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SPEED CONTROL AT MAXIMUM TORQUE

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Abstract: *In the paper presented the method to maximize torque in the stator flux and current requirements. Based on orthogonal design of asynchronous machine, in the above-mentioned conditions were desus variation in time of voltage and frequency for a gap starts in an asynchronous machine.*
The paper continues with Part II of which shows the voltage and frequency at different speeds under the same conditions to maximize the electromagnetic torque.
Keywords: *voltage, frequency, maximize the electromagnetic torque*

1. SPEED CONTROL AT MAXIMUM TORQUE (SPEED DEPENDENT)

The following are calculated the maximum electromagnetic torque at a given speed, achieving a torque addicted to speed.
So every known speed currents and electromagnetic torque range so the conditions for flux and stator current.
Analyzed, for example, a startup (empty, or in load) is taking more speed at which is calculated maximum torque, currents, frequency and supply voltage. Maximum torque value is obtained by the method of Lagrange.
Multipliers The algebraic equations are solved for several values of speed (the speed ω Angular rotors):

ω= 0.50; 100; 200; 300; 314 [rad/s]

n= 0.477; 955; 1910; 2866; 3000 [rot/min]
For each speed, in part derived values:
-stator voltage U,
-stator pulse ω1; electromagnetic torque
1). The moment of inertia **J** are not required in the algorithm for speed control which provide voltage and frequency according to speed.
2). Control algorithm analysis can be applied to any couple develop strong MA because any amount of torque used up a couple possible restrictive conditions:
-stator current
-stator flux
By imposing the stator flux to be (in the stator flux relationship) remove one of the variables (eg current rotors $i_{qr} = W$)

For imposing a stator flux unsaturated, for example:
Ψ_s= 1.25 [Wb]
approximately
$\Psi_s = \Psi_q = (0{,}3 \cdot Y + 0{,}21 \cdot W) = 1{,}25$

by eliminating the variable W:
$W = (-5.952 - 1{,}43Y)$
we obtain:

$$\begin{cases} U_d = 3X + 0{,}3\dfrac{dX}{dt} - \omega_1\big(0{,}3 \cdot 0{,}21 \cdot (-5{,}952 - 1{,}43Y)\big) + 0{,}21\dfrac{dZ}{dt} \\ U_q = 3Y + 0{,}3\dfrac{dY}{dt} + \omega_1(0{,}3 \cdot 0{,}21 \cdot Z) + 0{,}21\dfrac{d(-5{,}952 - 1{,}43Y)}{dt} \\ 0 = 2Z + 0{,}2\dfrac{dZ}{dt} - (\omega_1 - \omega)(0{,}2 \cdot (-5{,}952 - 1{,}43Y) + 0{,}21Y) \\ 0 = 2(-5{,}952 - 1{,}43Y) + 0{,}2\dfrac{d(-5{,}952 - 1{,}43Y)}{dt} + (\omega_1 - \omega)(0{,}2 \cdot Z + 0{,}21\dfrac{dY}{dt}) \\ J\dfrac{d\omega}{dt} = 0{,}21[YZ - X(-5{,}952 - 1{,}43Y)] - M_{rez} \end{cases}$$

or

$$\begin{cases} U_d = 3X + 0{,}3\dfrac{dX}{dt} - \omega_1(1{,}25) + 0{,}21\dfrac{dZ}{dt} \\ U_q = 3Y + \omega_1(0{,}3 \cdot X + 0{,}21 \cdot Z) \\ 0 = 2Z + 0{,}2\dfrac{dZ}{dt} - (\omega_1 - \omega)(-1{,}1904 - 0{,}076Y) + 0{,}21\dfrac{dX}{dt} \\ 0 = 2(-5{,}952 - 1{,}43Y) - 0{,}286\dfrac{dY}{dt} + (\omega_1 - \omega)(0{,}2 \cdot Z + 0{,}21 \cdot X) + 0{,}21\dfrac{dY}{dt} \\ J\dfrac{d\omega}{dt} = 0{,}21[YZ - X(-5{,}952 - 1{,}43Y)] - M_{rez} \end{cases}$$

In the stationary regime by removing the derivatives, the system becomes:

$$\begin{cases} U_d = 3X - \omega_1(-1{,}25) \\ U_q = 3Y + \omega_1(0{,}3 \cdot X + 0{,}21 \cdot Z) \\ 0 = 2Z - (\omega_1 - \omega)(-1{,}1904 - 0{,}76Y) \\ 0 = 2(-5{,}952 - 1{,}43Y) + (\omega_1 - \omega)(0{,}2 \cdot Z + 0{,}21 \cdot X) \\ M_{rez} = 0{,}21[YZ - X(-5{,}952 - 1{,}43Y)] \end{cases}$$

or

$$\begin{cases} U_d = 3X - \omega_1(-1{,}25) & (equation\ 1) \\ U_q = 3Y + \omega_1(0{,}3 \cdot X + 0{,}21 \cdot Z) & (equation\ 2) \\ 0 = 2Z - (\omega_1 - \omega)(-1{,}1904 - 0{,}76Y) & (equation\ 3) \\ 0 = 2(-5{,}952 - 1{,}43Y) + (\omega_1 - \omega)(0{,}2 \cdot Z + 0{,}21 \cdot X) & (equation\ 4) \\ M_{rez} = 0{,}21[YZ - X(-5{,}952 - 1{,}43Y)] & (equation\ 5) \end{cases}$$

From the second equation can eliminate variable **Y**

$Y = -\omega_1\,(0.1 \cdot X + 0.07 \cdot Z)$

Rotors resulting equations of the following relations between currents:

$$-\frac{I_{dr}}{I_{qr}} = \frac{L_2 I_{qr} + M I_q}{L_2 I_{dr} + M I_d}$$

or

$$L_2(I_{dr}^2 + I_{qr}^2) + M\,(I_q I_{qr} + I_d I_{dr}) = 0$$

or

$$0.2(I_{dr}^2 + I_{qr}^2) + 0.21(I_q I_{qr} + I_d I_{dr}) = 0$$

From the condition to achieve a flow in the car equal to the nominal and equation 2 is a stator eliminate variables Y and W and thus obtain 3 equations and 3 unknown:

I_d - X - stator current in d axis;

I_{dr} - Z - axis stator current in d;

$Melmg$ - electromagnetic torque.

Question of determining the maximum function:

$$M_{elmg} = 0.21(I_q I_{dr} - I_d I_{qr})$$

Lagrange Function $L(I_d, I_{qr}, I_q, I_{dr}, \lambda_1, \lambda_2, \lambda_3)$ is :

$$\begin{aligned} L(I_d, I_{qr}, I_q, I_{dr}, \lambda_1, \lambda_2, \lambda_3) = \\ &= 0.21(I_q I_{dr} - I_d I_{qr})(couple) + \lambda_1\left(I_d^2 + I_q^2 - 64(current)\right) \\ &+ \lambda_2\left(2Z - (\omega_1 - \omega)(-1{,}1904 - 0{,}76Y)(equation\ 3)\right) + \lambda_3\big(-11{,}9 \\ &+ \omega_1(0{,}5X + 0{,}4Z) - \omega(0{,}2 \cdot Z + 0{,}21 \cdot X)(equation\ 4)\big) \end{aligned}$$

With the above substitutions and links from the stream, and the current equations 2 rotors, the torque function Langrange attached $M_{elmg} = p_1 M(I_q I_{dr} - I_d I_{qr})$ become :

$$\begin{aligned} L(I_d, I_{dr}; \lambda_1, \lambda_2, \lambda_3) = \\ &= 0.21\big[\big(-\omega(0{,}1 \cdot X + 0{,}07 \cdot Z)\big)Z - X(5{,}952 - 1{,}43(-\omega(0{,}1 \cdot X \\ &+ 0{,}07Z)))\big](cuplu) + \lambda_1\left(X^2 + \omega_1^2(0{,}1 \cdot X + 0{,}07 \cdot Z)^2 - 64(current)\right) \\ &+ \lambda_2\left(2Z - (\omega_1 - \omega)(-1{,}1904 - 0{,}76\omega_1(0{,}1 \cdot X + 0{,}07 \cdot Z))(equation\ 3)\right) \\ &+ \lambda_3\left(-11{,}9 + \omega_1(0{,}5X + 0{,}4Z) - \omega(0{,}2 \cdot Z + 0{,}21 \cdot X)(equation\ 4)\right) \end{aligned}$$

The very speed at a given (ω) resulting from the system:

$$\begin{aligned} &0{,}21(-\omega_1 0{,}2 \cdot Z + 5.952 - 0.286\omega 1 \cdot X) + 2\lambda_1\left(X + 0{,}1\omega_1^2(0{,}1 \cdot X + 0{,}07 \cdot Z)\right) \\ &\quad + \lambda_2(\omega - \omega_1)0{,}0076\omega_1 + \lambda_3(\omega_1 0{,}5 - \omega 0{,}21) = 0\left(din\frac{\partial L}{\partial X} = 0\right) \end{aligned}$$

$$\begin{aligned} &0{,}21(-\omega_1 0{,}2 \cdot X - 5.952 - 0.286\omega 1 \cdot X) + 2\lambda_1\left(X + 0{,}1\omega_1^2(0{,}1 \cdot X + 0{,}07 \cdot Z)\right) \\ &\quad + \lambda_2(\omega - \omega_1)0{,}0076\omega_1 + \lambda_3(\omega_1 0{,}5 - \omega 0{,}21) = 0\left(din\frac{\partial L}{\partial X} = 0\right) \end{aligned}$$

$$\begin{aligned} &0{,}21(-(0{,}2 \cdot X + 0{,}07 \cdot Z)Z - 0{,}143 \cdot X^2) + 2\lambda_1\omega_1(0{,}1 \cdot X + 0{,}07 \cdot Z)^2 \\ &\quad - \lambda_2\left(-1{,}1904 + 0{,}152\omega_1(0{,}1 \cdot X + 0{,}07 \cdot Z) - 0{,}076\omega(0{,}1 \cdot X + 0{,}07 \cdot Z)\right) \\ &\quad + \lambda_3(0{,}5X + 0{,}4Z) = 0\ (din\ \frac{\partial L}{\partial \omega_1} = 0) \end{aligned}$$

$$X^2 + \omega_1{}^2(0{,}1 \cdot X + 0{,}07 \cdot Z)^2 - 64 = 0\ (din\ I^2 = 64)$$

$$0 = 2Z - (\omega_1 - \omega)(-1{,}1904 + 0{,}076\omega_1(0{,}1 \cdot X + 0{,}07 \cdot Z))(equation\ 3)$$
$$0 = -11{,}9 + \omega_1(0{,}5 \cdot X + 0{,}4 \cdot Z) - \omega(0{,}2 \cdot Z + 0{,}21 \cdot X)\ (equation\ 4)$$
$$\omega = 0, 50, 100, 150, 200, 250, 300, 314$$
$$U = 3X + \omega_1 \cdot 1{,}25\ (ecuation\ 1)$$
$$M = 0{,}21(-\omega_1(0{,}2 \cdot X + 0{,}07 \cdot Z)Z - X(-5{,}95 + 0{,}143\omega_1 \cdot X))(equation\ 5)$$

MA STARTING TO STATOR FLUX AND CURRENT CONSTANT AND MAXIMUM TORQUE

In the below examines the process start at MA, so that, through a feed right in voltage and frequency to achieve maximum value for the electromagnetic torque.
Speeds Angular rotors are analyzed:

ω = 0, 50,100,150, 200, 250, 300, 314 $[\frac{rad}{sec}]$

In each of these values to have been built Langrange functions attached electromagnetic torque function:

$$M_{elmg} = p_1 M(I_q I_{dr} - I_d I_{qr})$$

It maximizes the value of the electromagnetic torque:
- Stator current required: $I_{dm}^2 = I_d^2 + I_q^2 = 64[A^2]$
- Stator flux imposed : $\psi_s = 1{,}25[Wb]$

$\omega = 0$

$\omega_1 = 3{,}9482\ \lambda_1 = -2{,}4197 \times 10^{-2}\ X = 7{,}6130\ U = 27{,}774$
$M = 4{,}9482,\quad \lambda_1 = 0{,}25587,\quad \omega = 0,\quad \lambda_3 = 0{,}34085$
$Z = -1{,}9812,\quad X = 7{,}2149,\quad \omega = 0,\quad \lambda_2 = 4{,}2929 \times 10^{-2}$
$\omega_1 = 15{,}232,\quad \lambda_3 = 0{,}23304,\quad U = 40684$
$Z = -7{,}065,\ \lambda_1 = -3{,}4806 \times 10^{-2},\ M = 6{,}6416$

$\omega = 50$

$U = 104{,}72,\ \lambda_2 = 4{,}0316 \times 10^{-2},\ M = 6{,}367,\ \omega_1 = 69{,}163$
$\lambda_1 = -1{,}1364 \times 10^{-2},\ Z = -7{,}6278,\ \lambda_3 = 0{,}13489,\ X = 6{,}089,\quad \omega = 50{,}0$

$\omega = 100$

$\omega_1 = 120{,}05,\quad \lambda_2 = 0{,}03702,\quad M = 6{,}5824,\quad X = 5{,}9417,\ Z = -7{,}8507$
$\lambda_3 = 9{,}4575 \times 10^{-2},\ \lambda_1 = -7{,}1641 \times 10^{-3},\ U = 167{,}88,\ \omega = 100{,}0$

$\omega = 150$

$\omega = 150{,}0,\quad \omega_1 = 170{,}64,\quad M = 68408,\quad X = 6{,}0128, \lambda_1 = -5{,}393 \times 10^{-3},$
$\lambda_2 = 3{,}2302 \times 10^{-2},\ U = 231{,}34,\quad \lambda_3 = 7{,}2068 \times 10^{-2},\ Z = -8{,}1479$

$\omega = 200$

$\omega_1 = 200{,}0,\quad \omega = 221{,}13,\quad \lambda_1 = -4{,}4257 \times 10^{-3}\quad Z = -8{,}4908$
$\lambda_3 = 5{,}7339 \times 10^{-2},\ U = 294{,}93,\ M = 7{,}1126,\ X = 61737,\ \lambda_2 = 2{,}8058 \times 10^{-2}$

$\omega = 250$

$U = 385{,}55,\quad \lambda_3 = 4{,}6651 \times 10^{-2}\quad Z = -8{,}8643,\quad \lambda_1 = -3{,}8396 \times 10^{-3},$
$M = 7{,}3890,\ \lambda_2 = 2{,}4358 \times 10^{-2},\quad \omega_1 = 271{,}52,\ X = 6{,}3827,\ \omega = 250{,}0$

$\omega = 300$

$\lambda_3 = 2{,}1041 \times 10^{-2},\ Z = -9{,}2585,\ U = 422{,}12,\quad \lambda_2 = -3{,}4787 \times 10^{-3}$
$M = 7{,}6639,\quad \lambda_1 = 3{,}8265 \times 10^{-2}\ \omega_1 = 321{,}81,\ X = 6{,}6205\ \omega = 300{,}0,$

$\omega = 314$

$M = 7{,}7398,\ \lambda_3 = 3{,}6193 \times 10^{-2},\quad \lambda_1 = -3{,}4080 \times 10^{-3},\quad X = 6{,}3827,$
$\lambda_2 = 2{,}0160 \times 10^{-2},\ U = 439{,}91,\ \omega_1 = 335{,}87,\ Z = -9{,}3713,\ \omega = 314{,}0$

By using the method of Lagrange multipliers were obtained the functions:

- $U(\omega)$ - stator voltage (angular speed rotor);
- f(ω) - stator frequency (angular speed rotor);
- $M_{elm}(\omega)$ - electromagnetic torque (angular speed rotor);

Analysis system, in time, based on the equation of motion:

$$J\frac{d\omega}{dt} = M_{elmg} - M_{rez}$$

To solve them is necessary to know the moment of inertia J (eg J = 0.2[kgm^2]) and torque-resistant M_{rez}.

Erroneous estimate of the moment of inertia J leads to results that no longer correspond to reality.1) To start with the empty M_{rez} =0 equation of motion becomes:

$$0,2\frac{\Delta\omega}{\Delta t}=M_{elmg}$$

or the time Δt wich corresponding intervals Angular speed rotors $\Delta\omega$:

$$\Delta\omega = 0 \div 50\left[\frac{rad}{s}\right]\ la\ \Delta t = t_1 - t_0 = t_1 - 0 = t_1$$

$$\Delta\omega = 50 \div 100\left[\frac{rad}{s}\right]\ la\ \Delta t = t_2 - t_1$$

$$\Delta\omega = 100 \div 150\left[\frac{rad}{s}\right]\ la\ \Delta t = t_3 - t_2$$

$$\Delta\omega = 150 \div 200\left[\frac{rad}{s}\right]\ la\ \Delta t = t_4 - t_3$$

$$\Delta\omega = 200 \div 250\left[\frac{rad}{s}\right]\ la\ \Delta t = t_5 - t_4$$

$$\Delta\omega = 250 \div 300\left[\frac{rad}{s}\right]\ la\ \Delta t = t_6 - t_5$$

$$\Delta\omega = 300 \div 350\left[\frac{rad}{s}\right]\ la\ \Delta t = t_7 - t_6$$

$$0,2\frac{\Delta\omega}{t_1} = 0,2\frac{50-0}{t_1} = 6,6416, \quad t_1 = 1,5057(\text{on the time } \Delta t = 0 \div 1,5057)$$

$$0,2\frac{\Delta\omega}{t_2 - t_1} = 0,2\frac{100-50}{t_2 - 1,5057} = 6,367, \quad t_2 = 3,0763(\text{on the time } \Delta t = 1,5057 \div 3,0763)$$

$$0,2\frac{\Delta\omega}{t_3 - t_2} = 0,2\frac{150-100}{t_3 - 3,0763} = 6,5824, \quad t_3 = 4,5955(\text{on the time } \Delta t = 3,0763 \div 4,5955)$$

$$0,2\frac{\Delta\omega}{t_4 - t_3} = 0,2\frac{200-150}{t_4 - 4,5955} = 6,8408, \quad t_4 = 6,0573(\text{on the time } \Delta t = 4,5955 \div 6,0573)$$

$$0,2\frac{\Delta\omega}{t_5 - t_4} = 0,2\frac{250-200}{t_5 - 6,0573} = 7,1126, \quad t_5 = 7,4633(\text{on the time } \Delta t = 6,0573 \div 7,4633)$$

$$0,2\frac{\Delta\omega}{t_6 - t_5} = 0,2\frac{300-250}{t_6 - 7,4633} = 7,389, \quad t_6 = 8,8167(\text{on the time } \Delta t = 7,4633 \div 8,8167)$$

$$0,2\frac{\Delta\omega}{t_7 - t_6} = 0,2\frac{314-300}{t_7 - 8,8167} = 7,6639, \quad t_7 = 9,182(\text{on the time } \Delta t = 8,8167 \div 9,182)$$

In this way led to the change in time of Angular speed rotors, if maximize electromagnetic torque (given in Figure 3.1)

Changes in time of Angular speed rotors

Knowing the variation in time of Angular speed rotors w (t) by a linear approximation of the form:

$$\omega(t) = kt = 33,3t$$

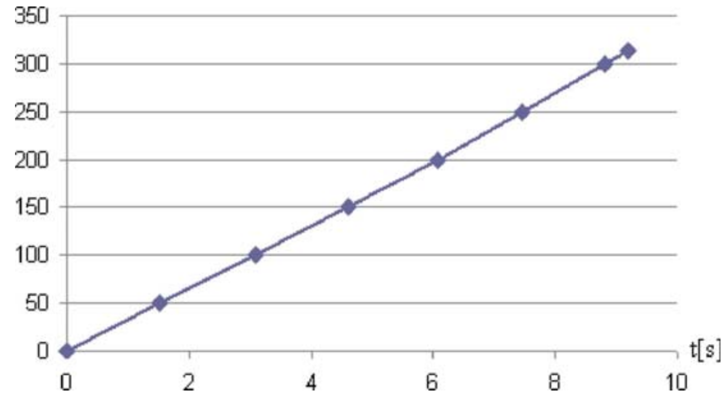

Fig. 3.1 Variation in time of Angular speed rotors

Can determine the functions and U(t) and f(t) (the variation in time of voltage and frequency) of

$U_{\omega(t)}$ şi $f_{\omega(t)}$

$U_{(t)} = U_{\omega(t)}$

$f_{(t)} = f_{\omega(t)}$

DEPENDENCE OF SPEED OF STATOR VOLTAGE

For the stator voltage U resulted following U=40,7, 104,7, 167,8, 231,3, 294,9, 358, 422, 439[V].

Angular velocities the rotors:

$\omega =$ 0, 50,100,150, 200, 250, 300, 314$\left[\frac{rad}{s}\right]$

Knowing $U = f_1(\omega)$ and $f = f_2(\omega)$, any angular speed is known to speed the voltage and frequency so that electromagnetic torque is the maximum current in the stator flux and imposed.

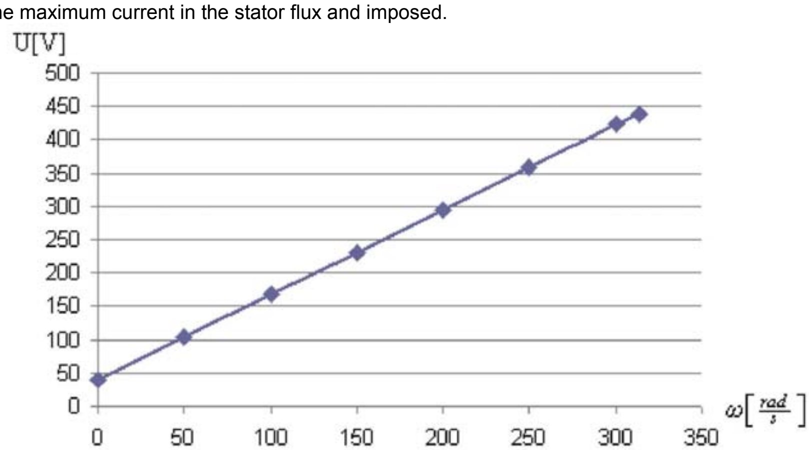

Fig. 3.2 Changes tesiunii rotors with angular velocity

Knowing the variation in time of Angular speed rotors u(t) by a linear approximation of the form:

$$\omega(t) = kt = 33{,}3t$$

obtained for voltage variation in the approximate time:

$$U(t) = 40{,}684 + k_u\omega(t) = 40{,}684 + 1{,}271\omega(t) = 40{,}684 + 1{,}271 \cdot 33{,}3t$$

or

$$U(t) = 40{,}684 + 42{,}338t$$

SPEED DEPENDENCE OF STATOR PULSE ω_1

For stator pulse resulted following ω_1 = 15,23, 69,163, 120, 170,6, 221, 271,5, 321,8, 335,8 $\frac{rad}{s}$

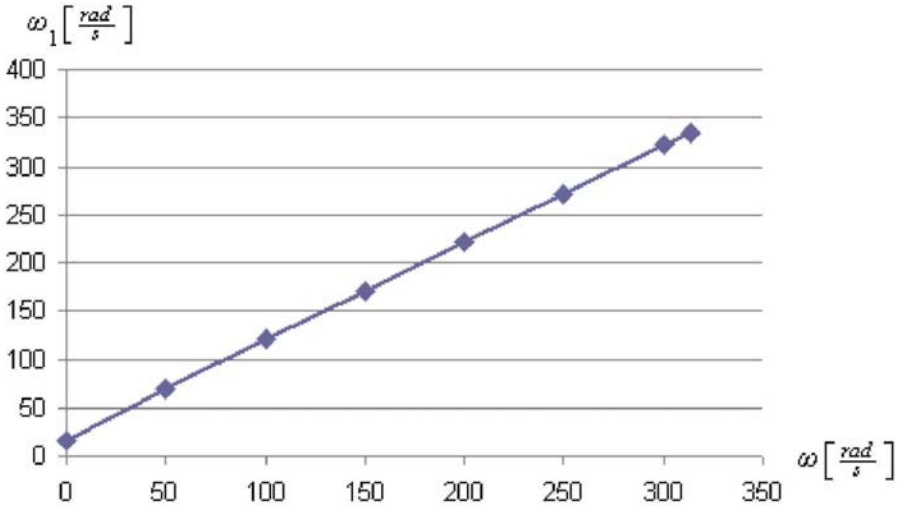

Fig. 3.3 Changes puls stator angular with speed angular. Rotors angular velocity ω (t) are:

$\omega(t)$ = kt = 33,3t

obtain the stator pulse variation in time approximately:

$\omega_1(t) = 15{,}232 + k_\omega\omega(t)15{,}232 + 1{,}02\omega(t) = 15{,}232 + 34{,}92t$

$\omega_1(t) = 15{,}232 + 34{,}92t$

It must be stated that these variations in time of the actual voltage U stator pulse ω_1 (or frequency f_1) are obtained for a given value of moment of inertia J. If this value is incorrect, changes in time for the voltage and frequency are erroneous.
Variation of torque with speed for electromagnetic torque resulted following

$M_{elmg} = 6{,}6,\ 6{,}36,\ 6{,}58,\ 6{,}8,\ 7{,}1,\ 7{,}3,\ 7{,}6,\ 7{,}7\,[Nm]$

Angular velocities the rotors: ω = 0, 50, 100, 150, 200, 250, 300, 314 $\left[\frac{rad}{s}\right]$

Electromagnetic torque values are maximum values. They differ very little from one value to another and around the 7 $[N \cdot m]$

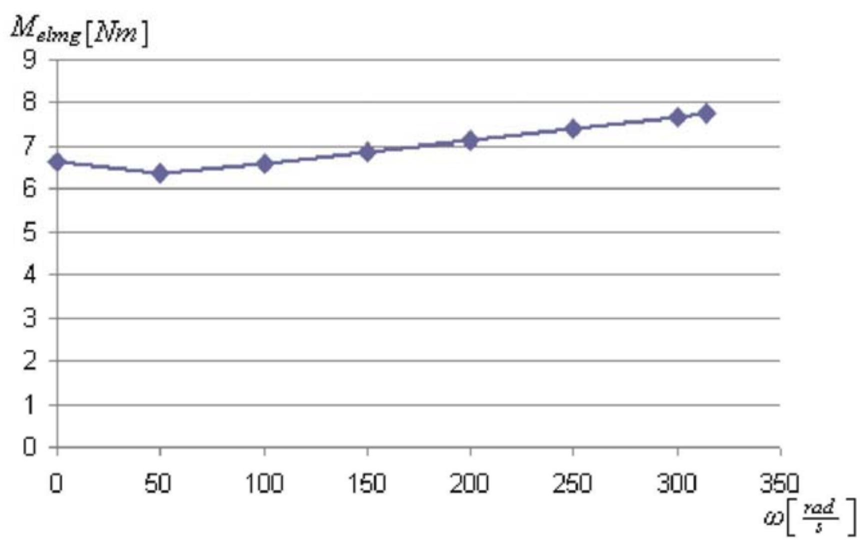

Fig. 3.4 Dependence of electromagnetic torque angular speed rotors Remarks:

1) starting torque is approximately constant: 7 [Nm].
2) Maximization of torque does not depend on speed, as could be seen from the above. Speed depends on the voltage and stator frequency. At any value of the speed and maximum torque is it in circumstances where not exceed the limit values for flux and stator current. Otherwise said MA is used to maximum capacity.
Maximum torque is achieved by imposing voltage and frequency values calculated from algebraic system generated by Lagrange function.

VIEWING IN THE TIME VARIATION OF VOLTAGE AMPLITUDE AND STATOR CURRENT I(T)

Viewing the time variation of stator voltage amplitude written in the form:

$$u = U\sqrt{2}\sin\omega_1 t = U\sqrt{2}\sin(15{,}622 + 32{,}236t)t$$

Is presented below. Changes in actual voltage u(t) during shows such as in Fig.6.10:

$$u = U\sqrt{2}\sin\omega_1 = (40{,}684 + 46{,}524t)\sqrt{2}\sin(15{,}622 + 32{,}236t)t$$

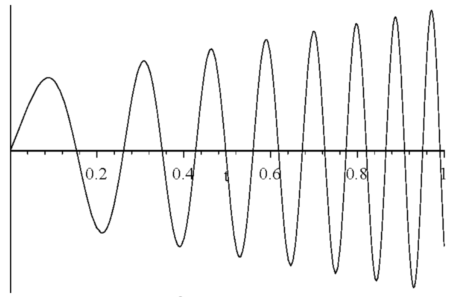

Fig. 6.10 Changes in voltage u(t) during

Changes in current i(t) over time shows such as in Fig. 6.11:

$$i(t) = I\sqrt{2}sin\omega_1 t = 8\sqrt{2}\sin 15{,}622 + 32{,}236t)t$$

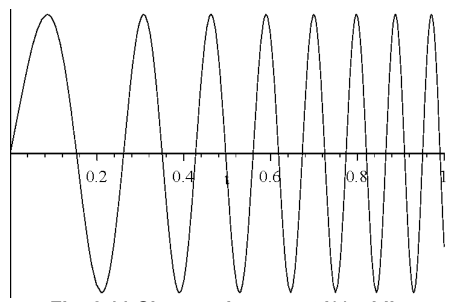

Fig. 6.11 Changes in current i(t) while

Remarks:
1. There is at voltage u(t), increased amplitude over time.
2. Current i(t) maintains its magnitude at a constant value given that imposed in the process of adjusting the stator current is constant in nominal value of the area.

Remarks:
1) The starting torque is approximately constant: 6.5 [Nm].
2) When any amount of speed, the torque is maximum and it provided not exceeding the limit values for current flow rotors and stator. Otherwise said MA is used to maximum capacity.
Maximum torque is achieved by imposing voltage and frequency values calculated from algebraic system generated by Lagrange function.

At the initial $\omega = 232{,}6\left[\frac{rad}{s}\right]$ determine the currents:

- $I_d = X$ axis stator current in d;
- $I_{dr} = Z$ current axis of rotors d;
- U voltage stator;
- ω_1 pulse stator (the stator frequency);
- M_{elmg} electromagnetic torque;

At $\omega = 232{,}6\left[\frac{rad}{s}\right]$ have obtained solutions:

- voltage U = 336.41[V]

Pulse stator $\omega_1 = 232{,}6\left[\frac{rad}{s}\right]$

- electromagnetic torque M_{elmg} = 7.29[N • m]

- angular speed rotors ω = 243.97 $\left[\frac{rad}{s}\right]$

At ω = 243.97 $\left[\frac{rad}{s}\right]$ have obtained solutions:

-voltage U = 350.88[V]

Pulse stator $\omega_1 = 265{,}45\left[\frac{rad}{s}\right]$

- electromagnetic torque $M_{elmg} = 7{,}355[N \cdot m]$

- angular speed rotor $\omega = 253{,}97\left[\frac{rad}{s}\right]$

At $\omega = 253{,}97\left[\frac{rad}{s}\right]$ have obtained solutions:

-voltage U = 363.6[V]

- statoric pulse $\omega_1 = 275{,}52\left[\frac{rad}{s}\right]$

- electromagnetic torque $M_{elmg} = 7{,}41[N \cdot m]$

- angular speed rotor $\omega = 263{,}97\left[\frac{rad}{s}\right]$

At $\omega = 253{,}97\left[\frac{rad}{s}\right]$ have obtained solutions:

-voltage U = 376.32[V]

- statoric pulse $\omega_1 = 258{,}56\left[\frac{rad}{s}\right]$

- electromagnetic torque $M_{elmg} = 7{,}466[N \cdot m]$

CONCLUSION

The amount of actual stator voltage U is change linearly with angular velocity ω rotors with a flux and stator current and a constant value of electromagnetic torque possible with the method of Lagrange multipliers.Palpitation stator and stator frequency, modify all linearly with u.

Of course, these results are obtained when a cvasistaționar for the equations that compose the Lagrange function associated electromagnetic torque:

$$M_{elmg} = f\left(i_d, i_{dr}, i_q, i_{qr}\right) = p1M\left(i_q i_{dr} - i_d - i_{qr}\right)$$

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