Different Methods of Improvement in Speed, Power & Efficiency of Induction Motor: Review Paper

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Abstract : Induction motors are most commonly used motor in industrial motion control system. Earlier, the nature of industrial purpose of induction motor where off constant speed mechanical drives due to different speed control systems but the recent development in power electronics component have given the way for the development for the power electronics based variable speed induction motor drives replacing DC drives. This paper contains study of the different methodology of induction motor drives. The speed, power & efficiency of induction motor controlled by the process industrial motor drives using a variety of techniques. Among the number of methods of induction motor drive techniques, this paper explain the details about slip power recovery scheme by using multilevel inverters.

IndexTerms **- Induction motors drives, variable speed drives, Multilevel inverter, Slip power recovery scheme, Power factor, Harmonics.**

I. INTRODUCTION

An induction motor is an AC electric motor in which the magnetic field of the stator winding induces the magnetic flux in the rotor, intern produce the rotating torque on it. It has two important parts that is rotor and stator. Stationary part of induction motor is stator and it has winding on it and rotating part is a rotor. The rotor is connected to the mechanical load devices by using the shaft. According to input supply, induction motor are divided into two types, single and three phase induction motor. Out of both types of induction motors, three phase induction motor is a self starting motor. Single phase and three-phase IM motor working principle is same but slightly differs in controlling mechanism. Induction motor drives having control on speed have enormous use in the modern industry. More than 75% of the load today in the industry of any country having induction motor drives. As slip power easily available from slip rings, wound rotor induction motor drives have found enormous applications in modern industry, which can be used for best speed control. Slip power may be recovered from static converters rather than wasting power in the resistance. High performance induction motor drives application needs high efficiency, low cost and simple control circuitry for the complete speed range. Slip Power Recovery System is a variable speed etc. Slip Power Recovery System (SPRS) is a variable speed drives for three- phase induction motors. It recovers and delivers the rotor power from the motor to the grid. SPRS is attached to the rotor at changeover speed and the rotor resistance disconnected. The diode rectifier gives DC voltage by converting the rotor AC voltage. A line commutated inverter used for counter balancing of rectified rotor voltage. By controlling the "counter-balancing" of inverter voltage and the rotor current, hence rotor speed is regulated. The slip power collected at the slip rings is fed back to the grid through the inverter and step up transformer.

II. MULTILEVEL INVERTERS

Multilevel inverters are more powerful because of their high efficiency, low switching losses, high voltage operation capability and low output of Electro Magnetic Interference (EMI). Multilevel inverters are become more popular day by day in power applications, as ability to get the increasing demand of power rating and quality associated with reduced harmonic distortion and lower electromagnetic interference. As comparing with conventional two level inverter, multilevel inverters has several advantages that use high switching frequency pulse width modulation. The most attractive characteristics of multilevel inverters are as follows-

- They generate smaller common-mode voltage.
- They are operated through multiple switches instead of one switch.
- Multilevel inverters give higher power.
- They can operate with lower switching frequency.
- They can generate output voltages with low distortion and lower dv/dt and draw input current with very low distortion.
- It can be use as environmental friendly energies like wind and solar energy and convert them to AC.

Multilevel inverters is a source of high power generally used in industrial purpose. It can be use either sine waves or modified sine waves. Rather than by using one converter to convert an AC current into a DC current, a multilevel inverter uses a series of semiconductor power converters for generating higher voltage. While by using conventional inverter you would transfer energy with the flip of one switch but by using multilevel inverter you would have to flip several switches, each and every switch requiring a circuit. Because of these multiple switches and circuits, multilevel inverters are generally more expensive than conventional inverters.

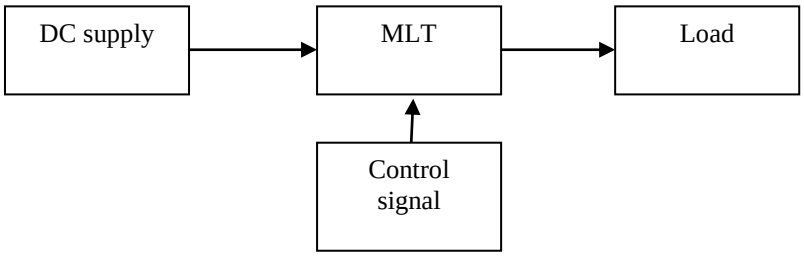

Fig-1 Block diagram of multilevel inverter

Multilevel inverters have an arrangement for power switching devices and capacitor voltage sources. Multilevel inverters are more suitable for high-voltage applications as of their ability to arrange output voltage waveforms with a better harmonic spectrum and attain higher voltages with a limited maximum device rating. There are three main types of multilevel inverters: diode clamped(neutral-clamped), capacitor-clamped (flying capacitors), and cascaded H-bridge inverter

III. METHODS

There are various method for speed control of induction motor, slip energy loss and to improve overall poor efficiency of system.

A. V/F CONTROL OR FREQUENCY CONTROL

Whenever induction motor coil connected to AC supply, an rotating magnetic field is produced and it which rotates at synchronous speed given by **Ns=120f/p** Where, N is speed of rotor of induction motor, Ns is synchronous speed and S is slip. In three phase induction motor, emf is induced in rotating magnetic field by induction same as that of transformer, which is given by E **or V=4.44φ KTF.** Now by modifying frequency, synchronous speed changes but with reduce in frequency, the flux will increase and this vary in flux value causes saturation of rotor and stator cores which further cause increase in no load current of the motor, its key to maintain flux ĭ constant and it is only achievable if we change voltage i.e. by reducing frequency, flux increases but at the same time if we decrease voltage, flux will also decease causing no vary in flux and hence it remains stable. Since by maintaining the ratio of V/F as constant in drive method, the name is given as V/F control method.

B. CONTROLLING SUPPLY VOLTAGE

The torque produced by running induction motor is depends on number of poles,[8] rotor resistance, induced EMF, etc. Since rotor induced emf **E2 ∝ V** So, **T ∝ sV2** From the equation given it is clear that by decreasing supply voltage torque also decreases. But for supplying the same load, torque must remain the same and it only possible if we raise the slip and if the slip rise the motor will run at reduced speed. The disadvantage of this method is small change in speed require large reduction in voltage and hence current drawn by motor is increased which cause overheating of induction motor that's why this motor is hardly used. Hence driving efficiency is reduced.

C. MULTIPLE STATOR WINDING METHOD

In multiple stator winding method of speed control of induction motor, the stator is provided by two separate winding. These two stator windings are electrically separated from each other. They are wound for two different pole numbers. The supply is provided to one winding only and hence speed control is possible. Because of unable to gain smooth speed control, this method is more expensive and less efficient as two different stator winding are required. This method of speed control can only be used in squirrel cage motor.

D. ADDING RHEOSTAT IN THE STATOR CIRCUIT

In this method of speed control of induction motor technique, rheostat is added in the stator circuit due to this voltage gets reduced. In three phase induction motor, torque produced is given by T ∝sV2. If there is decrease in supply voltage, torque also decreases. But for given the same load, the torque must remain the same and it is only possible if there is raise the slip and if the slip raise motor will run reduced speed.

E. ADDING EXTERNAL RESISTANCE ON ROTOR SIDE

In this method of speed control of induction motor, external resistance are connected on rotor side. If there is increase in rotor resistance, torque decreases. So if increase in slip, there will further results in reduce in rotor speed. Thus by attaching additional resistance in rotor circuit, speed of three phase induction motor is reduced. The major advantage of the method is that with addition of external resistance, increase starting torque but this method of speed control of induction motors also suffers from some disadvantages like, the speed above the normal value is not possible, large speed change requires large value of resistance and if such large value of resistance is added in the circuit it will cause large copper loss and hence efficiency reduced, presence of resistance causes more losses, this method cannot be used for squirrel cage induction motor.

F. CASCADE CONTROL METHOD

In this method of speed control of induction motor, the two three phase induction motor are connected on common shaft and hence called cascaded motor. That motors are called are main motor and auxiliary motor. Three phase supply is provided to the stator of the main motor while the auxiliary motor is derived at a slip frequency from the slip ring of main motor.

G. INJECTING SLIP FREQUENCY EMF INTO ROTOR SIDE

In this method of speed control of induction motor, speed control is done by connecting resistance in rotor circuit, some part of power called, the slip power is lost as I^2R losses.Because of that the efficiency of three phase induction motor is reduced in this method of speed control. This slip power loss can be recovered and given back in order to improve the overall efficiency of three phase induction motor and this scheme of recovering the power is called slip power recovery scheme and this is done by connecting an external source of emf of slip frequency to the rotor circuit. The injected emf can either oppose the rotor induced emf or aids the rotor induced emf. If it oppose the rotor induced emf, the total rotor resistance increases and hence speed decreases and if the injected emf aids the main rotor emf the total resistance decreases and hence speed increases. Therefore by injecting induced emf in rotor circuit the speed can be easily controlled. Wide range of speed control is possible above normal or below normal speeds in this type of speed control of three phase induction motor, this is the main advantages.

IV. PROPOSED WORK

Slip Energy Recovery is also one of the methods of controlling the speed of an Induction motor. This method is also known as Static Scherbius Drive. In the rotor resistance control method, the slip power in the rotor circuit is wasted as I^2 R losses during the low-speed operation. The efficiency is also lowered. The slip power can be recovered from the rotor circuit and injected back to the AC source and utilize it outside the motor. Thus, the overall efficiency of the drive system can be increased. Figure shows the connection and method of recovering the slip energy and power recovery from an Induction Motor.

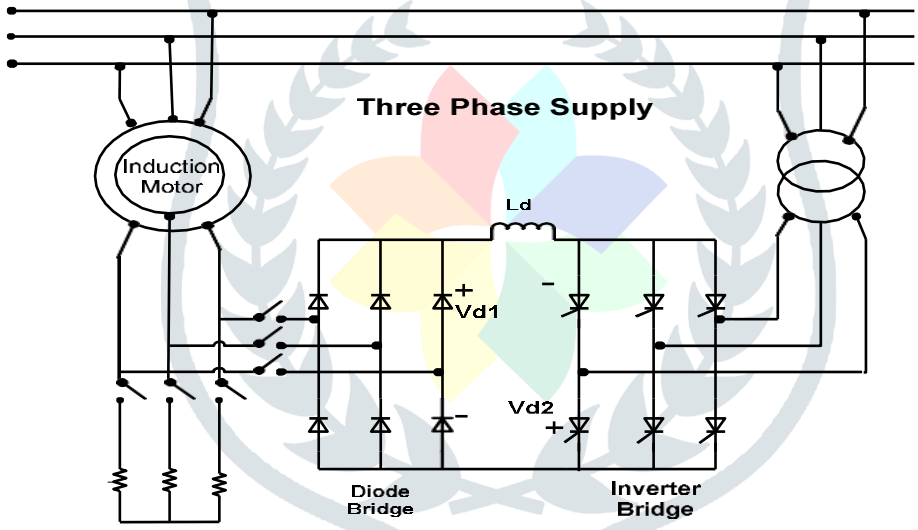

Fig-2 schematic diagram of slip power recovery scheme

The basic principle of the slip power recovery is to attached an external source of the EMF of the slip frequency of the rotor circuit. The slip energy recovery method provides the speed control of a slip ring induction motor below its synchronous speed. A portion of rotor AC power is converted into DC by a diode bridge.

The smoothing reactor is provided for smoothen the rectified current. Then output of the rectifier is connected to the DC terminals of the inverter. The inverter inverts the DC power to the AC power and feeds it back to the AC source. The inverter is a controlled rectifier operated within inversion mode.

This method of speed control is used in large power applications where the variation of speed over a wide range involves a large amount of slip power.

A portion of rotor AC source converted into DC source by Diode Bridge. The controlled rectifier working as inverter, the DC source convert back to AC source and feed at back to source of power supply can be controlled by controlling inverter counter emf (Vd2) which is control by firing angle. This DC link inductor is providing to reduce ripple in DC link current (Id). Since, slip power feedback to source, unlike rotor resistance control where it is wasted in resistor so, drive has high efficiency.

V. CONCLUSION

The various techniques which are using in this paper to overcome one or many problems. Each techniques unique and having its advantages and disadvantages with respect to power quality, complexity cost, size an application its has been observed that multilevel inverters generate output voltage with very low distortion with lower switching frequency compared to conventional

invertors hence instead of conventional inverters, use of higher order multilevel invertors is suggest for the performance improvement of the slip power recovery scheme.

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