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Experimental studies of starting modes synchronous motor of longitudinal-transversal excitation

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ABSTRACT: The article presents the results of an experimental study of the starting modes of a synchronous motor of longitudinal-transverse excitation. The area of application, advantages in comparison with an asynchronous motor, ways to increase the stability of synchronous motors are briefly described. Next, the issue of starting a synchronous motor with longitudinal-transverse excitation is considered. An engine with longitudinal-transverse excitation has been developed and experimental studies have been carried out. The results of the experiment are given in the form of an oscillogram showing the processes of starting the engine. The oscillograms show the patterns of changes in the voltage of the stator winding, the currents in the stator and rotor windings, and the engine start time. A comparative analysis of the starting modes of a uniaxial and biaxial synchronous motor is made.

KEY WORDS: Synchronous motor, longitudinal-transverse excitation, starting mode, Stator voltages, stator current, rotor current, starting time.

I.INTRODUCTION

A synchronous electric motor (SM) is used in installations that do not require speed control, for example, for fans, pumps, compressors. SM has a higher efficiency than asynchronous, can work with over excitation, i.e. with a negative angle φ, thereby compensating for the inductive power of other consumers.
Although the SM is more complex in design, requires a direct current source, has slip rings, nevertheless it turns out to be more cost-effective than asynchronous, especially for driving powerful mechanisms.
SM with conventional excitation in some operating modes cannot meet the requirements imposed on them. Therefore, the search for new means of increasing stability led to the creation of SM with two windings on the rotor [1, 2].

With two mutually perpendicular excitation windings, at the cost of a certain complication of the design of the inductor and the power circuit of the excitation windings, they achieve higher machine performance in terms of stability and controllability [3]. In this case, the excitation windings can be either the same, i.e., creating equal magneto motive forces (MMF), or different, creating unequal MMF.
By their nature, they are synchronous machines with a rotary magnetization axis. When the excitation windings are powered by independent regulated DC sources, they are called synchronous machines of longitudinal-transverse excitation (SM d-q) [1, 2].

In [4], a comparative analysis of the operational properties of synchronous machines with conventional excitation and with two mutually shifted windings on the rotor, excited from independent regulated DC sources, is given. On the basis of research, it has been shown that the use of a transverse control excitation winding significantly improves the performance of synchronous machines at low costs for its manufacture.

II. SIGNIFICANCE OF THE SYSTEM

In this article, based on the results of experimental studies, a comparative analysis of the starting properties of a conventional SM and SM d-q is given. The study of literature survey is presented in section III, Methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses conclusion.

III. LITERATURE SURVEY

The issues of launching conventional SM have been studied quite fully [5-7]. However, SM d-q excitation studied insufficiently. It is known that starting modes lead to an accelerated failure of synchronous motors, since at the moment the motor is connected to the network, a large starting current occurs in the stator winding, which is several times higher than the nominal value. Only experimental research makes it possible to analyse the operation of the SM for a specific mode of operation.

IV. METHODOLOGY

In this paper, an analysis of the starting characteristics of a non-salient-pole SM d-q excitation has been carried out. The research was carried out in the operating engine located in the scientific laboratory of the Department of "Electrical Machines" of the Tashkent State Technical University, in order to determine the patterns of changes in voltage and currents in the asynchronous start mode.

The start of a synchronous motor is carried out as the start of an asynchronous motor. A three-phase alternating current is supplied to the stator winding, which creates a rotating magnetic field. This field, during rotation, crosses the conductors of the excitation winding and indicates the electromotive force in them. Since the rotor winding is short-circuited, current appears in it. The rotor current, interacting with the magnetic field of the stator, creates a force under the action of which the rotor goes into rotation.

A synchronous motor, rotating as an asynchronous motor, reaches almost synchronous frequency. The resulting slip depends on the load on the shaft and on the parameters of the electrical circuits of the rotor. The entry into synchronism is achieved after the inclusion of direct current in the excitation winding under the action of the resulting synchronizing torque.
A Tektronix MSO64 four-channel digital oscilloscope was used to measure and oscilloscope the results.

V. EXPERIMENTAL RESULTS

Experimental studies were carried out in an implicit-pole synchronous motor of longitudinal-transverse excitation with a power of 2.2 kW, voltage 220V, rotation speed 1500 rpm.
This non-salient SM d-q is based on a wound rotor induction motor type MTO-12-4 and the following modifications have been made:
1. In the rotor, two identical symmetrical windings are placed in place of the three-phase winding;
2. The fourth contact ring is inserted to the rotor;
3. A fourth brush and a brush holder have been added to the contact-brush assembly;
4. All terminals of the longitudinal and transverse windings are connected to slip rings separately.

Figure 1 shows an oscillogram of an asynchronous start of a non-salient-pole SM d-q excitation, while the longitudinal excitation winding is short-circuited and the transverse excitation winding is open. In this case, the experimental motor can be considered as a conventional single axle motor. When removing the starting characteristic, the electrical parameters of the motor had the following values: voltage U=220 V, stator current I_s=3,5 A, rotor current I_r=1,5 A. It can be seen from the oscillogram that at start-up the stator current is I_{ss}=13,8 A (current ratio is 3,96), rotor current I_{rs}=18,4 A (current ratio is 12,26), voltage drops to U=184 V. Motor start time was 1,9 seconds.

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Figure 2 shows an oscillogram of an asynchronous start of a non-salient-pole SM d-q excitation, while the longitudinal excitation winding and the transverse excitation winding are short-circuited. In this case, the experimental motor will operate as a biaxial excitation motor. When taking the starting characteristic, the electrical parameters of the motor had the following values: voltage U=220 V, stator current I_s=3,1 A, rotor current I_r=1,0 A. Analysis of the oscillogram gives the following results, that at start-up the stator current is I_{ss}=12,3 A (current ratio is 3,94), rotor current I_{rs}=12,2 A. (current ratio is 12), voltage drops to U=189 V. Motor start time was 1,28 seconds.

After carrying out experiments for a single-axis and two-axis engine, a comparative analysis was made. From the results of the analysis, the following conclusions can be drawn: when starting the motor of biaxial excitation, the voltage drop decreased by 3% compared to the start of a single-axis motor; the starting current of the stator winding of a two-axis motor is 12% less than the starting current of the stator winding of a single-axis motor; the starting current of the rotor winding of a biaxial motor is 13% less than the starting current of the rotor winding of a uni axial motor; the start time of a two-axis motor is 48% less than the start time of a single-axis motor.

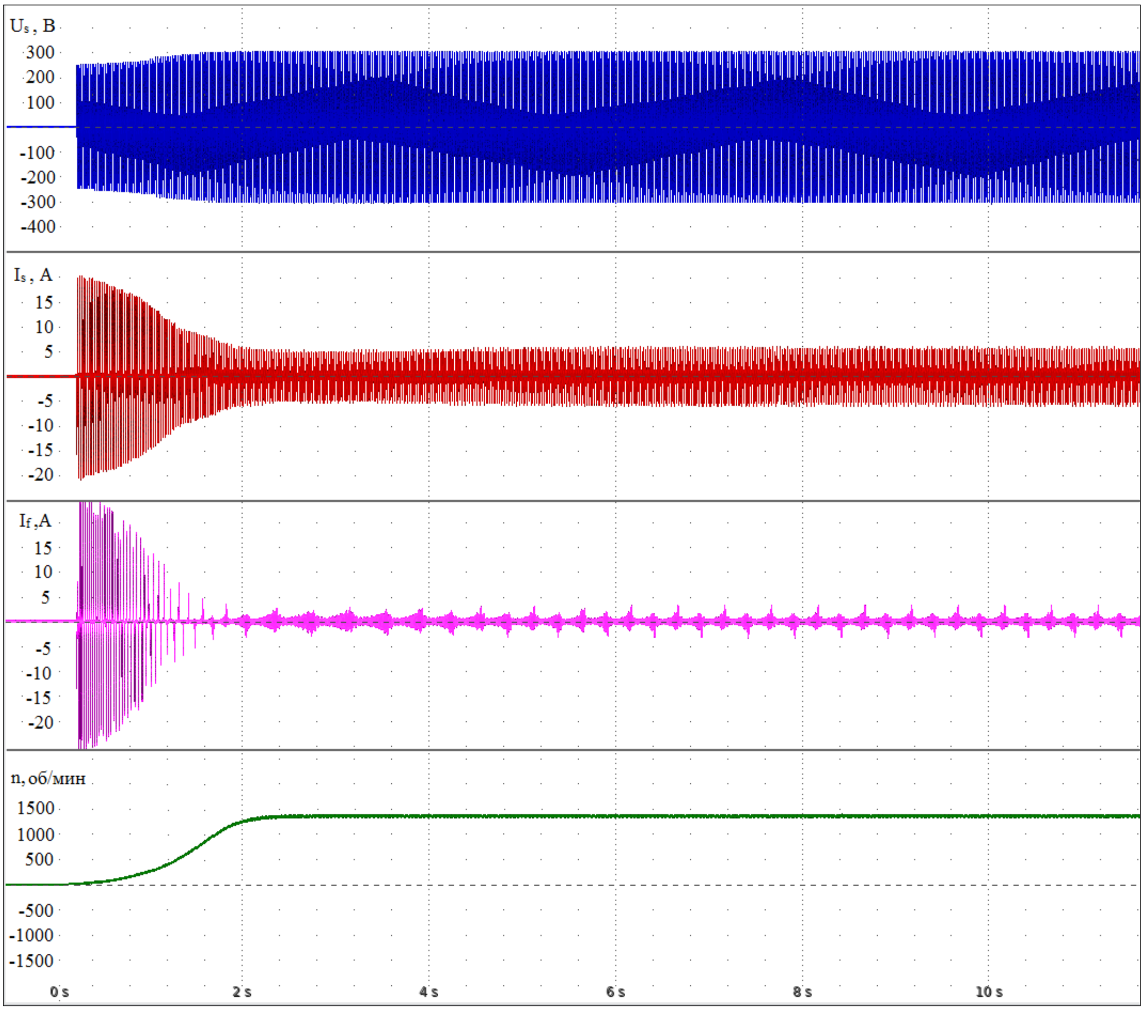

Fig 1: Asynchronous start of non-salient-pole SM d-q excitation,
d - longitudinal winding short-circuited, q - transverse winding open.

Previously conducted similar experimental and theoretical studies in other salient-pole and non-pole SM d-q also showed positive results of the SM d-q starting process [8, 9]

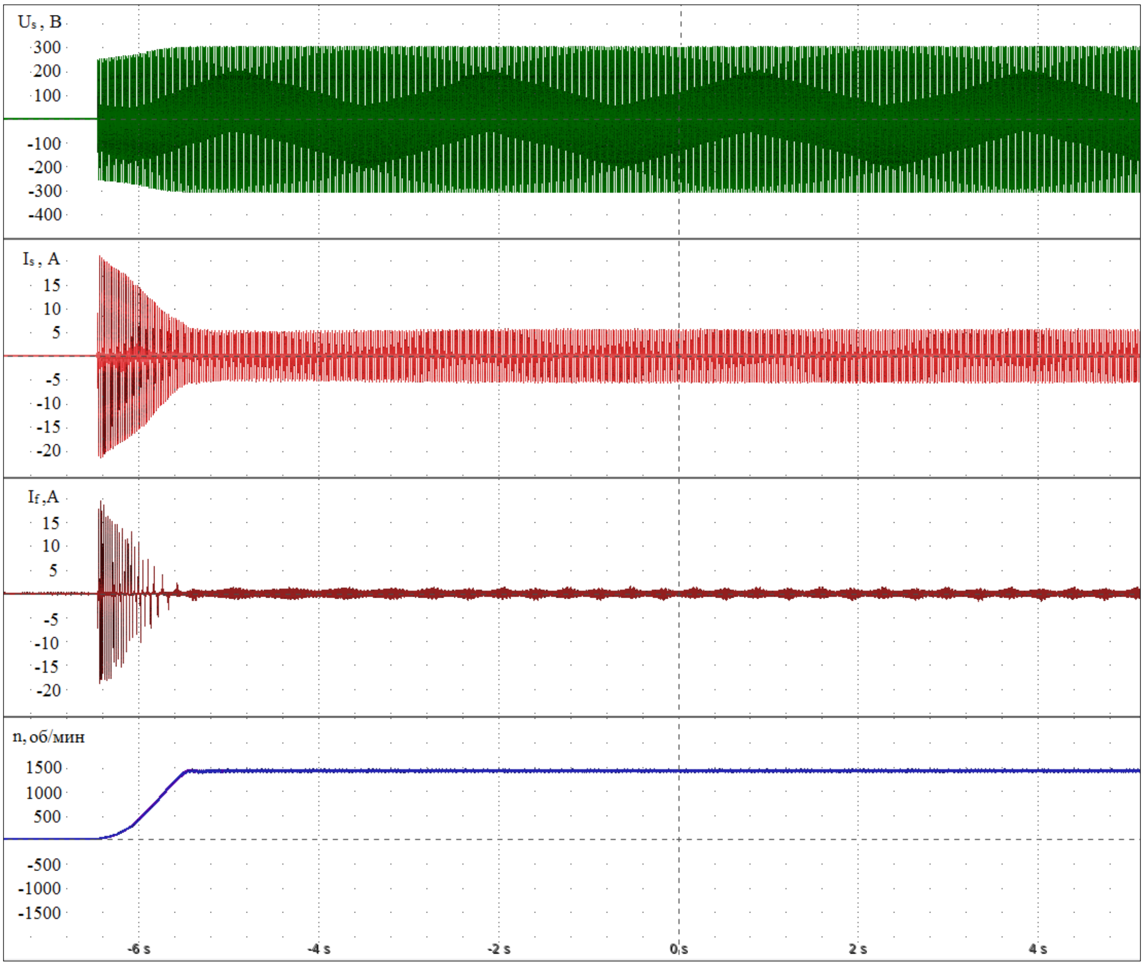

Fig 2: Asynchronous start of non-salient pole SM d-q excitation
d- longitudinal and q - transverse windings are short-circuited

VI. CONCLUSION

The use of SD d-q in place of a conventional synchronous motor leads to a decrease in starting currents and a reduction in start time.
The currents increase during start-up, but their values do not exceed the permissible level according to the heating conditions.

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