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Speed Monitoring and Control Of Three Phase Induction Motor for Batching Motion System of Textile Industry

Shilpa A. Lingawar*, Saurabh M. Ingale**
*(Department of Electrical Engineering, Amravati University, Amravati (MS), INDIA)
** (Department of Electrical Engineering, Amravati University, Amravati (MS), INDIA)

ABSTRACT
Normally the Variable Frequency Drive is used for the Speed control of the 3 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 feedback is provided to the drive for controlling speed of motor. The speed reference generation for the Variable Frequency Drive formulated on the startup sequence of the main Motor Drive and Load on the Main Motor. The reference generated by the feedback system, the speed of motor is controlled within the limit. This work not only helps the industry to reduce the breakdowns as well as reduce the maintenance cost, labor cost and it increases the capacity of the batching role.
The work is batching system for looms in which existing DC system is replaced with AC system in textile industry.
In this work induction motor is used where power is supplied to the rotor by means of electromagnetic induction. ABB's ACS550 drive incorporates built in filter and breaking chopper. The batching System which is a part of weaving machine which rolls the cloth with specific tension such that it should neither slacken the cloth nor tighten it. 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 pulleys and sprocket mechanism.
Keywords- Batching Motion System, Counter Meter, Encoder, Induction Motor, Variable Frequency Drive

I. Introduction

The batching system is the system which continuously rolls the cloth of weaving machine so that it should neither slacken the cloth nor tighten it over the cloth drum. The existing system in industry is DC system where permanent magnet shunt motor is used. But the motor is coupled with gear box and is specially designed for the system by Original Equipment Manufacturer.

Drawbacks
1)If any fault arises in motor or in gear box, the whole system has to be replaced. The time for replacement is more and one/ two months is required for getting the motor from original equipment manufacturer from the date of delivery. Also, there is loss of production in the industry.
1)The capacity of role is up to 1000 meter. The capacity of role can be increased by replacing the existing DC system by AC system of approximately same capacity. For the existing system the number of roles and labor for replacement of role is more and increases in case of the fault in the system.
2)The DC motor used in industry is not equipped with a DC drive. The fine tuning in speed of the motor is required depending on the type of cloth to be rolled. This is done by conventional method using resistance control. Also, there is no indication of thermal alarm, over currents. If any fault arises, operator has to check the whole system so that more time is required for isolation of fault.

The Ac drive is most commonly used in industrial purposes as they provide wide variety of speed range[1]. The control methods of induction motor are more complex and more expensive than DC motors[2]. AC drive has various limitations such as poor efficiency, larger space but power electronics devices replaced the variable frequency drive with smaller size, high efficiency[3]. The advances in power electronics helps to implement modern techniques for induction machines[4]. The paper explains the induction motor is equipped with AC drive for speed control of electric machine[5]. Induction motors can be used for high performance applications[6]. The use and application of VFD in various areas as residential, commercial areas are described[7,8]. The smooth speed control can be obtained by using the control logic for VFD[9]. It is desirable to replace the single phase induction motor drive with three phase in farming and low power industrial applications[10].

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 beambots 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 shunt motor. The motor is of very small rating but this motor is used only to rotate batching role and total weight of the fabric is taken up by role and gear box. As motor and gear box are not separate, if any fault arises in motor or gear box, the total system has to be replaced and more time is required for replacement. Dimmerstat is used for speed control of motor or by connecting rheostat in armature circuit or field circuit, speed control can be achieved. The ratings of DC motor are

180 V,1500 rpm, 0.3 N-m, 0.8 Amp

The speed of the motor was reduced to 7 rpm by using gear ratio.

2.1 Gear Ratio

The gear ratio is calculated as

$$I = \frac{\text{speed at output shaft of motor}}{\text{Required speed}}$$

$$I = \frac{1500}{7}$$

$$I = 200$$

Gear ratio is selected as 200:1

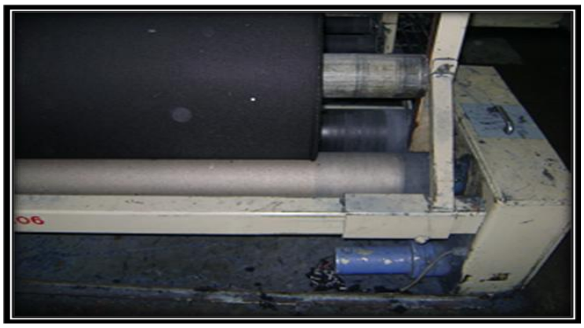


Fig.Batching System with DC Motor

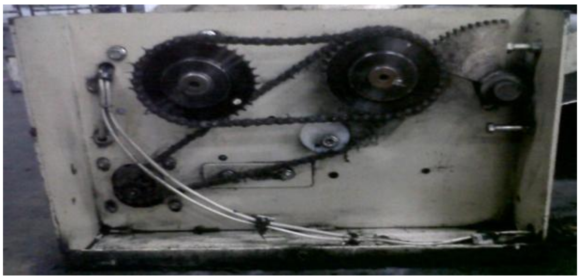


Fig. Gear Mechanism of Batching System

III. AC System

The DC System is replaced with AC system by using three phase induction motor.

The ratings of motor are

0.25 KW, 400 Volts, 0.78 Amp, 1380 rpm.

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 Drive

AC drives receive AC power and convert it to an adjustable frequency, adjustable voltage output for controlling motor operation. A typical inverter receives 480 VAC, three-phase, 60 Hz input power and in turn provides the proper voltage and frequency for a given speed to the motor. The three 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:

[i] Converter

[ii] DC Link

[iii]Control logic generation using microcontroller, DSP, etc

[i] Converter:

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

[i] Variable Voltage Converter

[ii] Current source Converter

[i] 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. The rectified DC value is approximately 650 VDC for a 480 VAC supply.

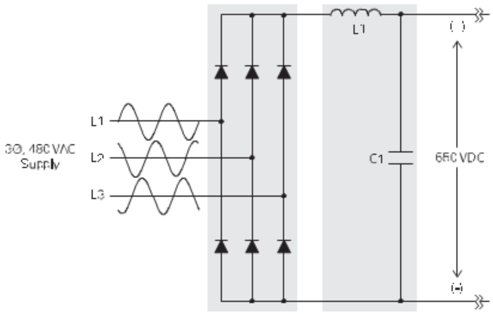


Fig Converter and Dc link Circuit

The converter section consists of a fixed diode bridge rectifier which converts the three-phase power supply to a DC voltage. The L1 choke and C1 capacitor(s) smooth the converted DC voltage. The rectified DC value is approximately 1.35 times the line-to-line value of the supply voltage. The rectified DC value is approximately 650 VDC for a 480 VAC supply.

[ii] DC Link:

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

[iii] Control Logic and 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 motor.

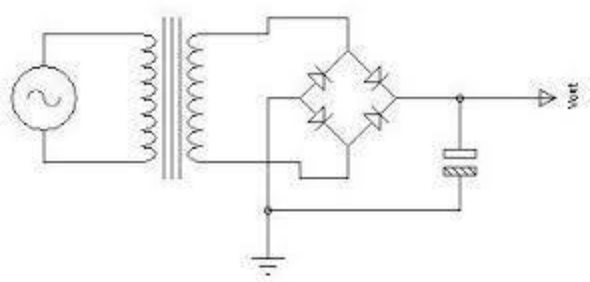


Fig. Inverter Circuit

4.1Variable 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.

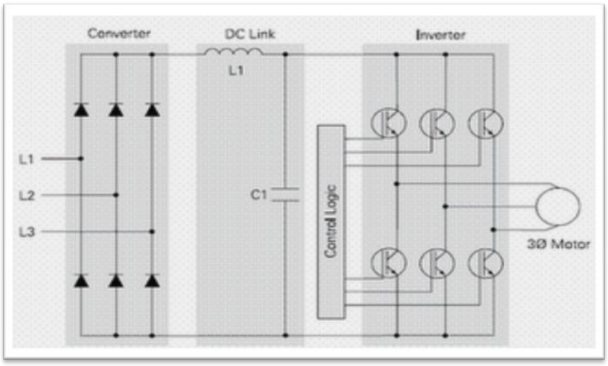


Fig. Variable Voltage Converter

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.

4.2Current 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.

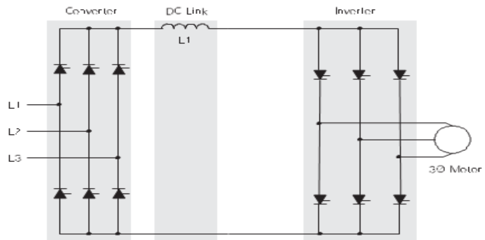


Fig. Current Source Converter

4.3 IR Compensation

When IR compensation enabled, provides an extra voltage boost to the motor at low speed.
It sets the IR compensation voltage used for 0 Hz. Keep the IR compensation as low as possible to prevent overheating.

Table. IR Compensation

KW	3	7.5	15	37	132
IR Compensation Voltage	18	15	12	8	3

V. V/f Speed Control of Induction Motor

The torque developed by motor is directly proportional to the magnetic field produced by stator. So the voltage applied to the stator is directly proportional to the product of stator flux and angular velocity.
stator voltage(V) α [Stator Flux (Ø)] * [Angular Velocity (ω)]

$$V = Ø * 2\Pi f$$

$$Ø = V/ 2\Pi f$$

This makes constant V/F is the most common speed control of an induction motor. V/f method is the variable frequency drive motor control strategy in which the voltage and frequency applied to the motor are simultaneously adjusted to maintain a relatively a constant value of ratio V/f. This method is very easy and simple to implement.It provides the motor performance that is adequate for most applications.If we change particular frequency, then speed is maintained constant whatever the load connected. So, V/f method is used to maintain linear speed.

VI. Methodology

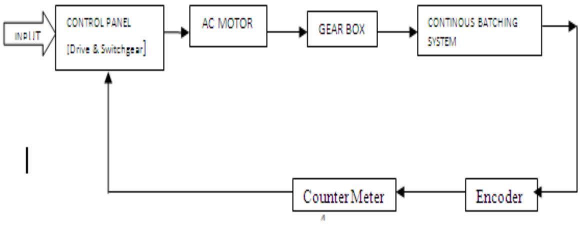


Fig. Batching Motion System

VII. Simulation and Experimental Results

7.1 Gear Ratio

The gear ratio is calculated as

$$I = \frac{\text{speed at output shaft of motor}}{\text{Required speed}}$$

$$I = \frac{1500}{7}$$

$$I = 200$$

Gear ratio is selected as 200:1

7.2 Sprocket Mechanism

As out put speed was 7 rpm which was required to transfer on the batching role was obtained by using chain sprocket (pulley**)** .

chain sprocket which is required can be calculated are as follows

$$\frac{N1}{N2} = \frac{T1}{T2}$$

Where,

N_1 – Input speed at shaft
N_2 - Output speed at shaft
T_1 – Number of teeths (Drive)
T_2 – Number of teeths (Driven)
By knowing any three parameters, we calculate the unknown parameter.

7.3 AC System

The DC system is replaced by AC system by using three phase slip ring induction motor.
The ratings of motor are
0.25 KW, 400 Volts, 0.78 Amp, 1380 rpm.
The torque is calculated as

$$T = \frac{9.55*0.25*1000}{1380}$$

$$T = 1.73 \text{ Nm}$$

Available gear ratios are 100:1, 150:1, 200:1, 300:1, 400:1
Gear ratio used as again 200:1to reduce the motor speed up to 7 rpm.

7.4 Shaft Encoder and Counter meter

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

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 feed back 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.

7.5 DC Motor Simulation

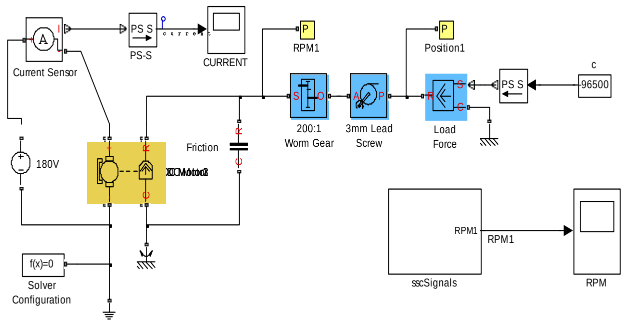
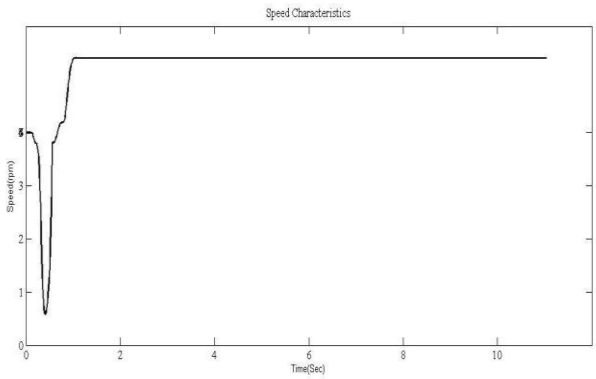


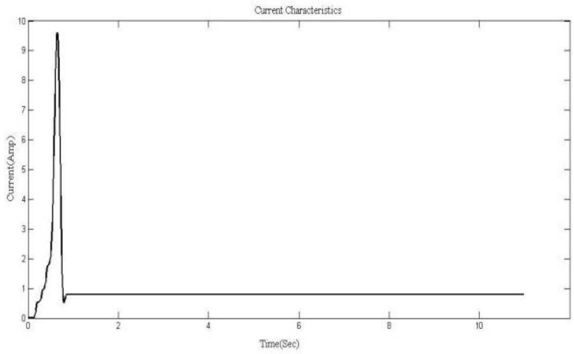
Fig. DC Motor Model

Characteristics of DC Motor Model

Speed Characteristics of DC Motor Model



Current Characteristics of DC Motor Model



7.6 AC Motor Simulation

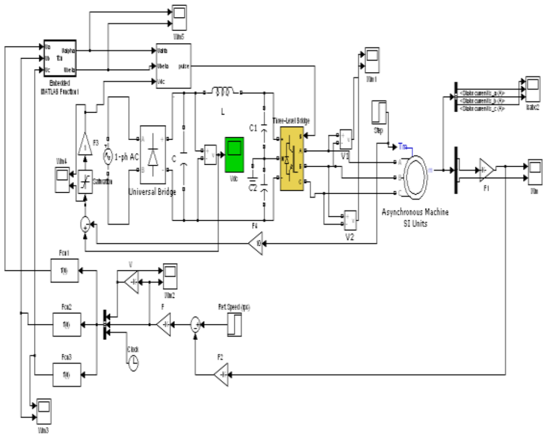


Fig.AC Motor Model

Characteristics of AC Motor

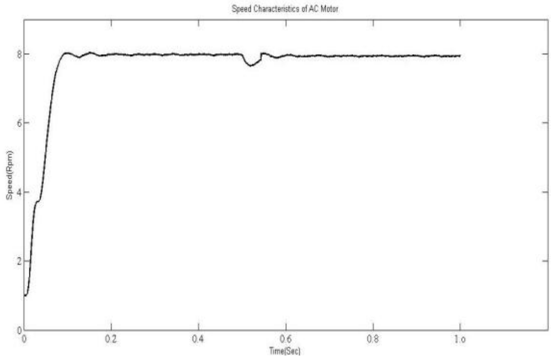


Fig. Speed Characteristics of AC Motor

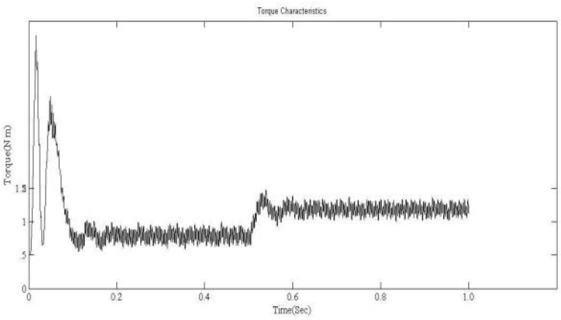


Fig. Torque Characteristics of AC Motor

VIII. Implemented Work

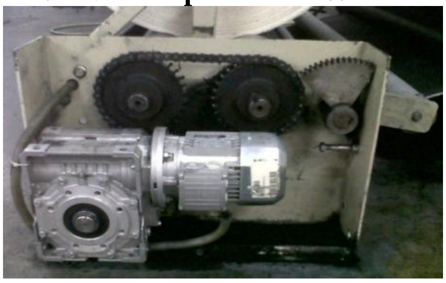


Fig. Batching System Employed with AC Motor

Fig. Control Panel of Drive

Fig. Drive Circuitry

IX. 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:

1. The speed achieved with AC system is 7 rpm which was also possible with the DC system.
2. In PWM control method, as per requirement torque and speed can be maintained by maintaining voltage and frequency ratio.
3. Efficiency of designed of Induction motor is better as compared to existing DC system at required torque.
4. 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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