DETERMINING THE CAPACITY CONDENSER VALUE AT SINGLE-PHASE MOTOR SPEED CHANGE

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Abstract: *This paper determines the value of capacitor connected in series with the auxiliary phase for a single-phase induction machine. Capacitance of the capacitor is determined by a certain gap between the main and auxiliary phase of the machine, having variable speed.*

Keywords: *Single phase induction motor, capacitance of the capacitor*.

1. INTRODUCTION

Considering a single-phase asynchronous machine type with a capacitive booster phase having the lag angle θ between the axis of the main phase (A) and the axis of the booster phase (B), (figure 1).

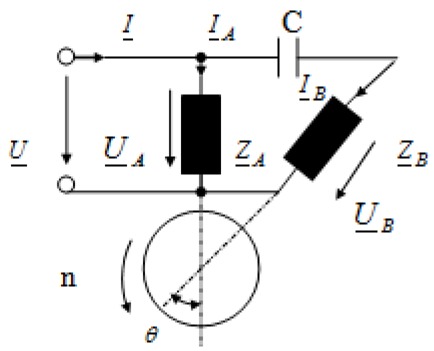

FIG.1. Asynchronous machine with capacitive booster phase.

It applies the method of symmetrical components in the general case, the different electrical parameters of the main and auxiliary phase.

The stator magnetic range is an elliptical range, it is in two parts, the forward and the reverse, and the impeller featuring the same range components as a result of the reaction of the rotor range The homopolar component of the stator coil current is different from zero, which determines a magnetic range the same size as the dispersion range, because the range lines approach to the homopolar flux close through low magnetic permeability environments. The homopolar component of the rotor flux is of no value, having no place to enwrap.

2. THE MATHEMATICAL MODEL

As a reference axis for writing equations A axis is chosen to which we have all the electrical quantities from stator and rotor.

Considering asynchronous machine analysis with split phase in symmetrical components [1,2,4] and for a gap of $\pi/2$ between the main and auxiliary phase shows the following:

$$\underline{U}_A = \underline{Z}_1 \underline{I}_A + \underline{Z}_2 \underline{I}_B \quad (1)$$

$$\underline{U}_B = -\underline{Z}_2 \underline{I}_A + \underline{Z}_3 \underline{I}_B \quad (2)$$

$$\underline{U}_A = \underline{U} \quad (3)$$

$$\underline{U}_B = \underline{U} - \underline{I}_B \underline{Z} \quad (4)$$

$$\underline{Z}_1 = \frac{1}{3}\left(\underline{Z}_{e2Ad} + \underline{Z}_{e2Ai} + 2\underline{Z}_A + \underline{Z}_{A0}\right) \quad (5)$$

$$\underline{Z}_2 = \frac{j}{K}\left(\underline{Z}_{e2Ai} - \underline{Z}_{e2Ad}\right) \quad (6)$$

$$\underline{Z}_3 = \frac{1}{3}\left(\frac{\underline{Z}_{e2Ad} + \underline{Z}_{e2Ai}}{K^2} + 2\underline{Z}_B + \underline{Z}_{B0}\right) \quad (7)$$

$$\underline{Z} = \frac{-j}{\omega_1 C} \quad (8)$$

$\underline{Z}_A = R_A + jX_A$ - the main phase impedance;

$\underline{Z}_B = R_B + jX_B$ - the auxiliary phase impedance;

$\underline{Z}_{A0} = R_A + j\alpha X_A$ - the main phase of the monopolar impedance;

$\underline{Z}_{B0} = R_B + j\alpha X_B$ - the auxiliary phase of the monopolar impedance;

$\underline{Z}_{Am} = R_{Am} + jX_{Am}$ - the magnetization impedance;

$\underline{Z}'_{2Ad} = \frac{R'_{2A}}{s} + jX'_{2A}$ - the direct sequence rotor impedance relative to the main phase;

$\underline{Z}'_{2Ai} = \frac{R'_{2A}}{2-s} + jX'_{2A}$ - the reverse sequence rotor impedance relative to the main phase;

$K = \frac{N_A k_{bA}}{N_B k_{bB}}$ - the conversion factor of voltages between the main and auxiliary phase;

$$\underline{Z}_{e2Ad} = \frac{\underline{Z}_{Am}\underline{Z}'_{2Ad}}{\underline{Z}_{Am} + \underline{Z}'_{2Ad}} \quad (9)$$

$$\underline{Z}_{e2Ai} = \frac{\underline{Z}_{Am}\underline{Z}'_{2Ai}}{\underline{Z}_{Am} + \underline{Z}'_{2Ai}} \quad (10)$$

The main and auxiliary phase currents using equations (1.1-1.4):

$$\underline{I}_A = \underline{Y}_{eA}\underline{U} \quad (11)$$

$$\underline{I}_B = \underline{Y}_{eB}\underline{U} \quad (12)$$

Where equivalent admittance of the main and auxiliary phase have the expressions:

$$\underline{Y}_{eA} = \frac{\underline{Z}_3 + \underline{Z} - \underline{Z}_2}{\underline{Z}\underline{Z}_1 + \underline{Z}_2^{\,2} + \underline{Z}_1\underline{Z}_3} \qquad (13)$$

$$\underline{Y}_{eB} = \frac{\underline{Z}_1 + \underline{Z}_2}{\underline{Z}\underline{Z}_1 + \underline{Z}_2^2 + \underline{Z}_1\underline{Z}_3} \qquad (14)$$

The reverse component of the electromagnetic torque is canceled for $\underline{I}'_{2Ai} = 0$, meaning [3]:

$$K\underline{Y}_{eA} + j\underline{Y}_{eB} = 0 \qquad (15)$$

where you obtain the condenser capacity value, depending on the power supply frequency in the form:

$$C = \frac{3K^2}{2\pi f_1 \left| \left[\left(4\underline{Z}_{e2Ad} - 2\underline{Z}_{e2Ai}\right)\left(1 + jK\right) + 2j\underline{KZ}_A + \underline{jKZ}_{A0} + 2K^2\underline{Z}_B + K^2\underline{Z}_{B0} \right] \right|} \qquad (16)$$

The equivalent impedances corresponding to direct sequence $\underline{Z}_{e2Ad}$ and reverse $\underline{Z}_{e2Ai}$ shown in relations (9,10), are depending of sliding and machine speed.

Condenser capacity value for different frequencies is determined at rated slip s_N of the machine.

3. CASE STUDY

It is considered a single-phase asynchronous motor with auxiliary phase power P_N=370W and RPM n=1500rot/min at C=20μF, with electrical parameters: R_A=7,47Ω; R_B=11,97Ω; L_A=0,039H; L_B=0,07H; M_A=0,345H; M_B=0,448H; R_2=1,6.10^{-4}Ω; L_2=4,4.10^{-7} H

Table 1 shows the values for voltage and capacity condenser at different machine speeds having stator phase angle difference of θ=90^0.

Table 1

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f=25Hz	U_A=130V	C=90μF	n_N=660rot/min
f=40Hz	U_A=176V	C=40μF	n_N=1056rot/min
f=50Hz	U_A=220V	C=25μF	n_N=1320rot/min
f=70Hz	U_A=220V	C=16μF	n_N=1848rot/min
f=100Hz	U_A=220V	C=10μF	n_N=2640rot/min

Table 2 shows the values for gap between stator phases of θ=30^0.

Table 2

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f=25Hz	U_A=130V	C=90μF	n_N=660rot/min
f=40Hz	U_A=176V	C=40μF	n_N=1056rot/min
f=50Hz	U_A=220V	C=25μF	n_N=1320rot/min
f=70Hz	U_A=220V	C=16μF	n_N=1848rot/min
f=100Hz	U_A=220V	C=10μF	n_N=2640rot/min

Table 3 shows the values for gap between stator phases θ=120^0.

Table 3.

f=25Hz	U_A=130V	C=210μF	n_N=660rot/min
f=40Hz	U_A=176V	C=100μF	n_N=1056rot/min
f=50Hz	U_A=220V	C=70μF	n_N=1320rot/min
f=70Hz	U_A=220V	C=40μF	n_N=1848rot/min
f=100Hz	U_A=220V	C=25μF	n_N=2640rot/min

Table 4 shows the values for gap between stator phases θ=150^0

Table 4.

f=25Hz	U_A=130V	C=148μF	n_N=660rot/min
f=40Hz	U_A=176V	C=65μF	n_N=1056rot/min
f=50Hz	U_A=220V	C=75μF	n_N=1320rot/min
f=70Hz	U_A=220V	C=25μF	n_N=1848rot/min
f=100Hz	U_A=220V	C=16μF	n_N=2640rot/min

CONCLUSIONS

The optimal capacity of the capacitor is determined by the condition of reverse component of the electromagnetic torque cancellation.

From the tables is observed that the value of the capacitor power decreases with increasing RPM.

A gap θ between auxiliary and main phase other than $\frac{\pi}{2}$ determinates a considerable increase in the output capacitor, especially at low motor speed.

The capacitor power value can be adjusted using electronic devices connected in parallel with the capacitor of fixed value.

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