The Characteristics Experiment of the Single – phase Induction Motor

OBJECTS :

1 : To understand the difference between the Single – phase and Three - phase Induction Motor .

2 : To understand the difference among all kinds of Single – phase Induction Motor .

Theory :

The stator part of the single phase induced motor is of a single winding. If such single winding is connected to single phase power, it can only generate interchange field and it can not be started. On the operation of a 3-phase induced motor, if the winding is broken, the other two windings may be operated with two individual single phase. This proves if a single phase induced motor has a outside power to start, it can still be operated as single phase.

The rotor of the actual single phase induced motor is of mouse cage type. There are driving winding and starting winding in the stator. When single phase power is added in, use the split phase function of the driving winding and starting winding to split to two phase-like power. This may generate rotary field or moving field and to start.

Classification :

There is one set of driving winding and one set of starting winding on the single phase induced motor to generate rotary field or moving field to provide starting torque; the torque can also be generated with the repulsion principle, so usually a single phase induced motor is classified with the starting devices as followings:

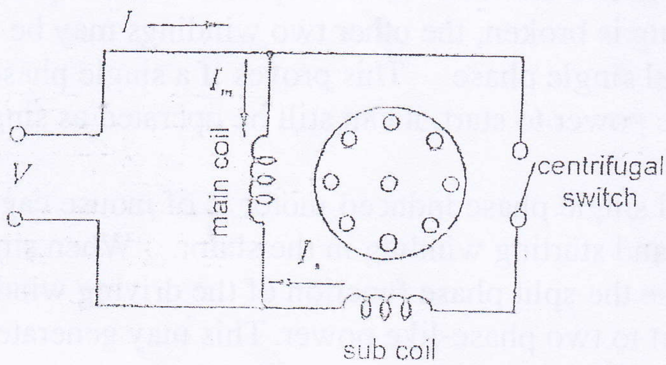
1. Split phase started motor;
2. Capacitor started motor;
3. Shaded-pole started motor;
4. Repulsion started motor.

1 : Split phase Started Motor :

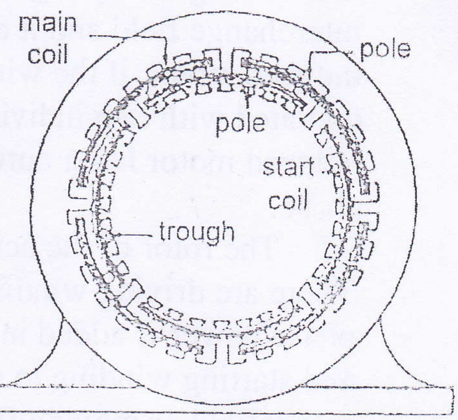
The circuit is as illustrated in Fig. 3-4-1(a). The space distance in the axle of the driving winding and starting winding is in 90°dynamo angle. The driving winding is at the bottom of the line slot so as to increase the electric induction. The starting winding is wind around the top of the line slot to reduce the magnetic leakage induction as illustrated in Fig. 3-4-1 (b), and the guide line of its winding revolution is less and finer so as to reduce the induction and increase the resistance. This method is to make the current I_n that passing through the driving winding to delay phase for about 90 °. The I_s that passing through the starting winding to delay phase for less angle as Fig. 3-4-1 c) is illustrated, in this way, we can get a similar two phase current and to generate rotary field to make the rotor to have a starting torque. Also, make the rotary direction from the current ahead phase to the current lag phase.

In order to reduce the electric loss and avoid starting winding from burning off, after the motor has started and the revolution speed has increased to 75% of the synchronized speed, use the centrifugal switch to isolate the circuit.

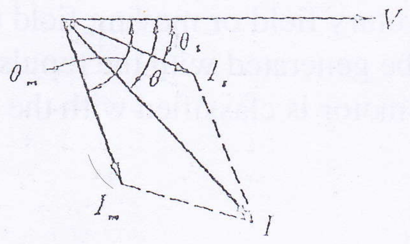
Due to the phase difference of angle at I_m and I_s split phase electric is not big, therefore, the starting current is big and the starting torque is small(about 1.5 - 2 folds of the rated).



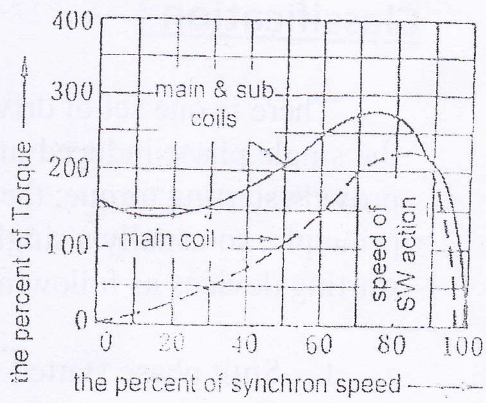
a) Circuit



b) Distribution



c) Vector diagram



d) Torque - Revolution characteristics current

Fig. 3-4-1 Split phase started motor

2 : Capacitor – Start Motor :

The biggest difference between the capacitor started motor and the split phase motor is that the starting winding loop of the former is connected with a capacitor to bring forward the phase, so it not only may improve the power factor, but also expand the phase angle difference between I_m and I_s to get larger starting torque. The capacitor started motor can further be classified into three types:

(1) Capacitor-start induction motor, as Fig. 3-4-2-(a);
(2) Permanent capacitor induction motor, as Fig. 3-4-3-(a);
(3) Double capacitor induction motor, as Fig. 3-4-4-(a);

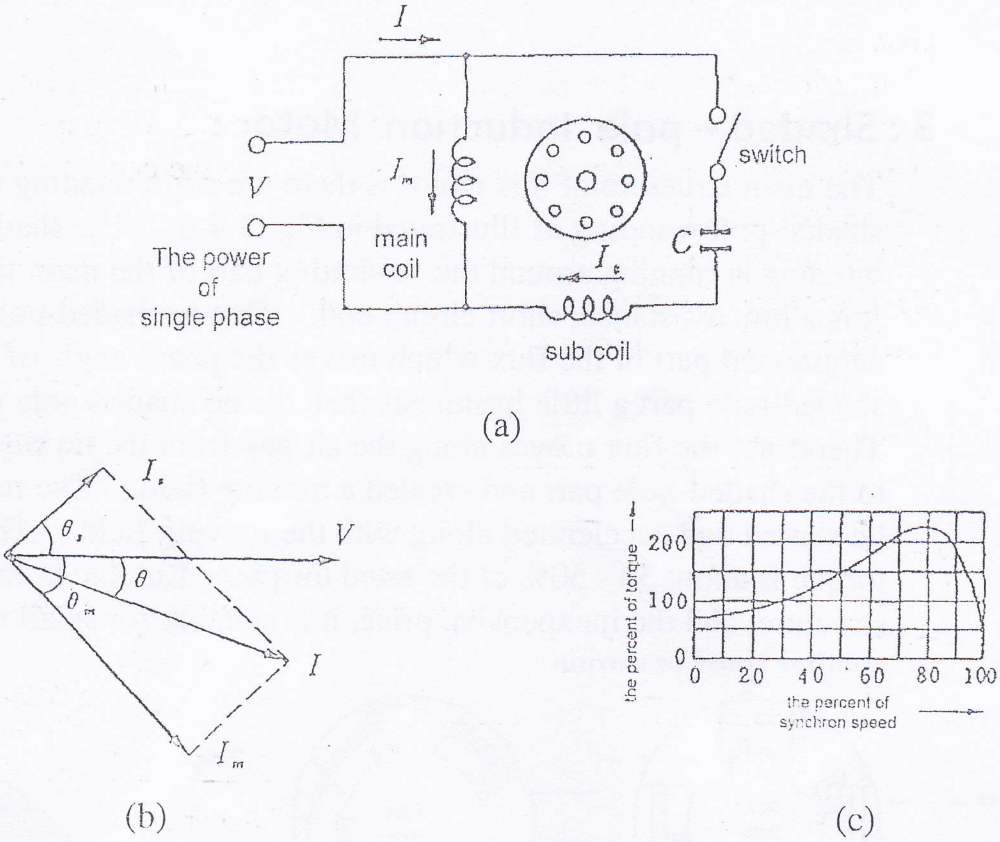


Fig. 3-4-2 Capacitor-start induction motor

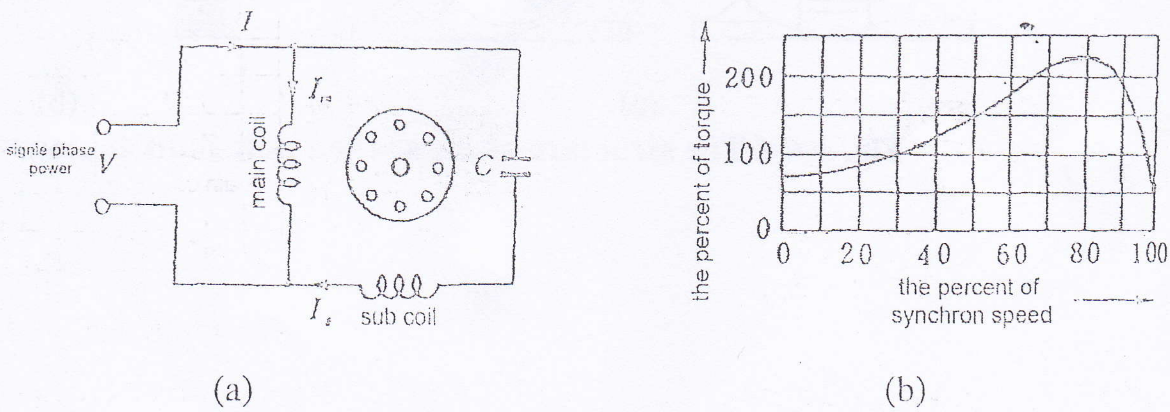
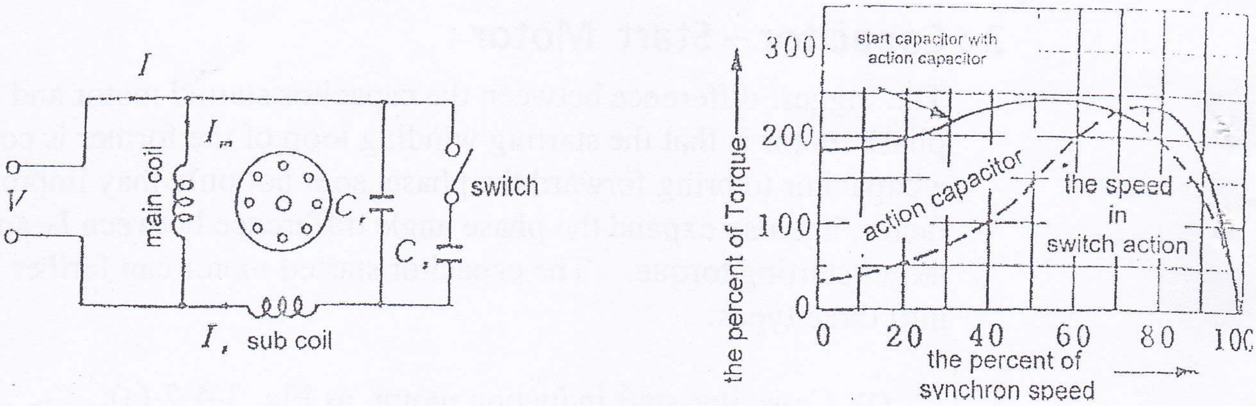


Fig. 3-4-3 Permanent capacitor induction motor

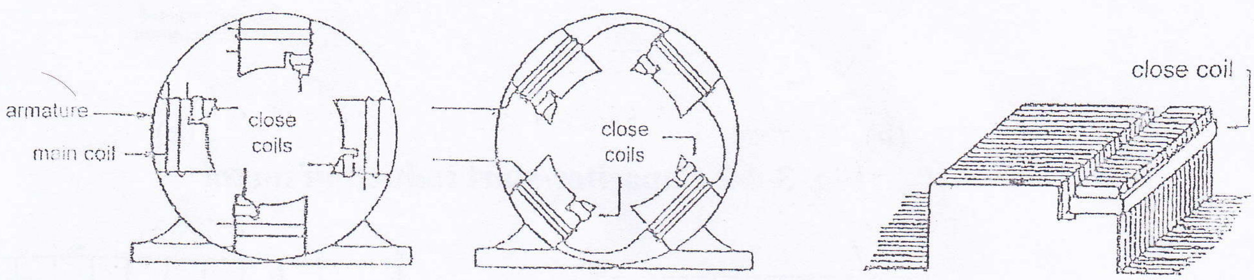


(a) (b)

Fig. 3-4-4 Double capacitor induction motor

3 : Shaded – pole Induction Motor :

The main structure of this motor is there are main winding and shaded-pole winding as illustrated in Fig. 3-4-6. The shaded-pole winding is running around the separating part of the main magnetic pole. It is a low resistance, short circuit coil. Due to shaded-pole coil suppressed part of the flux which makes the phase angle of the shaded-pole part a little hysteresis than the no shaded-pole part. Therefore, the flux moves along the air gap from the no shaded-pole part to the shaded-pole part and created a moving field. The rotor thus may be started and accelerated along with the moving field. The starting torque is about 30 - 50% of the rated torque. But due to its simple structure, and the inexpensive price, it is suitable for small motor of smaller starting torque.



(a) (b)

Fig. 3-4-6 The structure of the shaded-pole induction motor

4 : Repulsion – start Motor :

Repulsion-start motor, as illustrated in Fig. 3-4-7, is a four poles repulsion motor. The structure of which is a distribution winding similar to induction resistance on the stator, while the rotor has the same armature as the DC motor. However, the placement seat of the carbon body is movable, i.e. the axis and the field location can be moved. If the carbon body axis and the polar axis are in parallel as illustrated in Fig. 3-4-8, as the field flux is increased as the direction of the diagram, then the direction of the induced E.M.F. at the rotor part is also as illustrated. At this moment, the rotor part is like a secondary short circuit transformer that generates huge armature current. But due to the equal and reverse torque generated by the conductors at two sides, the torque is offset, so there is no torque at all, and the motor is unable to start. Such location is called hard neutral location. If the carbon body and the polar axis are in perpendicular to each other, due to there is no armature voltage, and it is unable to generate torque, as the armature is unable to start, such location is called soft neutral location as illustrated in Fig. 3-4-9. If one wishes to make the repulsion motor generate torque, then the carbon body axis and the polar axis must be in 18°to 20°dynamo angle as illustrated in Fig. 3-4-10.

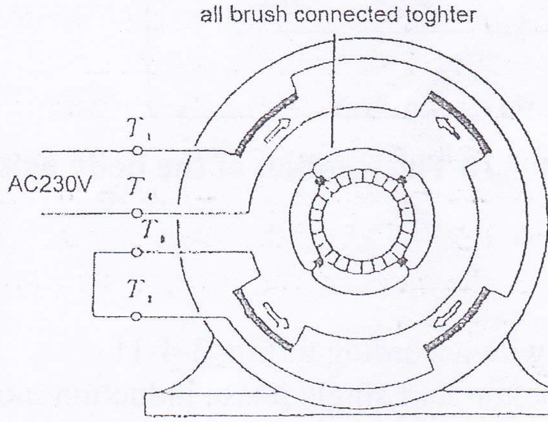


Fig.3-4-7 The repulsion-start motor

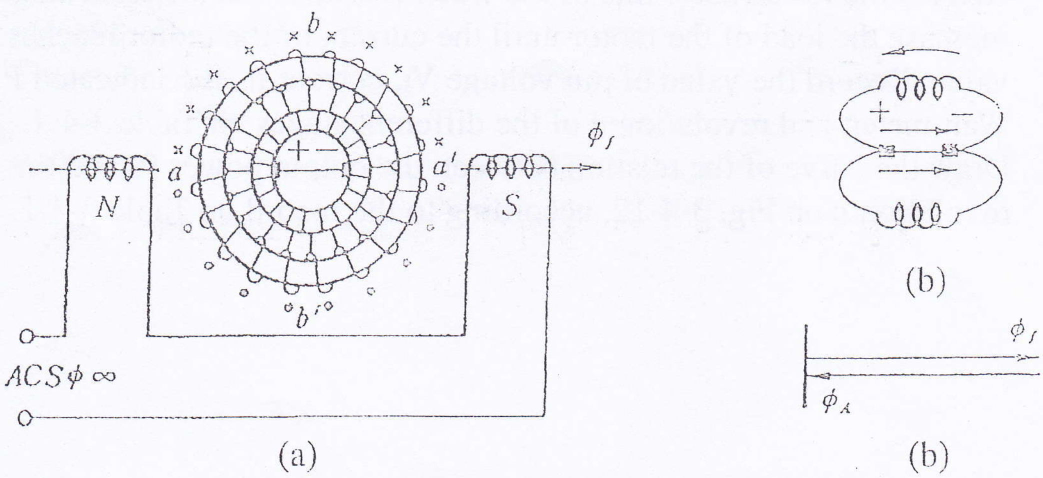


Fig.3-4-8 The hard neutral location

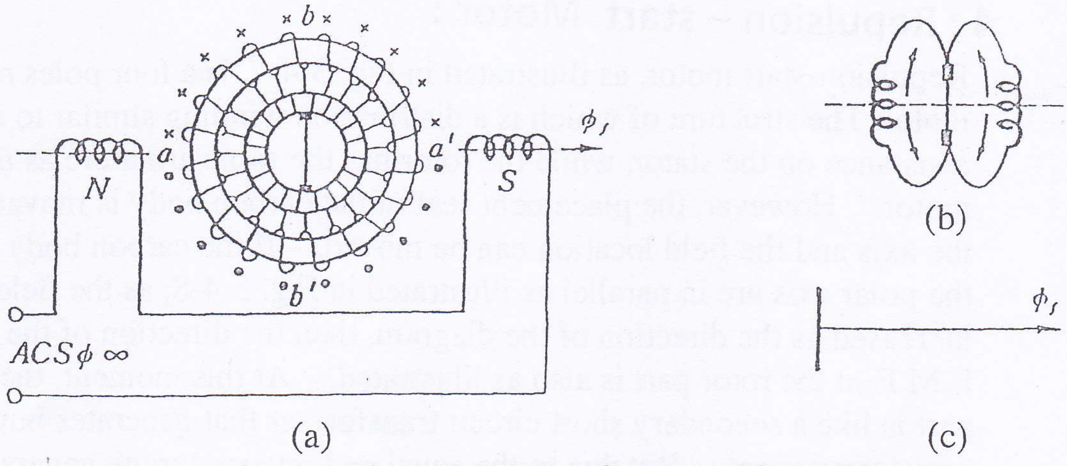


Fig.3-4-9 The soft neutral location

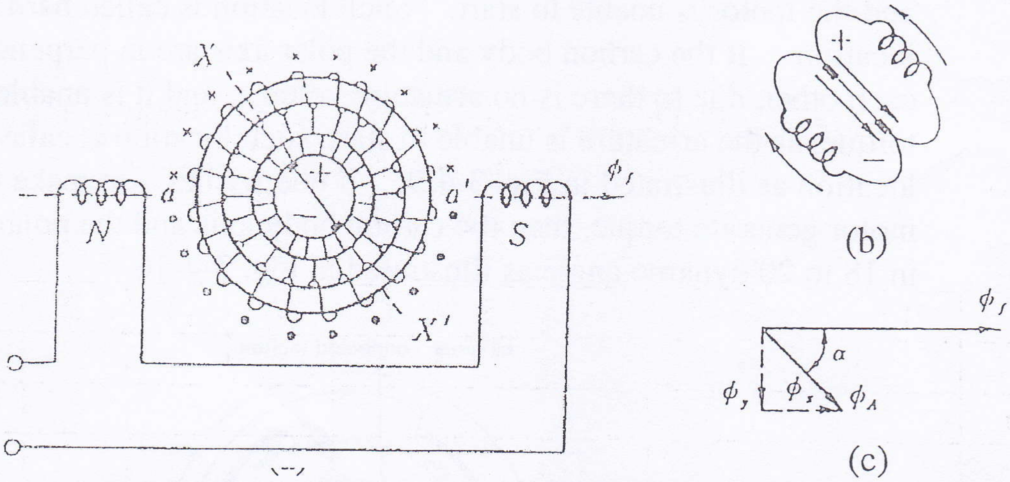


Fig.3-4-10 The location of the body axis and the polar axis

Procedure :

1. Connect the wire according to Fig. 3-4-11.
2. Start the capacitor-start single phase induction motor and make it operate at rated voltage.
3. Reduce the resistance value of the water resistance at different stages, i.e. to increase the load of the motor until the current of the motor reaches the rated value. Record the value of pin voltage V_t, current I_L, the indicated P value on Watt meter, and revolution n of the different stages on Table 3-4-1.
4. Draw the curve of the relation between the output power P_o and the revolution n on Fig. 3-4-12, according to the record on Table 3-4-1.

Circuit Diagram :

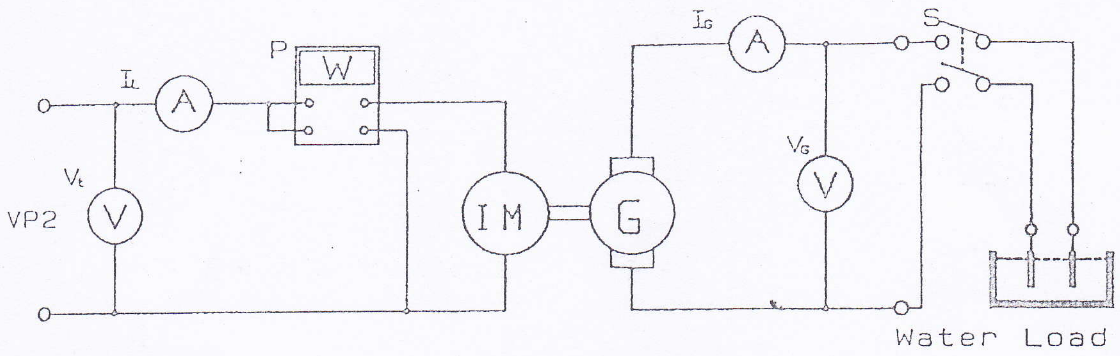


Fig. 3-4-11 The load characteristics experiment of the single phase induction motor (Use of DC motor)

Table 3-4-1

	1	2	3	4	5	6	7	8	9	10
V_L										
I_L										
P										
n										
V_G										
I_G										
P_o										
η										
$\cos\theta$										

Note: $P_o = V' I' \cdot 0.65$

$$\eta = \frac{P_o}{P}$$

$$\cos\theta = \frac{P}{V_t I_L}$$

Report & discussion:

3. Explain the effect of interchanging the mains leads on the direction of rotation of the experimental machine.
4. Explain with the aid of equations the effect of reducing the applied mains voltage on the induction motor output torque.