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Offset transients in asynchronous motor during start-up

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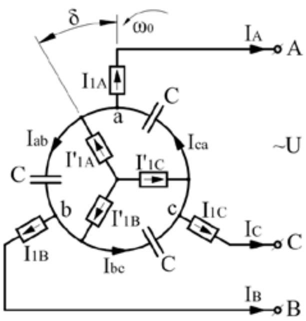
Studied transients during direct start compensated induction motor
Engine, direct start, electromagnetic torque.

Problem. Three-phase induction motor (hereinafter - DR), which is the basis of electric cars work is characterized by high nominal power indicators.

Analysis of recent research. However, due to technological errors in the manufacture DR, underemployment and heavy duty its actual energy performance deteriorate, leading to increased power consumption and reduce energy consumers [1]. To improve the power characteristics of AD is proposed to apply internal capacitive reactive power compensation (hereinafter - VYEKRP) [2].

Implementation of internal capacitive reactive power compensation in AD can be accomplished in different ways depending on the scheme and the number of parallel branches stator base machine [2]. The first method VYEKRP in AD is that for the serial connection napivobmotok stator phase one of them shunted capacitor electrical capacitance (Fig. 1 a).



a)

b)

Fig. 1. Scheme of stator windings (a) and appearance (b) compensated induction motor.

For the mathematical modeling of the KAD series connection napivobmotok phase stator chosen real system

phase coordinates, which allows to operate real currents stator phases as in conventional neperetvorenyh coordinates and makes it possible to get rid of periodic coefficients in the expressions for inductance and flux vzayemoinduktyvnostey in [1].

δ (Fig. 2).

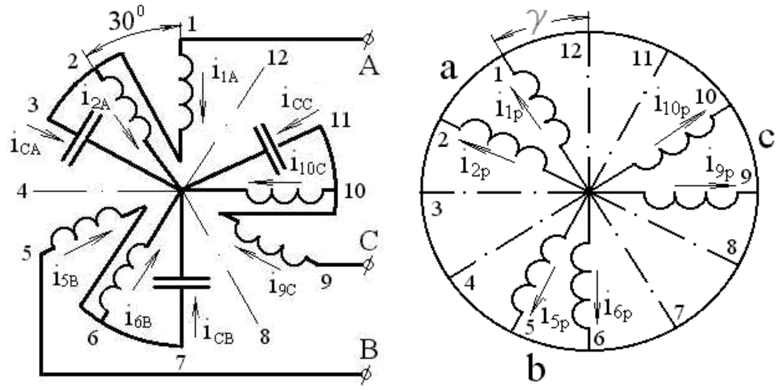


Fig. 2. Calculated electrical circuit of stator and rotor induction motor with an internal capacitive compensation.

The complete set of equations of equilibrium electric circuits of the stator and rotor KAD consists of 12 equations containing 6 desired stator currents napivobmotok 6 desired phase currents and rotor 3 capacitive currents determined difference stator currents napivfaz [4].

1) $$u_A = (i_{1A} + i_{2A})R_k + \frac{d\psi_A}{dt} = (i_{1A} + i_{2A})R_k + (L_k + \frac{3+\sqrt{3}}{2}M_k)\frac{d(i_{1A} + i_{2A})}{dt} - \\ - \frac{\sqrt{3}}{2}M_k \frac{d(i_{6B} + i_{9C})}{dt} + 3M_k \frac{d(i'_{1p} + i'_{2p})}{dt},$$

2) $$u_B = (i_{5B} + i_{6B})R_k + \frac{d\psi_B}{dt} = (i_{5B} + i_{6B})R_k + (L_k + \frac{3+\sqrt{3}}{2}M_k)\frac{d(i_{5B} + i_{6B})}{dt} - \\ - \frac{\sqrt{3}}{2}M_k \frac{d(i_{10C} + i_{1A})}{dt} + 3M_k \frac{d(i'_{5p} + i'_{6p})}{dt},$$

3) $$u_C = (i_{9C} + i_{10C})R_k + \frac{d\psi_C}{dt} = (i_{9C} + i_{10C})R_k + (L_k + \frac{3+\sqrt{3}}{2}M_k)\frac{d(i_{9C} + i_{10C})}{dt} - \\ - \frac{\sqrt{3}}{2}M_k \frac{d(i_{2A} + i_{5B})}{dt} + 3M_k \frac{d(i'_{9p} + i'_{10p})}{dt},$$

4) $$u_{2A} = \frac{1}{C}\int i_{CA}dt = i_{2A}R_k + \frac{d\psi_{2A}}{dt} = i_{2A}R_k + (L_k + \frac{3}{2}M_k)\frac{di_{2A}}{dt} + \\ + \frac{\sqrt{3}}{2}M_k \frac{d(i_{1A} - i_{9C})}{dt} + 3M_k \frac{di'_{2p}}{dt}$$

5) $$u_{6B} = \frac{1}{C}\int i_{CB}dt = i_{6B}R_k + \frac{d\psi_{2A}}{dt} = i_{6B}R_k + (L_k + \frac{3}{2}M_k)\frac{di_{6B}}{dt} + \\ + \frac{\sqrt{3}}{2}M_k \frac{d(i_{5B} - i_{1A})}{dt} + 3M_k \frac{di'_{6p}}{dt}$$

6) $$u_{10C} = \frac{1}{C}\int i_{CC}dt = i_{10C}R_k + \frac{d\psi_{10C}}{dt} = i_{10C}R_k + (L_k + \frac{3}{2}M_k)\frac{di_{10C}}{dt} +$$

$$+\frac{\sqrt{3}}{2}M_k\frac{d(i_{9C}-i_{5B})}{dt}+3M_k\frac{di'_{10p}}{dt}$$

$$7)\quad 0=i'_{1p}R_{kp}+\frac{d\psi'_{1p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{5p}-\psi'_{9p})=i'_{1p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{1p}}{dt}+\frac{3}{2}M_k\frac{d(i_{1A}+\frac{\sqrt{3}}{2}i_{2A})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{5p}-i'_{9p}\right)+\frac{3}{2}M_k(i_{5B}-i_{9C}+\frac{\sqrt{3}}{2}i_{6B}-\frac{\sqrt{3}}{2}i_{10C})\right],$$

$$8)\quad 0=i'_{2p}R_{kp}+\frac{d\psi'_{2p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{6p}-\psi'_{10p})=i'_{2p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{2p}}{dt}+\frac{3}{2}M_k\frac{d(i_{2A}+\frac{\sqrt{3}}{2}i_{1A})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{6p}-i'_{10p}\right)+\frac{3}{2}M_k(i_{6B}-i_{10C}+\frac{\sqrt{3}}{2}i_{5B}-\frac{\sqrt{3}}{2}i_{9C})\right],$$

$$9)\quad 0=i'_{5p}R_{kp}+\frac{d\psi'_{5p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{9p}-\psi'_{1p})=i'_{5p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{5p}}{dt}+\frac{3}{2}M_k\frac{d(i_{5B}+\frac{\sqrt{3}}{2}i_{6B})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{9p}-i'_{1p}\right)+\frac{3}{2}M_k(i_{10C}-i_{2A}+\frac{\sqrt{3}}{2}i_{9C}-\frac{\sqrt{3}}{2}i_{1A})\right],$$

$$10)\quad 0=i'_{6p}R_{kp}+\frac{d\psi'_{6p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{10p}-\psi'_{2p})=i'_{6p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{6p}}{dt}+\frac{3}{2}M_k\frac{d(i_{6B}+\frac{\sqrt{3}}{2}i_{5B})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{10p}-i'_{2p}\right)+\frac{3}{2}M_k(i_{10C}-i_{2A}+\frac{\sqrt{3}}{2}i_{9C}-\frac{\sqrt{3}}{2}i_{1A})\right],$$

$$11)\quad 0=i'_{9p}R_{kp}+\frac{d\psi'_{9p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{1p}-\psi'_{5p})=i'_{9p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{9p}}{dt}+\frac{3}{2}M_k\frac{d(i_{9C}+\frac{\sqrt{3}}{2}i_{10C})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{1p}-i'_{5p}\right)+\frac{3}{2}M_k(i_{1A}-i_{5B}+\frac{\sqrt{3}}{2}i_{2A}-\frac{\sqrt{3}}{2}i_{6B})\right],$$

$$12)\quad 0=i'_{10p}R_{kp}+\frac{d\psi'_{10p}}{dt}+\frac{\omega}{\sqrt{3}}(\psi'_{2p}-\psi'_{6p})=i'_{10p}R_{kp}+(L_{kp}+3M_k)\frac{di'_{10p}}{dt}+\frac{3}{2}M_k\frac{d(i_{10C}+\frac{\sqrt{3}}{2}i_{9C})}{dt}+$$
$$+\frac{\omega}{\sqrt{3}}\left[\left(L_{kp}+3M_k\right)\left(i'_{2p}-i'_{6p}\right)+\frac{3}{2}M_k(i_{2A}-i_{6B}+\frac{\sqrt{3}}{2}i_{1A}-\frac{\sqrt{3}}{2}i_{5B})\right]. \qquad (1)$$

To calculate the dynamic electromechanical processes KAD necessary to balance the electrical system of equations of motion equations circles add a drive to the calculation of electromagnetic torque machines:

$$M_e=-\frac{3pM_k}{\sqrt{3}}[i_{1A}(i'_{5p}-i'_{9p})+i_{2A}(i'_{6p}-i'_{10p})+i_{5B}(i'_{9p}-i'_{1p})+i_{6B}(i'_{10p}-i'_{2p})+$$

$$+i_{9C}(i'_{1p}-i'_{5p})+i_{10C}(i'_{2p}-i'_{6p})]. \quad (2)$$

Solution of the system of twelve equations (1), together with the equation of motion of the electric:

$$M_e = M_c + \frac{J}{p}\cdot\frac{d\omega}{dt}. \quad (3)$$

makes it possible to build dynamic engine performance and analyze electromechanical processes in different modes. In equation (3) M_c - Moment of static resistance; J - Moment of inertia about.

By The mathematical model (1) - (3) in computing system Matlab-Simulink virtual model was established to study the KAD (Fig. 3).

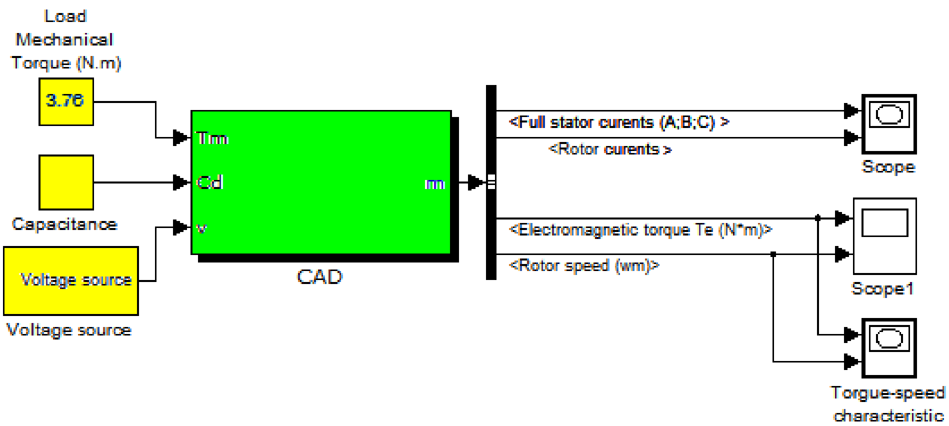


Fig. 3. Virtual model for the study of transients in the Ring Road.

The structure of the model are investigated KAD (SAD), a three-phase AC voltage (Voltage source), setting unit for mechanical moment on the motor shaft (Load Machanical Torque), universal power measurement engine parameters and oscilloscope to observe the instantaneous stator currents and rotor, and speed and torque KAD.

The purpose of research is to determine the impact on the value VYEKRP stator currents and electromagnetic torque compensated induction motor (hereinafter - KAD) during its launch.

Results. The nature of the settlement oscillograms start KAD made on the basis of blood pressure 4A71V2 (Fig. 4) corresponding to the physical understanding of the dynamics of starting the engine. In particular, there stator current fluctuations that after the end of the rotor acceleration flow nominal current. There are also fluctuations in the electromagnetic torque and rotor speed (Fig. 5). As seen on the nominal start KAD moment of resistance on the shaft (*Tm* = 3.76 nm), after completion of acceleration electromagnetic torque is also nominal.

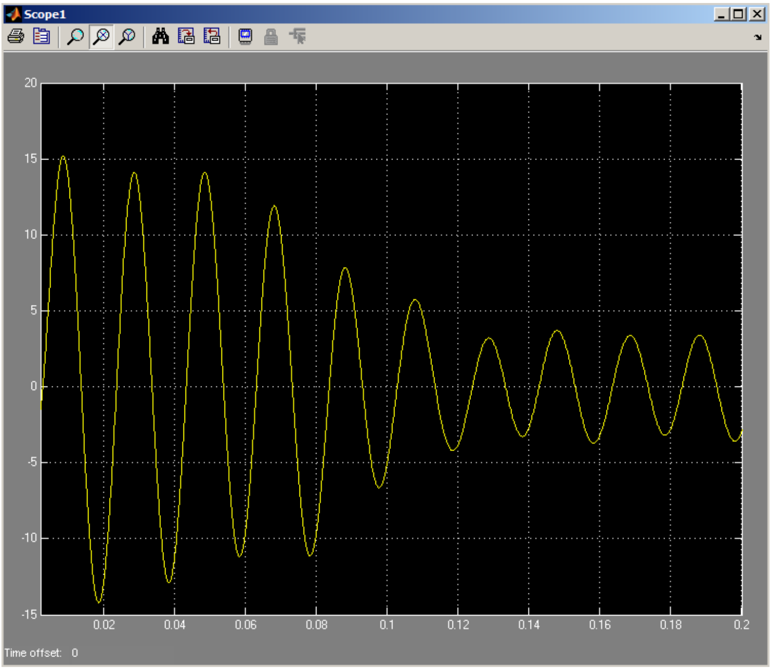


Fig. 4. oscillogram stator current KAD.

The amplitude of the trigger (percussion) current KAD (Fig. 4) is 15.2 A, and starting (percussion) point (Fig. 5, a) - 13 Nm. Acceleration time to rated speed at a given moment of inertia of the rotor (Fig. 5, b) is 0.15 s.

The ratio of the amplitude of the inrush current to the nominal found by oscillogram, is And_{1max}/ And_{1in}= 15.2 / 3.4 = 4.47, and the starting torque *Mmax /Mu* = 13 / 3.76 = 3.45. The results almost coincide with the calculated values for these ratios currents And_{1max}/ And_{1in}= 16.1 / 3.7 = 4.35 and points *Mmax /Mu* = 12.8 / 3.54 = 3.61.

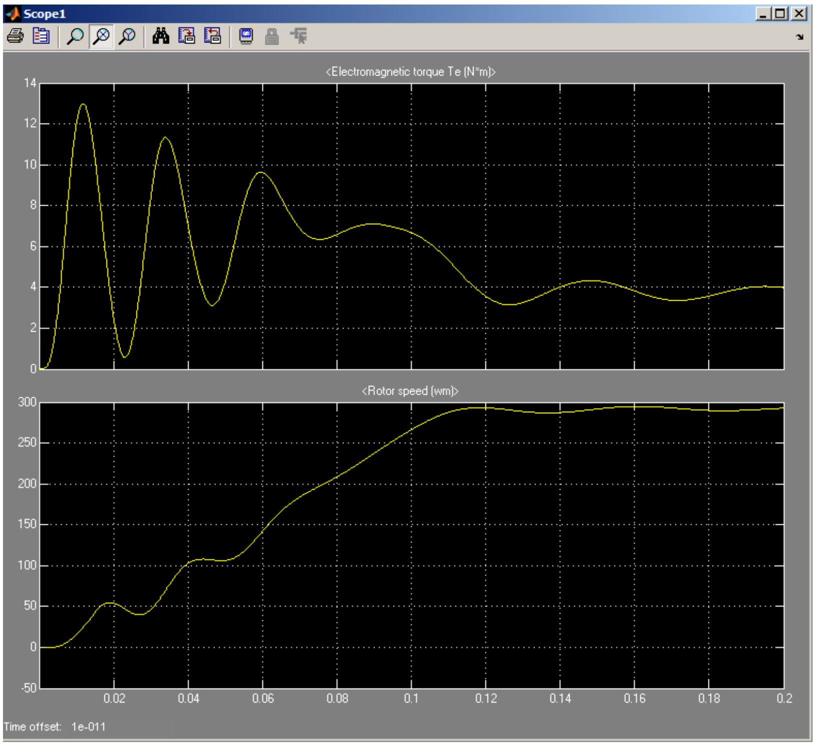


Fig. 5. Forms electromagnetic torque and rotational speed KAD.

Conclusion. Fulfillment by KAD serial connection napivobmotok phase stator one of them shunted capacitor electrical capacitance does not increase unacceptable inrush current and electromagnetic torque, the value of which would result in a decrease operating life KAD compared with the same serial AD.

References

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Yssledovanы perehodnыe Processes TIME vo direct start kompensyrovannoho asynchronous engine

Engines, Direct start, electromagnetic moment.

There were researched transients during direct start-up of compensated induction motor.

Motor, direct star-up, electromagnetic torque.