J. Basic. Appl. Sci. Res., 9(4)11-15, 2019
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Analysis of Changing of Run Capacitor Motor to Start-Run Capacitor Motor

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Received: May 22, 2019
Accepted: August 1, 2019

ABSTRACT

Common problem that occurs in capacitor run motors is the amount of starting current at start-up, especially when the motor is loaded. This research aimed to: Determine the starting and nominal currents then starting torque value of the run capacitor motor and start-run capacitor motor. Impact of changing of run capacitor motor to start-run capacitor motor will be done by testing variations in the addition of external capacitors parallelized with internal capacitors from the run capacitor motor. The results revealed that: 1) Starting currents of run capacitor motor was 2,3 Ampere increased by 5% to 2,44 Ampere after being converted into start-run capacitor motor; 2) Starting torque value of capacitor motor was 0,0042 N-m increased by 65% to 0,012 N-m after being converted into start-run capacitor motor; 3) Large current with a small torque problems in the capacitor run motor can be solved by converting the motor into a start run capacitor motor..
KEYWORDS: motors, capacitor, torque, start-run capacitor motor, run capacitor motor, currents

1. INTRODUCTION

Electric motors are generally used as water pumps or mechanical drives. It is called an electric motor because it uses electrical energy as its driving energy source [1]. Single-phase induction motors are classified in accordance with their starting methods and are usually referred to by names descriptive of these methods. Selection of the appropriate motor is based on the starting- and running-torque requirements of the load, the duty cycle of the load, and the limitations on starting and running current from the supply line for the motor. In induction machines, alternating currents are applied directly to the stator windings. Rotor currents are then produced by induction, i.e., transformer action [2].

One phase induction motor cannot start itself for initial start, for that one phase induction motor is equipped with an auxiliary coil which is connected in series with a capacitor whose capacitor size is suitable for starting one phase induction motor [3]. While one-phase capacitor induction start-run motor is a type of one-phase induction motor that has two capacitors, run capacitors which are permanently connected in series with auxiliary windings and the auxiliary winding is parallel with the main winding and start capacitors parallelized with the run capacitors equipped with the centrifugal switch is used to disconnect the circuit from the start capacitor when the rotation approaches the nominal rotation [4].

2. METHODS

This research through to several stages, namely [5]:

(a) Design and measuring parameters of motors;
Measuring of the induction motor is done by made design of a test circuit for the run capacitor motor circuit and the start-run capacitor motor circuit as shown in figure 1.

(b) Equivalent diagram of one phase induction motor;
In mathematically analyzing a single phase induction motor, an equivalent circuit is needed. The equivalent circuit needed consists of an equivalent circuit of commonly induction motors, an equivalent circuit motor of run capacitor and an equivalent circuit of motor start-run capacitor as shown in figure 2.

(c) Collecting data with experimental test;
Motor data are obtained from the measurement results using the test circuit as shown in figure 1, and variations of the test are carried out with reference to the equivalent circuit of each induction motor.

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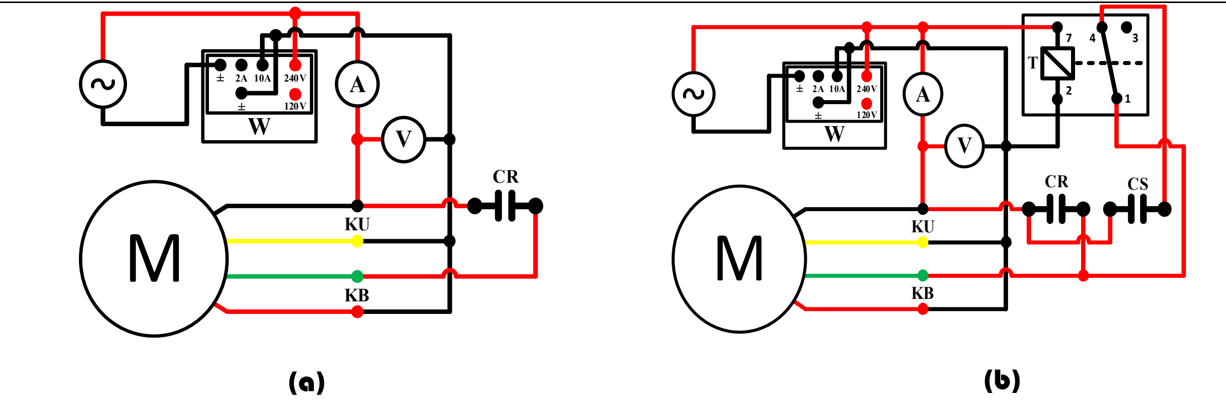


Figure 1. Testing circuits; (a) run capacitor motor, (b) start-run capcitor motor

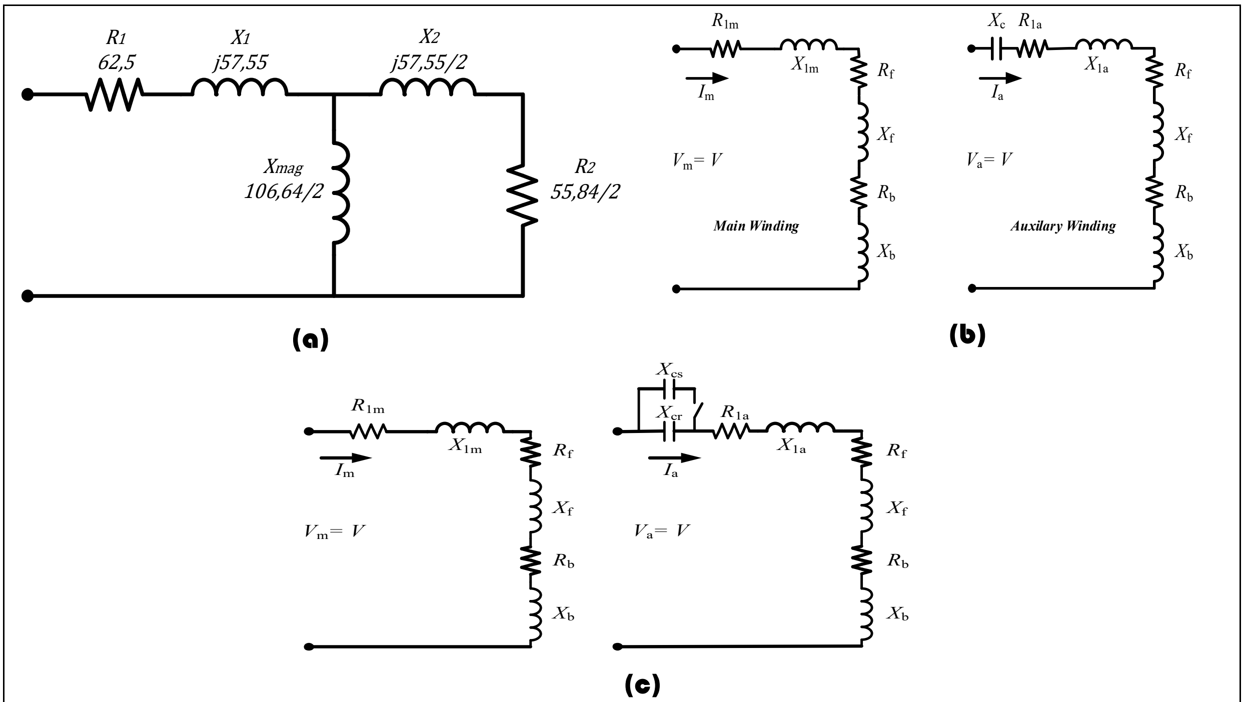


Figure 2. Equivalent circuits; (a) generally induction motor, (b) run capcitor motor and (c) start capacitor motor

Related equation based on Figure 2(b), obtained [7]:
Forward impedance :

$$Z_f = R_f + jX_f = \frac{(R_2/s + jX_2) \times (jX_m)}{(R_2/s + jX_2) + (jX_m)} \tag{1}$$

Backward impedance :

$$Z_b = R_b + jX_b = \frac{(R_2/(2-s) + jX_2) \times (jX_m)}{(R_2/(2-s) + jX_2) + (jX_m)} \tag{2}$$

Current of induction motors :

$$I_1 = \frac{V_1}{R_1 + jX_1 + 0{,}5\, Z_f + 0{,}5\, Z_b} \tag{3}$$

Torque :

$$T_s = \frac{2|I_m||I_a|(R_f+R_b)\sin(\theta_a-\theta_m)}{\omega_{syn}} \quad (4)$$

Capacity of the capacitor that needs to be added to become a start-run capacitor motor as shown Figure 5, obtanied [8] :

Reaktance of capacitor :

$$X_c = \frac{1}{\omega} = X_a + \frac{-X_m R_a + |Z_m|\sqrt{R_a(R_a+R_m)}}{R_m} \quad (5)$$

Capacitance :

$$C = \frac{1}{\omega X_c} \quad (6)$$

Additional capasitance :

$$C_s = [C - C_r] \quad (7)$$

3. RESULTS AND DISCUSSION

Data from the initial measurement of induction motor can be seen in the following table:

Table 1. Data of run capacitor motor

Nominal Current (Ampere)	Output Power (Watt)	Input Power (Watt)	Voltage (Volt)	Frequency (Hz)	Run Capasitor (µF)
1,3	125	300	220	50	8

Table 2. Data of run capacitor motor in full load operation

Nominal Current (Ampere)	Starting Current (Ampere)	Voltage (Volt)	Load (Watt)
1,3	2,308	220	280

Table 3. Parameters of run capacitor motor

Resistance of Main Winding (Ohm)	Reactances of Winding (Ohm)	Resistance of Auxilary Winding (Ohm)	Magnetic Reactance (Ohm)
62,5	57,55	55,84	106,64

Refered to anlysis of run capasitor motor, obtained :

starting currents :

$$I_s = 1{,}97 \angle -31{,}56° + 0{,}63 \angle 76{,}23°$$
$$= 2{,}46 \angle -41{,}86° \text{ A}$$

Result of motors torque :

$$T_s = \frac{2(1{,}97) \times (0{,}63)2 \times 0{,}20 \sin(76{,}23 + 31{,}56)}{1800 \times 2\pi/50}$$
$$= 0{,}0042 \text{ N} \cdot \text{m}$$

Same as above for anlysis of start- run capasitor motor, obtained :

Starting currents :

$$I_s = 1{,}97 \angle -31{,}56° + 1{,}77 \angle 47{,}82°$$
$$= 2{,}88 + \angle - 5{,}57° \text{ A}$$

Result of motors torque :

$$T_s = \frac{2(1{,}97) \times (1{,}77)2 \times 0{,}20 \sin(47{,}82 + 31{,}56)}{1800 \times 2\pi/50}$$
$$= 0{,}012 \text{ N} \cdot \text{m}$$

The measurement and calculation results can be verified by calculate the percentage difference, namely [9] :

starting current of run capasitor motor :

$$\varepsilon_a = \frac{2{,}46 - 2{,}3}{2{,}46} \times 100\%$$
$$= 6\%$$

starting current of start-run capasitor motor :

$$\varepsilon_a = \frac{2{,}88 - 2{,}44}{2{,}88} \times 100\%$$
$$= 15\%$$

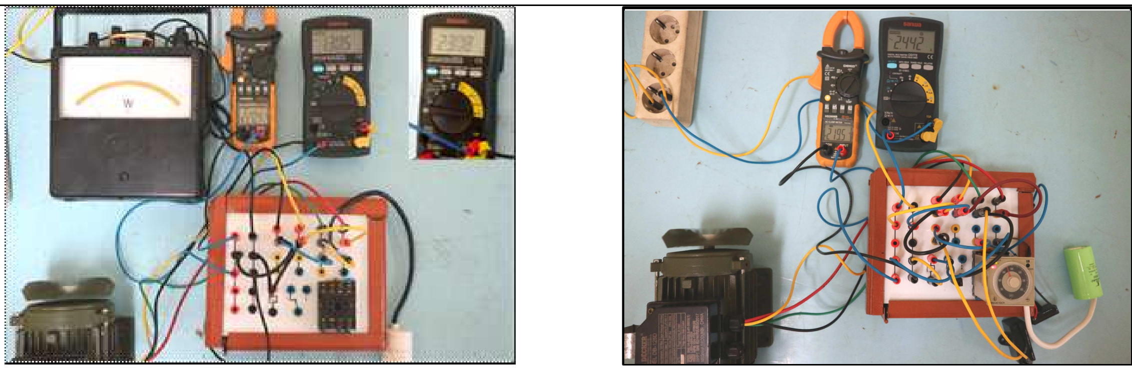
Based on the measurement results of the starting current, it can be seen that the impact of changing run capasitor motor to start-run capasitor motor can be increase starting current from 2.3 A to 2.44 A or an increase by :

$$Incresing\ of\ I_s = \frac{2{,}44 - 2{,}3}{2{,}44} \times 100\%$$
$$= 5\%$$

As in case motor torque, increased by :

$$Increasing\ of\ Torque = \frac{0{,}012 - 0{,}004}{0{,}0012} \times 100\%$$
$$= 65\%$$

Testing of the changing run motor capacitor motor into start-run capacitor motor can be seen in figure 3.



(a) (b)

Figure 3. Layout measurement; (a) run capacitor motor, (b) start-run capcitor motor

4. CONCLUSION

Based on the research and the results impact of changing of run capacitor motor to start-run capacitor motor are obtained:

(a) Low torque problems in the capacitor run motor can be solved by converting the motor into a start-run capacitor motor.
(b) Increasing level of starting current of start-run capacitor up to 5% and motor torque up to 65%.

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