## ELECTRICAL BRAKING OF AN INDUCTIONMOTOR

### D.C. Dynamic Braking

A quick stopping of an induction motor and its high inertia load can be achieved by connecting stator terminals to a d.c. supply. Any two stator terminals can be connected to a d.c. supply and third terminal may be kept open or may be connected directly to other stator terminal. This is called d.c. dynamic braking. If third terminal is kept open it is called two lead connections while if it is shorted directly with other stator terminal it is called three lead connections. A diode bridge can be used to get d.c. supply. The Fig. 4.5.1 shows two lead connections with a diode bridge for a d.c. dynamic breaking of an induction motor.

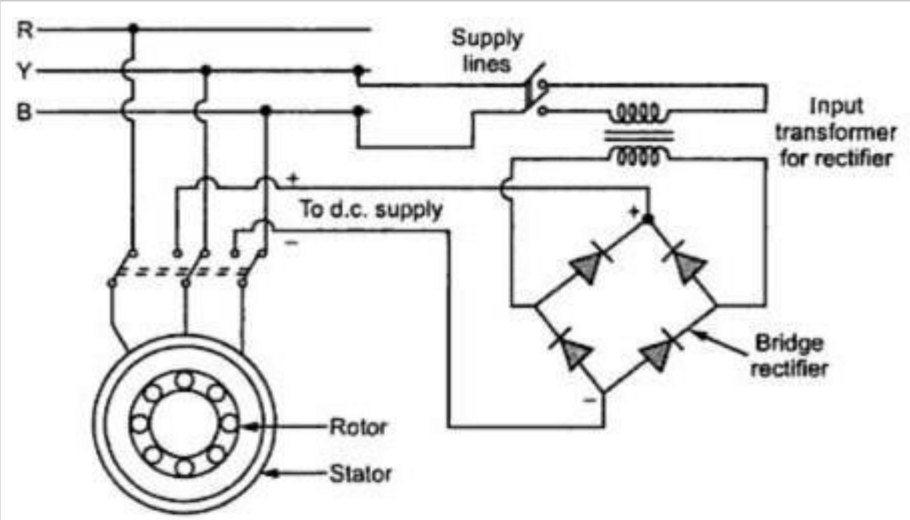


**Fig. 4.5.1 D.C. Dynamic braking**

When d.c. is supplied to the stator, stationary poles N, S are produced in stator. The number of stationary poles is P for which stator winding is wound. As rotor is rotating, rotor cuts the flux produced by the stationary poles. Thus the a.c. voltage gets induced in the rotor. This voltage produces an a.c. current in the rotor. The motor works as a generator and the R losses are dissipated at the expenditure of kinetic energy stored in the rotating parts. Thus dynamic braking is achieved. When all the kinetic energy gets dissipated as heat in the rotor, the induction motor comes to rest.

The advantages of d.c. dynamic braking are,

1. The heat produced is less compared to the plugging.
2. The energy dissipated in the rotor is not dependent on the magnitude of the d.c. current.
3. The braking torque is proportional to the square of the d.c. current.
4. Quick stopping of the motor is possible.
5. The method can be used for wound rotor or squirrel cage rotor induction motors.

**REGENERATIVE BRAKING**

The input power to a three phase induction motor is given by,

$$P_{in} = 3\ V_{ph}\ I_{ph} \cos$$

where $\Phi$ = Angle between stator phase voltage and phase current This $\Phi$ is less than $90^{o}$ for the motoring action.

If the rotor speed is increased greater than the synchronous speed with the help of external device, it acts as an induction generator. It converts the input mechanical energy which is given back to supply. It delivers active power to the 3 phase line. The $\Phi$ becomes greater than $90^{o}$. the power flow reverses hence rotor induced e.m.f. and rotor current also reverse. So rotor produces torque in opposite direction to achieve the braking. As the electrical energy is given back to the lines while braking, it is called regenerative braking. The arrangement for regenerative braking is shown in the Fig. 4.5.2

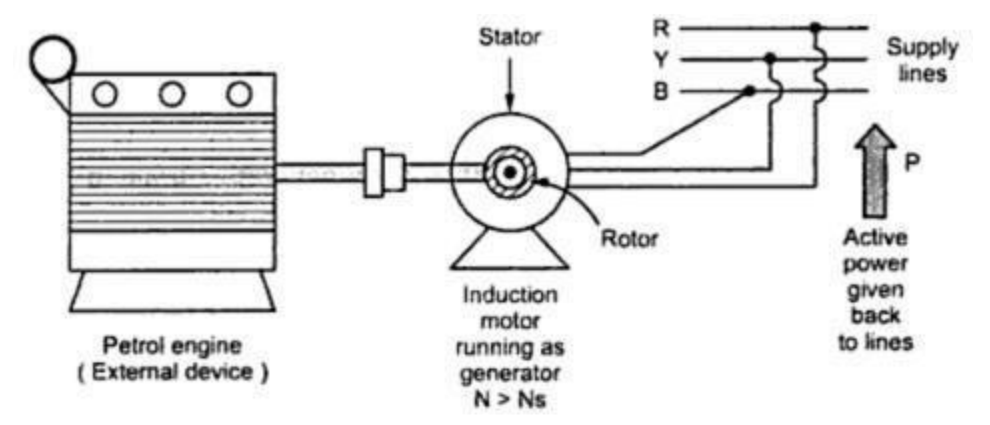


**Fig. 4.5.2 Regenerative braking**

**Note** : The active power delivered back is proportional to the slip above the synchronous speed. The slip is negative for such operation.

The torque-slip characteristics for motoring and generating action is shown in the Fig. 4.5.3

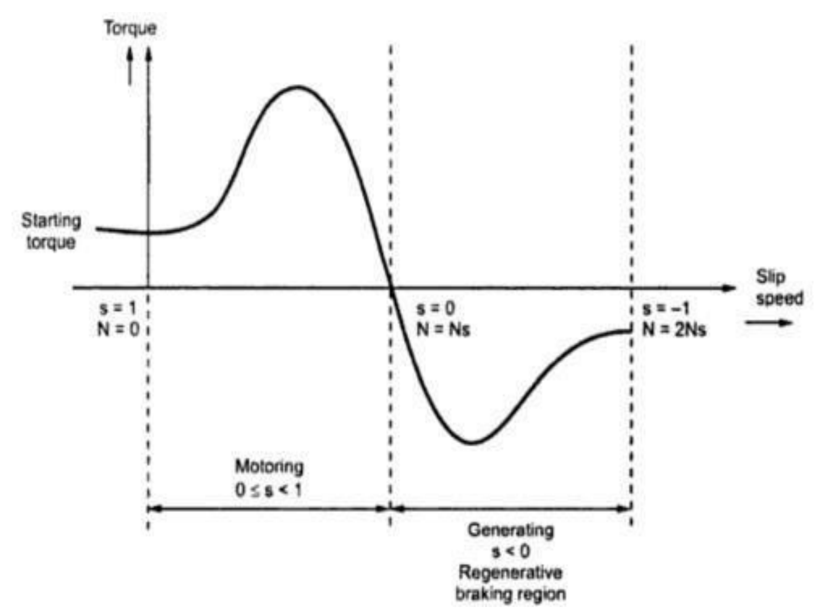


**Fig. 4.5.3 Torque-slip characteristics for regenerative**

The main advantage is that the generated power can be used for useful purposes. While the disadvantage is that for fixed frequency supply it can be used only for speeds above synchronous speed.

The mechanical brakes or electric brakes can be used to bring an electric motor to rest, quickly. But with the mechanical brakes, smooth stop is not possible. Similarly the linings, levers and other mechanical arrangements are necessary to apply mechanical brakes. Mechanical brakes also depends on the skill of the operator. As against this, an electric braking is easy and reliable hence it is used to stop the induction motors very quickly. Though the motor is brought to rest electrically, to maintain its state of rest a mechanical brake is must.

## DYNAMIC OR RHEOSTATIC BRAKING

In rheostatic braking, one supply line out of R, Y or B is disconnected from the supply. Depending upon the condition of this disconnected line, two types of rheostatic braking can be achieved.

1. Two lead connections : In this method, the disconnected line is kept open. This is shown in the Fig. 1(a) and is called two lead connections.
2. Three lead connections : In this method, the disconnected line is connected directly to the other line of the machine. This is shown in the Fig. 4.5.3

In both cases, a high resistance is inserted in the rotor circuit, with the help of rheostat.

**Note** : Thus this method is effective only for slip ring or wound rotor induction motors.

As one of the motor terminal is not connected to the supply, the motor continues to run as single phase motor. In this case the breakdown torque i.e. maximum toque decreases to 40% of its original value and motor develops no starting torque at all. And due to high rotor resistance, the net torque produced becomes negative and the braking operation is obtained.

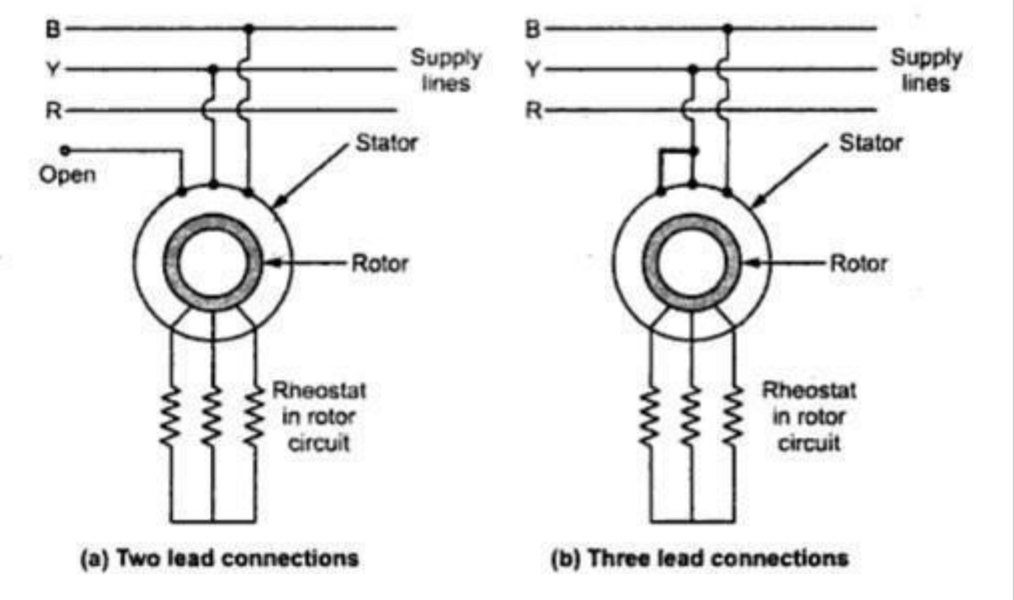


**Fig.4.5.3 Dynamic braking of induction motor**

In two lead connections, the braking torque is small while in three lead connections, The braking torque is high at high speeds. But in three lead connections there is possibility of inequality between the contact resistances in connections of two paralleled lines. This might reduce the braking torque and even may produce the motoring torque again. Hence inspite of low braking torque, two lead connections is preferred over three lead connections.

The torque-slip characteristics for motoring and braking operation is shown in the Fig. 4.5.4

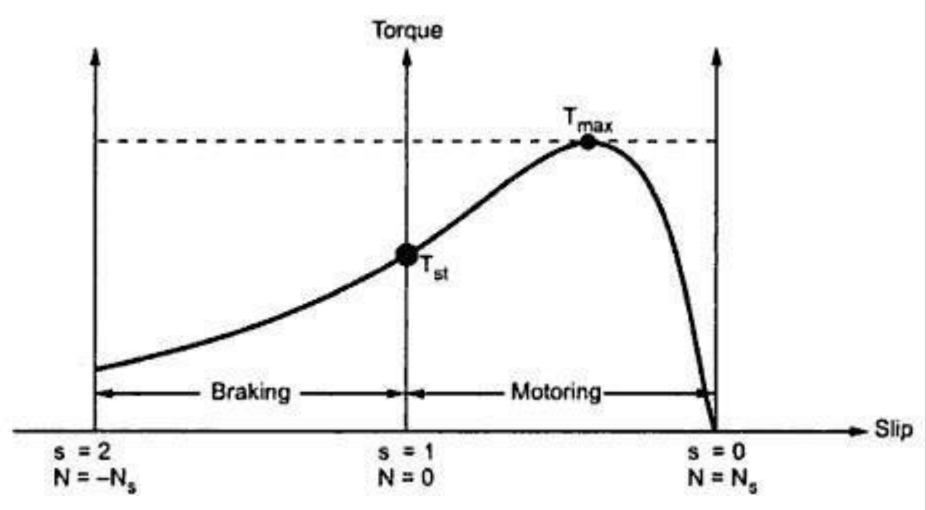


**Fig. 4.5.4 Torque-slip characteristics**

**Note** : Such a dynamic or rheostat braking is used mainly in crane hoist.

## PLUGGING

The reversal of direction of rotation of motor is the main principle in plugging of motor. In case of an induction motor, it can be quickly stopped by interchanging any two stator leads. Due to this, the direction of rotating magnetic field gets reversed suddenly. This produces a torque in the reverse direction and the motor tries to rotate in opposite direction. Effectively the brakes are applied to the motor. Thus during the plugging, the motor acts as a brake.

**Note** : The method can be applied to both squirrel cage as well as wound rotor induction motors.

One important aspect about plugging is production of very high heat in the rotor. While plugging, the load keeps on revolving and rotor absorbs kinetic energy from the revolving load, causing speed to reduce. The corresponding gross mechanical power is entirely dissipated as heat in the rotor. Similarly as stator is connected to supply, rotor continues to receive power from stator which also gets dissipated as heat in the rotor. This is shown in the Fig. 4.5.5

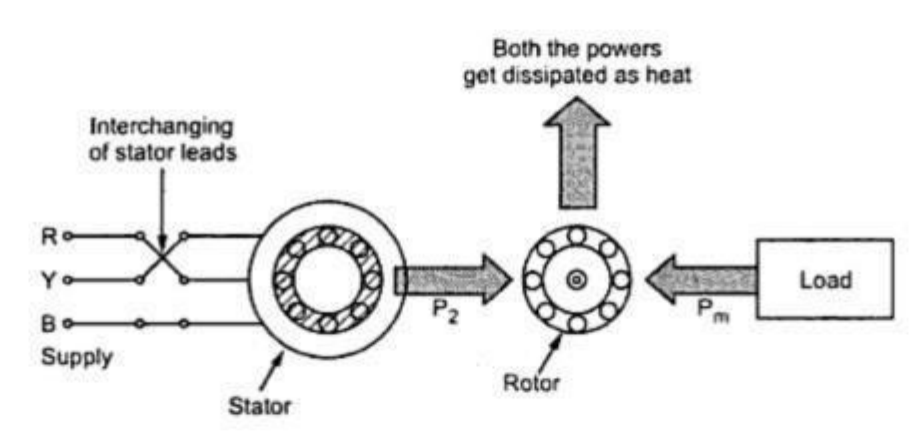


**Fig. 4.5.5 High rotor losses in plugging**

**Note** : The plugging produces very high $I^2R$ losses in the rotor which are more than those produced when rotor is locked.

The plugging should not be done frequently as due to high heat produced rotor may attain high temperature which can melt the rotor bars and even may over heat the stator as well.

**Note** : In some industrial applications where quick stop of motor and its load is necessary, the plugging method is used.