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Dynamic Breaking in Cage Induction Motor

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Abstract: In this paper, short circuit analysis, based on the electromagnetic transient program (EMTP), has been used to investigate the behavior of the DC reactor type FCL installed in an electrical distribution grid. System studies show that the DC reactor type FCL can not only limit the fault current to an acceptable value, but also can mitigate the voltage sag. A DC reactor type fault current limiter (FCL) in series with a downstream circuit breaker can be a solution to control fault current levels in electrical distribution systems. The Transient Recovery Voltage (TRV) could be damped in the presence of the DC reactor type FCL during fault clearing period, too. In order to integrate the DC reactor type FCL in to power grid, the performance of the DC reactor FCL should be studied.

Key words: 3Φ14 amps 4 pole MCB · RYB indicator:230V · on/off push button switch · 1Φ bridge rectifier (32 amps) · 440V 16 amp 3Φ NVC main contactor (NO and NC) · Off delay timer · Adden contactor · Copper wire · Working board

INTRODUCTION

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 shows two lead connections with a diode bridge for a d.c. dynamic breaking of an induction motor [1].

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 [2].

Rotor Induction Motors: Regenerative braking: The input power to a three phase induction motor is given by,

$$Pin = 3\ VphIphcos$$

Where, Φ = Angle between stator phase voltage and phase current

This Φ is less than 90o 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 3Φ line. The Φ becomes greater than 90o. 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 [3-5]. The arrangement for regenerative braking is shown in the Fig.

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.

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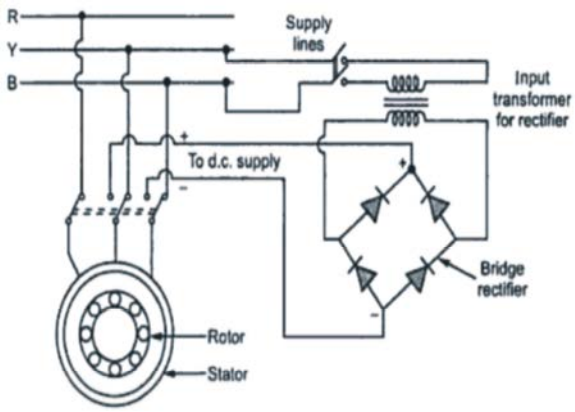

Fig. 1.1: D.C. dynamic braking

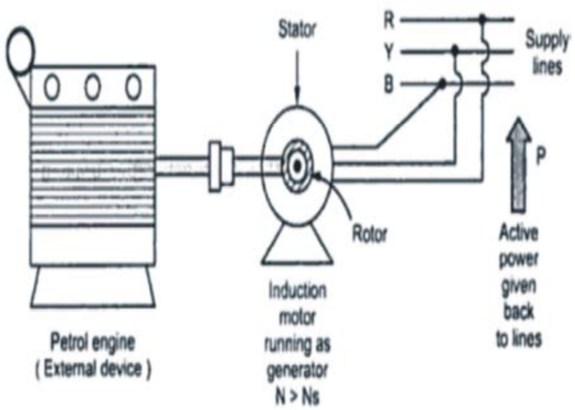

Fig. 2.1: Regenerative breaking

The active power delivered back is proportional to the slip above the synchronous speed [6]. The slip is negative for such operation.

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

Miniature Circuit Breaker:

- Lever- used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped).
- Actuator mechanism - forces the contacts together or apart.
- Contacts - Allow current when touching and break the current when moved apart.
- Terminals
- Bimetallic strip.
- Calibration screw-allows the manufacturer to precisely adjust the trip current of the device after assembly.
- Solenoid
- Arc divider/extinguisher

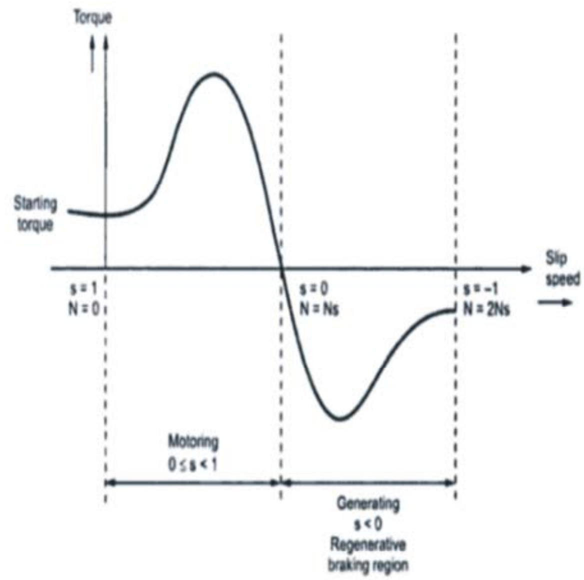

Fig. 3.1: Torque-slip characteristics for regenerative breaking

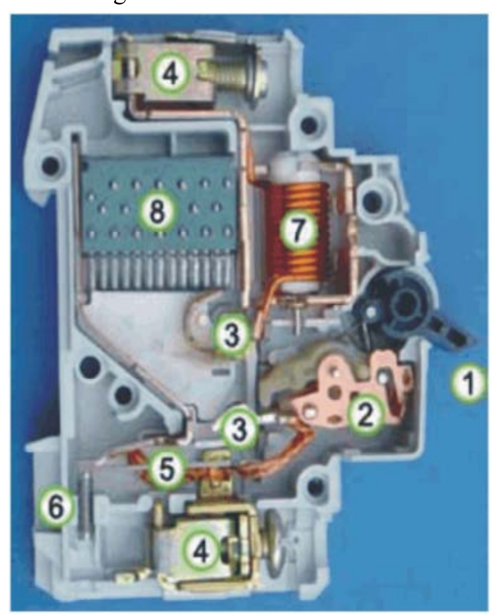

Fig 4.1: Miniature Circuit Breaker

Dynamic Breaking in Cage Motor: Working principle: An Induction motor can be brought to rest quickly by the dynamic braking principle, if during operation; the power supply to the stator winding is changed from A.C to D.C. The stator winding then develops a stationary magnetic field and the rotor conductors cut this magnetic field [7]. EMF is generated in the rotor and current flows through the rotor conductors as they are short circuited. The kinetic energy of rotation is then dissipated as copper loss and the motor stops quickly. A rectifier converts AC to DC for dynamic braking purpose.

Table 4.1: Technical data of circuit breaker

Rated voltage	Voltage up to 250VAC/48VDC
Rated current range	1A to 20A in increments of 0.5A
Interrupting capacity (maximum)	6 times standard current rating
Switching	Single Pole Single Throw snap-action
Endurance	Exceeds 100,000 trippings at 200% rated load
Dielectric strength	1500 VAC
Insulation resistance	100 mega ohm
Ambient temperature	-20…+70 °C (-4…+158 °F)

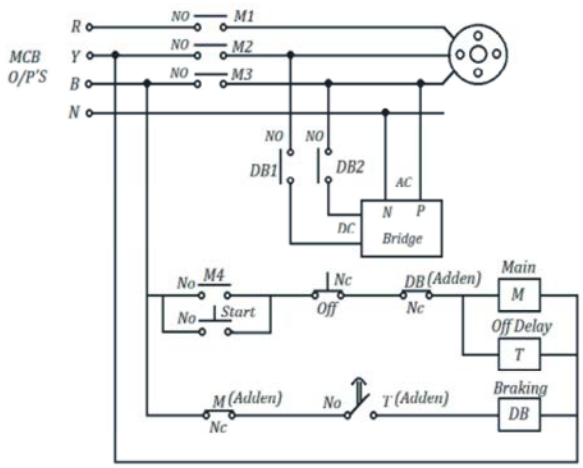

Fig. 5.1: Circuitdiagram

Operation of the Control Circuit: The fig show the power and control circuit diagram for dynamic braking of a squirrel cage induction motor. The d.c current to the motor stator is controlled by a variable resistance 'R'. The N.C contact A 'START' push button has been used in series with 'DB' coil for interlocking. This interlocking is to avoid simultaneous energization of contactor M and DB and thereby making of ac and dc supply.

- When 'START' button is pressed, the main contactor M gets energized. So, the sealing contact M1 closes.
- 'M2' is the electrical interlock to prevent energizing of dynamic braking contactor DB so long as main contactor M is energized is opened.
- 3Φ supply is going to the motor due to energization of contactor M. Simultaneously the off-Delay timer TR is energized and contact TR1 kept closed. The motor keeps running.

Braking:

- When 'stop' button is pressed, coil M is de-energized so main contacts [M-3]-[M-4]-[M-5] open. Disconnecting the stator winding form 3 phase supply.
- [M-2] closes instantly energizing the coil DB. As soon as DB is energized, contact [DB-1] opens and provides electrical interlock preventing energizing of coil M so long as DB is energized.
- Contact [DB-2]-[DB-3] close thereby applying DC to the stator winding from the rectifier.

Due to dynamic braking effect the motor stops quickly. Prolonged application of D.C to stator winding will damage the winding due to excessive current. To prevent this timing relay has been used. As soon as coil M is de-energized, braking beings. At the same instant [7-8], timing coil TR also is de-energized and the motor is now ready for next starting.

This circuit can be used where a smooth and fast stop is required. It also provides a stop without any tendency, to reverse such as is encountered in plug stop [9]. It produce less heat than plug-stop and hence is the better method of electric braking than plugging.

Advantages:

- The heat produced is less compared to the plugging.
- The energy dissipated in the rotor is not dependent on the magnitude of the D.C. current.
- The braking torque is proportional to the square of the D.C. current.
- Quick stopping of the motor is possible.
- The method can be used for wound rotor or squirrel cage.

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