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THE INFLUENCE OF THE TYPE OF LOAD AND PARAMETERS OF THE VOLTAGE SOURCE ON THE DYNAMIC CHARACTERISTICS OF A SINGLE-PHASE INDUCTION MOTOR

Oleksiy Iegorov
PhD, Ass. Professor
ORCID: 0000-0003-2599-1624
O.M. Beketov National University of Urban Economy in Kharkiv,
17 Marshal Bazhanov st., Kharkiv, Ukraine, 61002
Olga Iegorova
PhD, Ass. Professor
ORCID: 0000-0001-8593-1557
National Technical University «Kharkiv Polytechnic Institute»
2, Kyrpychova str., Kharkiv, Ukraine, 61002
Marina Glebova
PhD, Ass. Professor
ORCID: 0000-0002-0973-150X
O.M. Beketov National University of Urban Economy in Kharkiv,
17 Marshal Bazhanov st., Kharkiv, Ukraine, 61002

Abstract. *Single-phase induction electric motors (SPIM) are widely used in the modern society life various fields as an electric drive part for the various devices kinds powered by a single-phase AC network. First of all, SPIM have become widespread due to their use in household appliances (refrigeration units, water pumps, woodworking machines, medical equipment), which are constantly evolving, acquiring new functionality and intensively penetrating in the industrialized countries residential and office premises. Electric motors this class belongs to mass-manufacture motors and is produced in units tens millions per year, which determines the manufacturers increased interest to improve SPIM designs and production technology. The paper considers the influence of the load on the shaft of a single-phase asynchronous motor on its characteristics in the start-up mode and reaching the rated load. Calculation experiments have been carried out, which show the influence of the nature of the load on transient processes in starting modes.*

Keywords: *single-phase induction motors, field in the air gap, starting mode, shaft load, maximum torque*

In the mathematical modeling of electrical machines, two methods can be distinguished, based on the use of mathematical models in the form of state models and structural models. If the mathematical model is presented in the form of a state model, that is, a system of differential equations in Cauchy form, standard routines of numerical integration are used. When modeling complex nonlinear electric drive systems, it is advisable to use structural models and corresponding numerical modeling methods based on the use of a single model of a universal link, which is the core of the program.

In the theory of electric machines, there are several methods of obtaining differential equations based on idealized generalized machine models.

The theory of low-power electric machines developed as the tasks of determining dynamic characteristics became more complicated, the appearance of new types of machines, the need to account for new factors affecting the characteristics of the transition process. Robots made a great contribution to the research of single-phase induction motors [1, 2].

The basics of the approach in which electric machines are considered as parametric systems are described in works [3, 4]. The developed universal method of analysis of established and transient processes is based on the original method of reducing systems of differential equations with periodic coefficients to an extended system of equations with constant coefficients and is called the method of unified elementary variables. It is shown that such a reduction for asymmetric machines is possible only on the basis of multi-stage transformations.

The method of two reactions, the method of rotating fields, and the method of symmetrical components are used to study and calculate the characteristics and indicators of asymmetric machines in unstable operating modes. All these three methods are used for the analysis of single-phase induction motors. Each has its own advantages and disadvantages [5].

The static moment of resistance *Mc*, which is included in the equation, is determined by all resistance forces. It can facilitate and hinder the movement of the mechanism equipped with SPIM. During the operation of the electric drive, the static moment can remain constant or change. Static moments can be divided into two categories [6, 7]: reactive and active. The reactive category includes static moments that prevent movement and that change sign when the motor is reversed, such as frictional forces. Active static torques maintain their direction of action when reversing the motor, therefore, in one direction of rotation they will oppose, and in the opposite direction - promote movement. This category includes the moment created by the load when moving vertically.

The static moment of the mechanisms is influenced by the peculiarities of the technological process, the electromechanical and kinematic system of the mechanism. According to this, all executive mechanisms can be divided into the following classes according to the type of load:

1. Mechanisms in which the static moment is constant in modulus $Mc = |Mc| \, sign\omega$

2. Mechanisms in which the static torque is a function of speed. This

dependence can be expressed by the formula [8]:

$$Mc = Mo + (Mc_{nom} - Mo)\omega^{\rho}$$

where *Mo* is the initial resistance moment of the mechanism. Mc_{nom} - moment of resistance of the mechanism at the nominal load, *p* - an indicator that depends on the design of the mechanism.

3. The static moment depends on the angle of rotation of the motor shaft. This dependence, as a rule, cannot be expressed analytically, so it is presented in the form of a graph.

4. Static moment is a function of time. At the same time, the mechanism works under the influence of a force that changes over time according to some law. This force is usually random [9].

The operation of the electric drive of any mechanism is characterized by the dependence of the torque of the rotating motor on time, which can be obtained by solving a system of differential equations. Electric drives with capacitor Induction motors mainly belong to the first and second class. Let's consider how the dynamic characteristics of the DAC motor change depending on the type of load.

Research was conducted on the start-up modes of the DAC motor under different conditions: without load on the motor shaft, with a fan load, with a constant load. In fig. 1, 2, 3 present the curves of changes in the electromagnetic moment at the start of the DAC, respectively, at idle speed = 0, at a load linearly dependent on the rotation frequency at a constant load of *Mc* = 0.18 r.u.

Start-up time, if the start-up time without load is taken as a basis, with constant load this time increased by 40ms, with "fan" load by 14ms. The maximum value of the electromagnetic moment in the transition mode with a change in the nature of the load is practically unchanged.

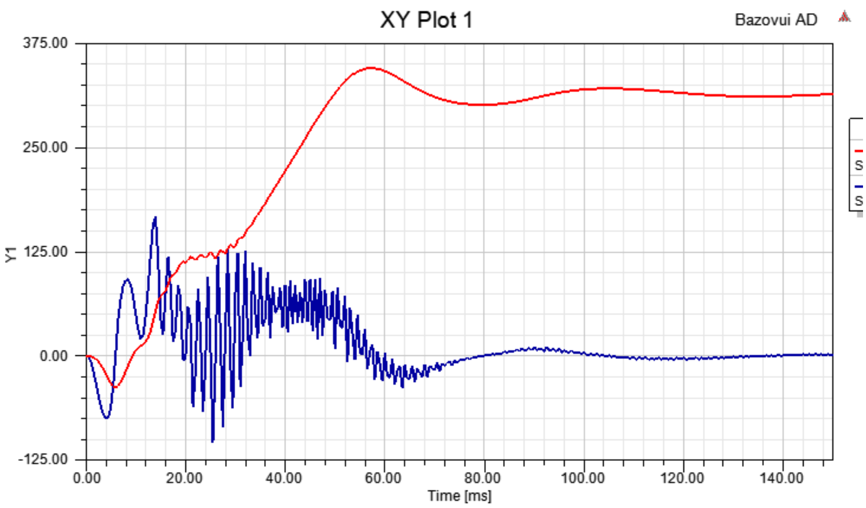

Fig. 1 - Start of the electric drive with capacitor IM without load

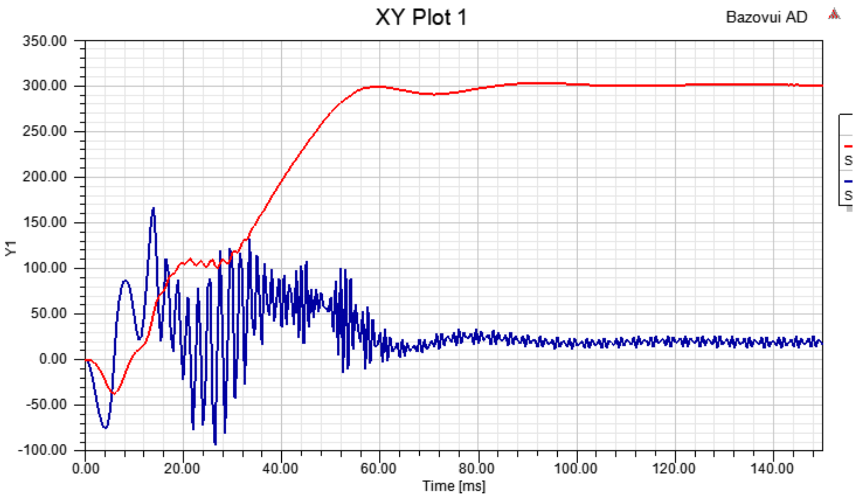

Fig. 2 - Start of the electric drive with capacitor IM with fan load

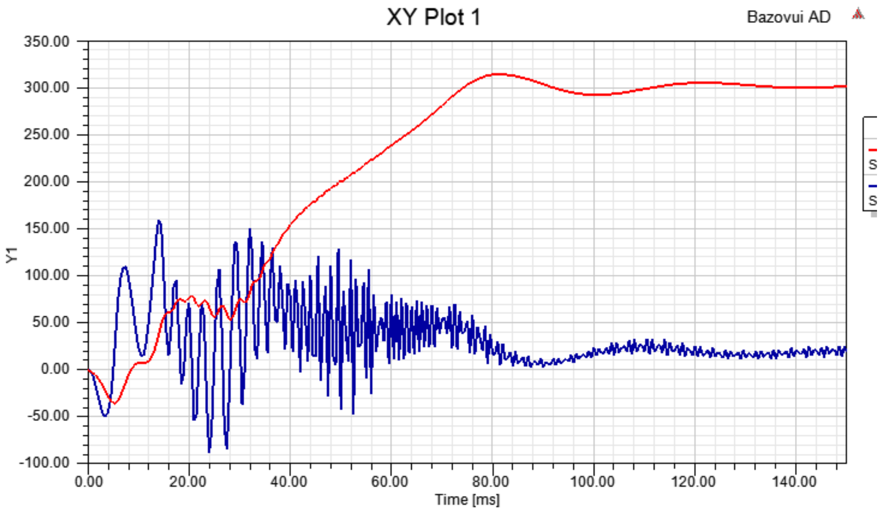

Fig. 3 - Start of an electric drive with a capacitor IM at a constant load

Comparison of the curves in fig. 1, 2, 3 shows that the transient processes during start-up with a load of the second class and start-up at idle proceed in a similar way.

The time of the transition process when reversing with a constant load is two times less than when it changes linearly. The maximum values of transient moments practically do not differ for different types of static moment.

The controllability of the induction electric drive is ensured by simultaneous regulation of the voltage and frequency of the alternating current supplied to the motor stator (frequency control) [2]. Frequency control is the usual smooth, stepless. And, although it requires a relatively complex converter, in some cases it can be used in an electric drive with OAD. When implementing this power supply method, the frequency converter has the properties of a voltage source or a current source.

Conclusions.

Analyzing the process of regulating the electromagnetic moment, it can be seen that with frequency control, the shock electromagnetic moment is reduced to a minimum, and the start-up time has increased by only 14%. Calculations show that a 40% reduction in start-up frequency helps to reduce the shock electromagnetic moment by 1.5 times. If, with the aforementioned law of frequency control, the initial value of the frequency and voltage is taken to be equal to 0.6 from the basic one, then the impact moment will decrease by 50%, and the starting time will increase by 5%.

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