Speed Control of Three Phase Induction Motor by V/F Method for Batching Motion System

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Abstract— A three phase induction motor is basically a constant speed motor so it's somewhat difficult to control its speed. The speed control of induction motor is done at the cost of decrease in efficiency and low electrical power factor. Normally the variable frequency drive is used for the speed for the speed control of three phase induction motor for the various applications. Also variable frequency Drive is used for power saving when the load on the motor is less. This work proposes a new concept of using variable frequency drive for controlling the speed of the batching motor by using variable frequency drive and three phase induction motor. The paper is depend upon the batching system which is one application of weaving machine which rolls the cloth with specific tension so that it should neither slacken the cloth nor tightened it by replacing DC system with the AC system.. The motion of this loom is controlled by induction motor where in the AC drive is used to run the induction motor which rotates the drum through pulley.

Key words: AC Drive, Batching System, Counter Meter, Encoder, Gear Box, Encoder, Three Phase Induction Motor

I. INTRODUCTION

Induction motors are widely used in many residential, commercial, industrial and utility applications. This is because the motor have low manufacturing cost, wide speed range, high efficiency and robustness. However, the use of induction motors also has its disadvantages, these lie mostly in its difficult controllability, due to its complex mathematical model, its nonlinear behaviour during saturation effect and the electrical parameter oscillation which depends on the physical influence of the temperature. Induction motor is essentially a constant-speed motor. Its speed of rotation is determined by the synchronous speed. In many industrial applications wide variation in motor speed is required. This can be achieved by varying the stator frequency of the motor thereby varying the synchronous speed. Therefore, Motor control is a significant. There are various control techniques available for the speed control of induction motor, like changing stator poles technique, torque vector control and several others.

Previously, the variable speed drives had various limitations such as poor efficiencies, larger space, low speed and etc. the power electronics transformed the variable speed drive into a smaller size, high efficiency and high reliability. The development of speed control system using frequency control has been designed by combinations of PWM control circuit, driver circuit and H-bridge inverter which makes the system simple, robust and compact open loop PWM controller circuit to control single phase induction motor and single phase induction motor can be driven to variable speed and frequency. But it is desirable to replace the single phase induction motor drives by three phase induction motor drives in residential appliances, farming and low power industrial applications .Induction motors have performed the main part of many speed control systems and found usage in several industrial applications. The advances in microprocessor and power electronics gives permission to implement modern techniques for induction machines such as field oriented control. Slip frequency control. Then a modern speed Ac machine system is equipped with adjustable frequency drive for speed control of electric machine. The speed of machine of machine is controlled by converting fixed voltage and frequency to adjustable values on machine side. The three phase inverter circuit changes the DC input voltage to three phase variable frequency variable voltage output. The three phase Ac is rectified into DC and then filtered to minimize the ripple current. This controlled dc is converted into controlled pulses by means of voltage to frequency converter. These controlled pulses are fed to Inverter Bridge for producing variable voltage variable frequency output. This output is fed to induction motor for controlling it's speed.

II. DC SYSTEM

At the most basic level, electric motors exist to convert electrical energy into mechanical energy. This is done by way of two interacting magnetic fields one stationary, and another attached to a part that can move. A number of types of electric motors exist, but most beam bots use DC motors in some form or another. DC motors have the potential for very high torque capabilities (although this is generally a function of the physical size of the motor), are easy to miniaturize, and can be "throttled" via adjusting their supply voltage. DC motors are also not only the simplest, but the oldest electric motors. The motor used is permanent magnet DC motor. The motor used is of very small rating but this motor is used to rotate gear and total weight of fabric is taken by gear.

A. Drawbacks

It require higher cost, its capacity is lower that is it rolls the cloth up to 1000 meter. It has very complicated circuitry such that it requires transformer, rectifier, relay, switches, fuse and potentiometer and there is no protection and no indication for thermal alarm and over current. It requires specially designed combination of motor and gear box which is very expensive. As motor and gear box is not separate, if any problem arises in motor or in gear box, the whole system has to be changed and for this the batching system has to depend upon OEM (Original Equipment Manufacturer) and it requires one to two months' time period from the date of delivery, so there will be a very much loss of production in the industry and this dc system is very costly.

III. AC SYSTEM

The above all drawbacks can be removed by replacing the DC system by AC system in which three phase squirrel cage induction motor is used. Induction motors are considered to be among the most reliable electrical machines. They carry out their function for many years with reduced maintenance and adapt themselves to different performances according to the requirements of both production as well as service applications. These motors find their application in the most different industrial sectors, such as food, chemical, metallurgical industries, paper factories or water treatment and extractive systems. The applications concern the equipment with machine components running at fixed or variable speed such as lifting systems as lifts or good hoists, transporting systems as conveyors, ventilation and air conditioning installations, without forgetting the commonest use with pumps and compressors.

IV. AC DRIVES

AC drives receive AC power and convert it to an adjustable frequency, adjustable voltage output for controlling motor operation. The Two common inverter types are the variable voltage inverter (VVI), current source inverter (CSI).

AC drives convert AC to DC, and then through various switching techniques invert the DC into a variable voltage, variable frequency output.

The drive consists of following components:

1) Converter
2) DC Link
3) Control logic generation using microcontroller, DSP, etc.

A. Converter

Two converters are required, one as rectifier and another as inverter. The converters are of two types:

1) Variable Voltage Converter
2) Current source Converter

B. Converter

The converter section consists of a fixed diode bridge rectifier which converts the three-phase power supply to a DC voltage. The rectified DC value is approximately 1.35 times the line-to-line value of the supply voltage.

C. DC Link:

The L1 choke and C1 capacitor(s) make up the DC link section and smooth the converted DC voltage.

D. Control Logic & Inverter

Output voltage and frequency to the motor are controlled by the control logic and inverter section. The inverter section consists of six switching devices. Various devices can be used such as thyristors, bipolar transistors, MOSFETS and IGBTs. The following schematic shows an inverter that utilizes IGBTs. The control logic uses a microprocessor to switch the IGBTs on and off providing a variable voltage and frequency to the

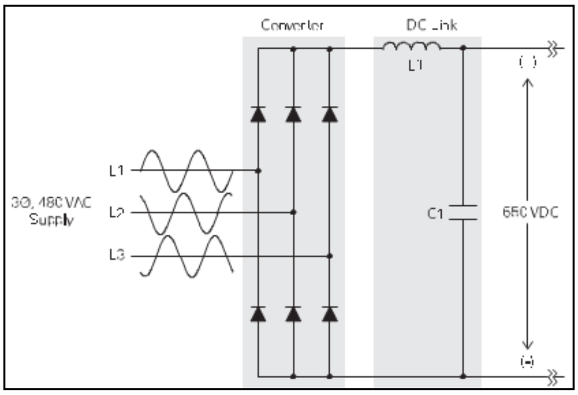

Fig. 1: Converter & DC Link Circuit

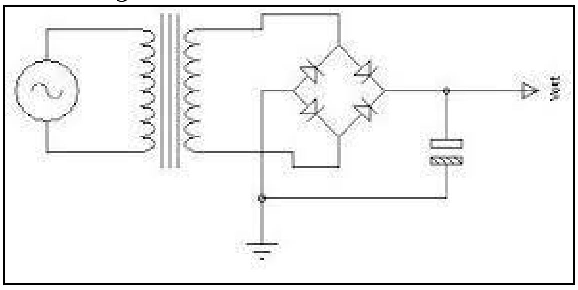

Fig. 2: Inverter Circuit

V. VARIABLE VOLTAGE CONVERTER

The variable voltage converter uses an SCR converter bridge to convert the incoming AC voltage into DC. The SCRs provide a means of controlling the value of the rectified DC voltage from 0 to approximately 600 V DC. The inverter section consists of six switching devices. Various devices can be used such as thyristors, bipolar transistors, MOSFETS, and IGBTs.

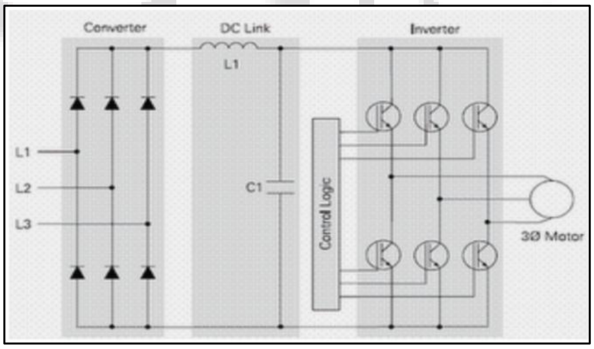

Fig: 3: Variable Voltage Converter

The following schematic shows an inverter that utilizes bipolar transistors.

Control logic is used to switch the transistors on and off providing a variable voltage and frequency to the motor. This type of switching is often referred to as six-step because it takes six 60° steps to complete one 360° cycle. Although the motor prefers a smooth sine wave, a six-step output can be satisfactorily used.

The main disadvantage is torque pulsation which occurs each time a switching device, such as a bipolar transistor, is switched. The pulsations can be noticeable at low speeds as there are speed variations in the motor. These speed variations are sometimes referred to as cogging. The non-sinusoidal current waveform causes extra heating in the motor requiring a motor derating.

VI. CURRENT SOURCE CONVERTER

The current source converter uses an SCR input to produce a variable voltage DC link. The inverter section also uses SCRs for switching the output to the motor. The current source converter controls the current in the motor. The motor must be carefully matched to the drive. Current spikes, caused by switching, can be seen in the output. At low speeds current pulses can causes the motor to cog.

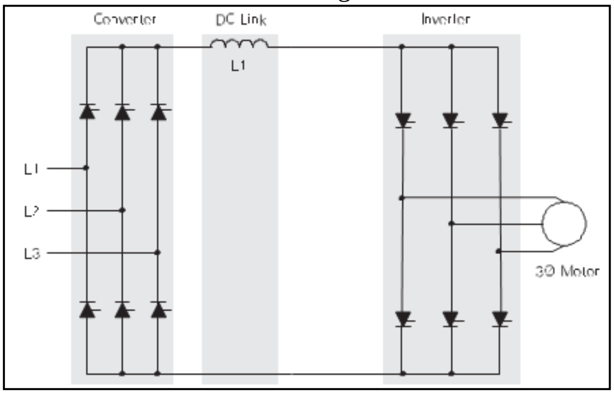

Fig. 4:

VII. PULSE WIDTH MODULATION DRIVES

A basic PWM drive consist of a converter, DC link, control logic and inverter. Siemens MICROMASTER and MASTERDRIVE are like PWM drives which provide more sinusoidal current output to control voltage and frequency applied to the motor. A PWM drive is more efficient and typically provides higher level of performance. It can adjust the speed of motor by changing the frequency applied to the motor. Motor speed can adjust by adjusting the number of poles of motor, but this is physical change to the motor. It requires rewinding and result in step change in speed. A drive provides many different frequency outputs.

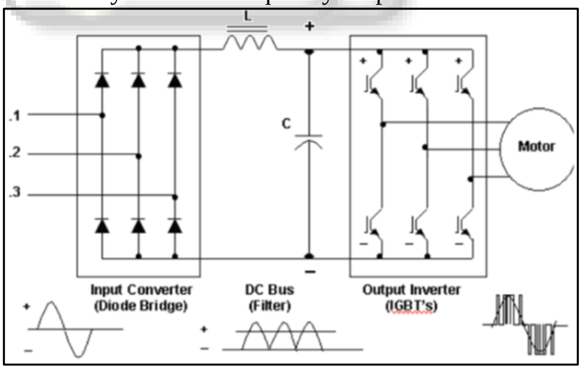

Fig. 5: PWM Inverter block diagram

VIII. IR COMPENSATION

When IR compensation enabled, it provides an extra voltage boost to the motor at low speed and It sets the IR compensation voltage used for 0 Hz. IR compensation factor is required when it is required to start the motor at loaded condition when any fault arises on motor and for that higher torque is required and this can be done by IR compensation which boost up the voltage and torque increases and it is necessary to keep the IR compensation as low as possible to prevent overheating.

IX. METHODOLOGY

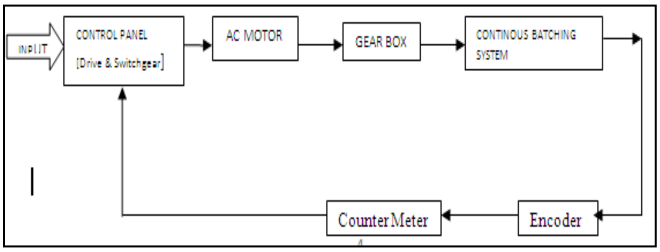

Fig. 6: Batching motion system

X. SHAFT ENCODER & COUNTER METER

– The shaft encoder is of Hengster make 10-30 VDC.
– The counter meter is of Autonics make 0- 230 V AC.

A. *Operation*

The shaft encoder connected on the motor shaft counts the speed of motor and converts the counted speed into digital pulses and giving this feedback to counter meter where set speed of motor is already set. If input received by counter meter is not match with the set speed, then it generates the voltage within the range 0 – 10 Volts and give this feed back to the drive then drive adjust the V/f to maintain the constant speed of the motor.

DC motor and AC motor are simulated in MATLAB Simulink.

XI. CONCLUSION

In the project, the existing DC system is replaced with the AC system. The basic requirements of the existing DC system are fulfilled as under:

a. The speed achieved with AC system is 7 rpm which was also possible with the DC system.
b. In PWM control method, as per requirement torque and speed can be maintained by maintaining voltage and frequency ratio.
c. Efficiency of designed of Induction motor is better as compared to existing DC system at required torque.
d. This work is successfully installed at project site the engineers and expert staff of industry are quite satisfied with the performance of proposed and implemented drive.

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