Materials and methods

Based on the assigned tasks, a solution to the scientific problem is established, a new type of motor-wheels is installed, power characteristics and energy indicators are developed and their parameters are set on the basis of the newly designed structural diagram of a children's electric car. The energy indicators of a prototype equipped with a motor made of a new magnetic material with reasonable parameters were determined and conclusions were drawn.

Experimental study design. The studies were carried out in the laboratory and in natural conditions. In the laboratory, the energy performance of the motor-wheel was studied using the newly developed design of a children's electric car, and the design was adapted to the parameters of the motor-wheel. A new design children's wheel motor was installed on an electric car.

Based on the results of the work, the following scientific novelties were obtained: the design of mini-electric transport was developed and the parameters were justified; theoretical and experimental studies and motor-wheel designs for an experimental model of mini-electric vehicles made from new magnetic materials; The operating parameters of the electric vehicle and technological operating modes were determined by the type of work performed.

3 Results and discussion

Carrying out tests of magnetic circuits based on the materials obtained for constructing an electric drive. Tests of the basic electromagnetic characteristics of magnetic circuits based on the materials obtained for constructing an electric drive were carried out using an express magnetometer (Figure 1), where losses, the magnitude of magnetic induction and other magnetic parameters were determined from the magnetization reversal curves of the samples. Before measurements, the express magnetometer is pre-calibrated for each sample under study. For this purpose, preliminary measurements of the magnetization curve for a given sample are carried out on a certified measuring device. In our case, we used a digital microweb meter. On the resulting magnetization curve, a reference point was selected, for example, the value of magnetic induction at a field strength equal to H = 5 kA/m, and the specified values were entered into the magnetometer program. From the above it follows that the results of testing the main functional characteristics using an express magnetometer are determined by standardization using a certified device for measuring magnetization curves.

The dynamic characteristics of magnetic circuits in the frequency range up to 100 kHz were studied using a 140 W low-frequency amplifier as a power element. Here, the input signal from the generator was amplified and applied to the primary winding of the magnetic circuit under study, the secondary winding of which was loaded with an active resistance of 6 Ohms. The output parameters were monitored by a two-channel electronic digital oscilloscope.

Figure 2 shows the magnetization curves measured at 1 kHz for components made of a composite magnetic material based on ABC100.30 iron powder encapsulated with a phosphorus oxide coating. Analysis of experimental data and comparison of them with the results of studies by other authors [3,6] showed that the magnetic induction of a composite material exceeds in magnitude the induction of electrical steel in almost the entire range of magnetic fields. At a voltage H = 22 kA/m for the new composite magnetic material, the induction value is B_m = 1.76 T, and for steel – B_m = 1.7 T with a sample density of ρ = 7.6 g/cm^3.

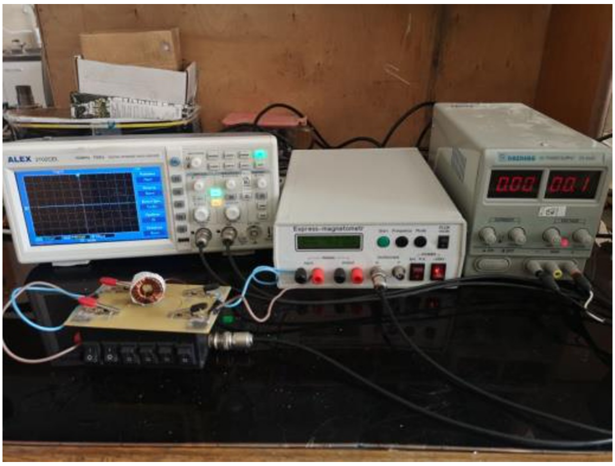

Fig. 1. Appearance of the express magnetometer

Figure 2 also shows the field dependences of hysteresis losses during magnetization reversal along a full loop for manufactured components. Since each particle of the material is covered with an insulating coating, in our case there are practically no eddy currents, only hysteresis losses remain, which increase linearly with induction over the entire measurement range. For an induction value of B = 1.55 T, the hysteretic losses of components from the developed composite are of the order of P = 70 W/kg, and for electrical steel P = 120 W/kg [4,6].

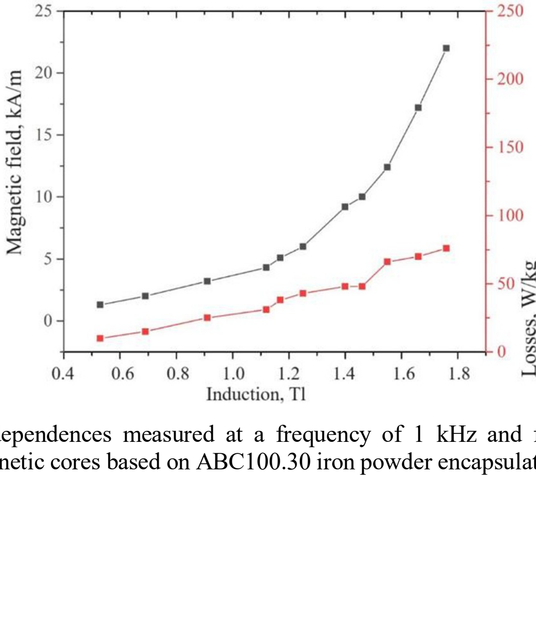

Fig. 2. Magnetization dependences measured at a frequency of 1 kHz and field dependences of hysteresis losses for magnetic cores based on ABC100.30 iron powder encapsulated with a phosphorus oxide coating

The advantages of the developed composite magnetic material over electrical steel make it possible to ensure its wider use for the manufacture of electrical products in order to increase power density at high rotation speeds with lower losses.

Production of experimental samples of motor-wheels using the obtained magnetic cores. Using the obtained magnetic cores, experimental samples of the motor-wheel were made. For this purpose, design documentation has been developed for all elements of the experimental sample. All body elements are made of D16 duralumin. The motor-wheel housing consists of a stator (1), a pressure ring (2), a protective (3) and a brake (4) cover (Figure 3). The magnetic cores were inserted into the grooves of the stator and fixed with a clamping ring (Figure 4). For insulation during winding, a pre-made plastic tab was attached to the magnetic cores. For winding, enameled copper wire PEV-2 with a diameter of 0.89 mm was used. Figure 5 shows an image of a wound motor-wheel stator.

Fig. 3. Produced elements of the motor-wheel housing: 1 – stator, 2 – clamping ring, 3 – protective cover, 4 – brake cover

Fig. 4. Motor-wheel stator

To assemble the motor-wheel, 40 NdFeB magnets with the following parameters were used: remanent induction 1.15 T, coercive magnetizing force 850 kA/m, magnetic permeability 1.05. The shaft is made of stainless steel. To ensure correct phase rotation and uniform rotation of the motor, three Hall sensors are installed, with the help of which the synchronous motor determines what position the rotor is in at a given time and supplies voltage to certain phases.

Fig. 5. Appearance of the motor-wheel

Figure 6 shows a photograph of an assembled experimental sample of a motor-wheel with an installed rim for mounting a tire. The weight of the experimental sample was about 9.0 kg, dimensions: diameter 18.5 cm, height 4 cm. Tests of the main electrophysical characteristics of the experimental sample of motor-wheel were carried out on a test bench.

Fig. 6. Appearance of an experimental sample of a motor-wheel

As a result of the tests of the main electrophysical characteristics of the experimental sample of the motor-wheel, the following data were obtained (Table 1).

Table 1. Main electrophysical characteristics of the experimental sample.

	At nominal conditions	**Under loads**
Engine's type	Motor-wheel	
power	450-600 W	600 W
voltage	220-380 V	
Supply frequency	1 kHz	1 kHz
Rotor speed	1500 rpm	1500 rpm
Efficiency	0,9	0,89

4 Conclusions

Magnetic cores based on the obtained materials were tested to construct an electric drive for a motor-wheel. Testing of the main electromagnetic characteristics of the manufactured magnetic components was carried out using an express magnetometer. At a voltage H = 22 kA/m at a frequency of 1 kHz for a pressed magnetic core, the value of magnetic induction is Bm = 1.76 T. The magnitude of hysteresis losses in the manufactured magnetic circuits is of the order of P = 70 W/kg for an induction value of B = 1.55 T. A preliminary assessment of the electrical parameters of the components showed that the magnetic components will be suitable for the manufacture of a wheel motor with a power of up to 600 W.

Using the obtained magnetic cores, experimental samples of the motor-wheel were made. For winding, enamelled copper wire PEV-2 with a diameter of 0.89 mm was used. When assembling the motor-wheel, 40 NdFeB magnets with a residual induction of 1.15 T, a coercive magnetizing force of 850 kA/m, and a magnetic permeability of 1.05 were used. To ensure correct phase rotation and uniform rotation of the motor, three Hall sensors are installed. All body elements are made of D16 duralumin. The weight of the experimental sample was about 9.0 kg, dimensions: diameter 18.5 cm, height 4 cm. Tests of the main electrophysical characteristics of the experimental sample motor-wheel were carried out on a test bench. During the tests, it was found that with a supply voltage of 36 V, the rotor speed is 1500 rpm, and the generated power is about 600 W.

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