Control and Automation of Industrial Machines using Electrical Drives

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Abstract

The main focus of this paper is on the control and automation of various machines. Automation is technique that allows machines and various parts of industries to move by itself in order to provide various benefits to the industry like increased efficiency, reduce cost, energy saving, increased productivity etc. Here in industrial automation, we use PLC, HMI, Sensors and various types of drives. The most commonly used prime mover in industry is electric motors. In many applications, the motors are provided with control equipment by which there characteristics can be adjust and their operating conditions can be varied with respect to various load requirements. The combination of electric motor, energy transmitting shaft and control equipment constitute electric drive. Drives are used to control the speed of various types of motors present in the machine. In this paper automation and control of various machines using various types of drives such as VFD, servo drive, AC and DC drive are discussed. Then the amount of energy saved in industries using electric drives is calculated.

Keywords-Programmable Logic Controller (PLC),Human Machine Interface(HMI), Servo Drive, Variable Frequency drive(VFD),Adjustable Speed Drive(ASD).

Introduction

The word ‘automation’ derived from two words auto and motion which means motion that is automatically controlled. Therefore automation is technique that allows machines and various parts of industries to move by itself. In other words automation is a set of various controlled strategies that operate the machine with little human interference, which also results in improved performance of machine. Industrial automation is the use of control such as computers to control industrial machinery and processes, replacing human operators. It deals with the optimization of energy-efficient drive systems by precise measurement and control technologies. Nowadays energy efficiency in industrial processes are becoming more and more relevant. Semiconductor companies are offering 8-bit micro-controller applications to reduce energy consumption and thus increase efficiency. As shown in Figure 1, in industrial automation we use PLC, HMI, sensors, SCADA system and various types of electric drives.

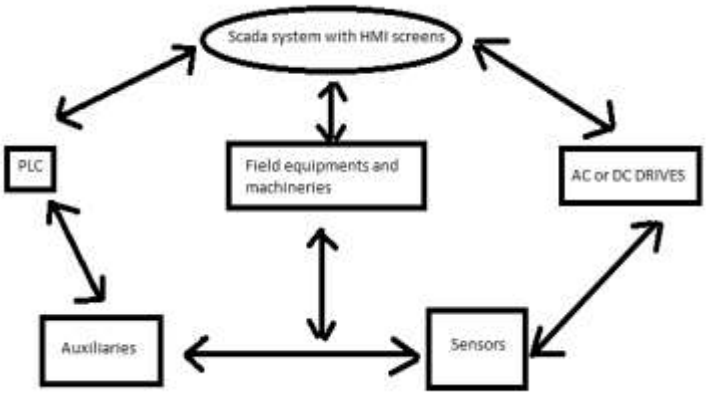

Figure 1: Various Component of Industrial Automation

Electric Drives

Drives in electrical engineering are used to control the speed of motor that may be AC or DC. Many applications require variable speed motors in industries; therefore drives have become an integral part of industries. Electric Drive controls both voltage and frequency input to the motor. If only voltage is controlled by drive, then speed of motor is controlled. If both voltage and frequency are controlled by drive then torque of motor is controlled.

Figure 2 shows the operation of drive. Drive consists of power processor, controller or control unit, motor and power supply. Speed of motor is controlled by controlling the voltage input to motor. Power processor is an electronic converter which controls the power flow to motor to obtain variable speed. AC-DC, AC-AC, DC-AC and DC-DC converters are some electronic converters used in drives. Sensor senses the speed of motor and sends signal to controller. Controller compares measured speed and reference speed, then accordingly to difference between the two, it controls the power output of power processor. Then this power processor sends controlled output voltage to motor. Microcontroller and microprocessor are most commonly used controllers.

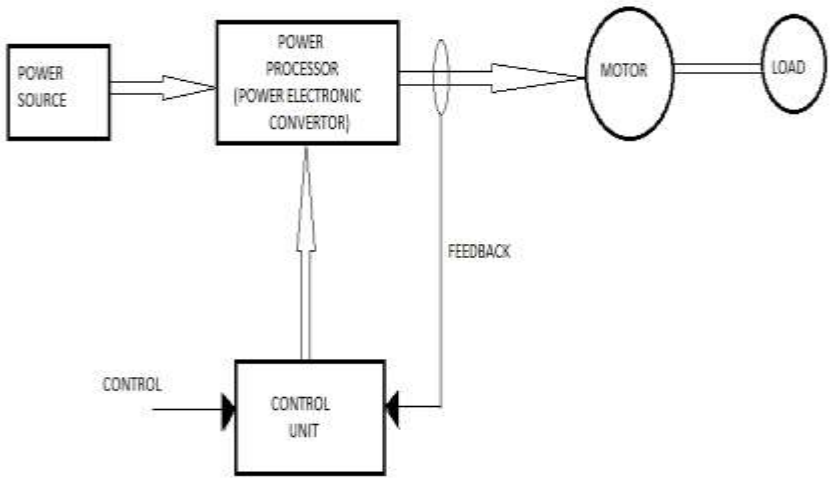

Figure 2: Block diagram of operation of Drive

Classification of Drives

1. AC Drives- AC drives are further divided into
   a) VFD (Variable Frequency Drive).
   b) VSD (Variable Speed Drive).
   c) ASD (Adjustable Speed Drive).
2. DC Drives
3. Servo Drives
4. Stepper motor drives

Main Objective of the Work

In any industry three important operating expenses are often found to be energy, labour and raw material. If we relate to the manageability of cost or potential cost savings in each of above components then energy would invariably be the top ranker. Energy constitutes a major area for cost reductions, since cost of energy is increasing day by .If this energy consumption is reduced, this will reduce total production cost which will prove to be efficient for industry. In this paper, we use various types of electric drives in order to control the working of electric motor and save the energy and thus increasing the overall efficiency of the machine.

Methodology Adopted

This has been done by two approaches i.e. hardware and software approaches. In hardware approach, a hardware circuit is fabricated in order to provide automated control of electrical machine. It includes Servo Drives, normal VFD's etc on various electrical machines in order to control the working of the motor in the machine. In Software approach, programming of drives is done on drives.

Automation of Various Machines Using Drives

Automation of Cylindrical Grinder

Here in figure 3, the entire working of the cylindrical grinder is controlled. In cylindrical grinding the major problem is in synchronising the speed of grinding wheel and the job piece, to control the movement of slide, on which cylindrical grinder is placed, to control the flow of coolant and lubricant. Various types of motors like servo motor, induction motor are used in the machine. The speed of servo motor is controlled by servo drive.(RYS 201 S 3-V V T 2) which is mounted with the servo motor , as servo motor is a rotary actuator which allows precise control of angular position..speed of induction motor is controlled by using Variable Frequency Drive ACS 335-03E-08A8-4+J404+).

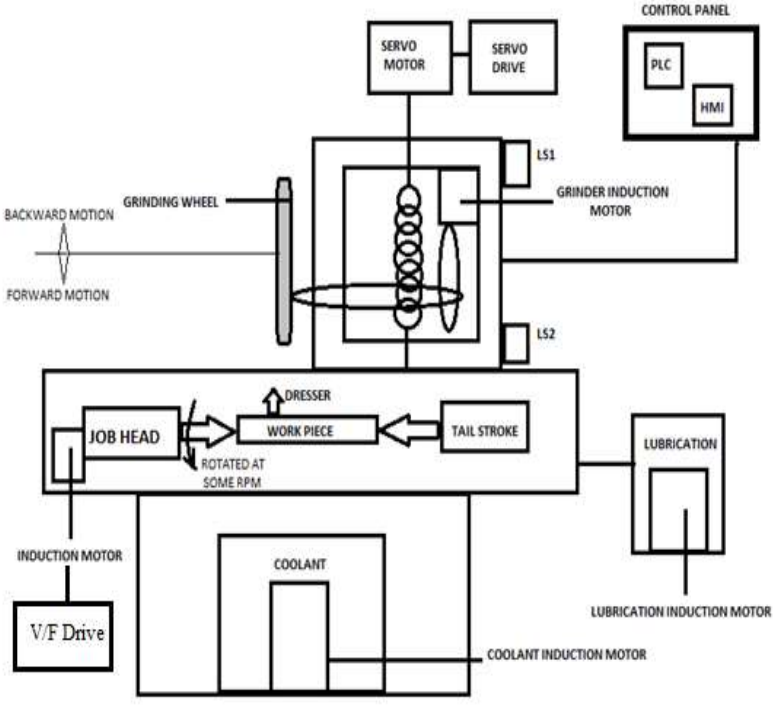

Figure 3: Block diagram of Automation of Cylindrical Grinder

After receiving the input command from HMI, PLC converts the distance, the grinder wheel has to cover into pulses which are given to servo amplifier, to which the servo motor is connected. The servo amplifier converts these pulses into exact distance the slide has to move ,on which the grinding wheel is attached, by controlling the speed of the servo motor. The work piece is attached to the job head and it is continuously rotating at a constant speed of more than 180 rpm for it we use induction motor and speed of induction motor is controlled by using variable frequency drive (VFD) i.e. ACS 335.Thus the proper synchronisation is maintained between the speed of grinding wheel and the speed of job head. Thus the speed of various motors is controlled in cylindrical grinder.

Automation of Carding Machine

In this the working of carding machine is controlled using PLC, HMI and Drives. In carding machine we face various difficulties such as fault detection problem, variation in input cotton to chute feed, problem in regulation of speed of doffer, feed and delivery motor, difficult to change their speed according to need, no indication of thickness of sliver, rate of delivery, no alarm indication and difficult to change timing of timers, no control of knife angle to cut the sliver. So we use PLC, HMI and variable frequency drives. PLC gives commands to Drive. Drives are used to control the speed of motors by controlling the frequency and voltage. Generally constant voltage of 410V is maintained in industry and frequency is varied to change the speed of motor. These are known as variable frequency drives. Here Danfoss VLT 2800 is used for controlling speed of doffer motor, feed motor and delivery motor. As shown in figure 4 drives used are U1 (Doffer Motor Drive), U2(Feed Motor Drive), U22(Delivery motor drive).

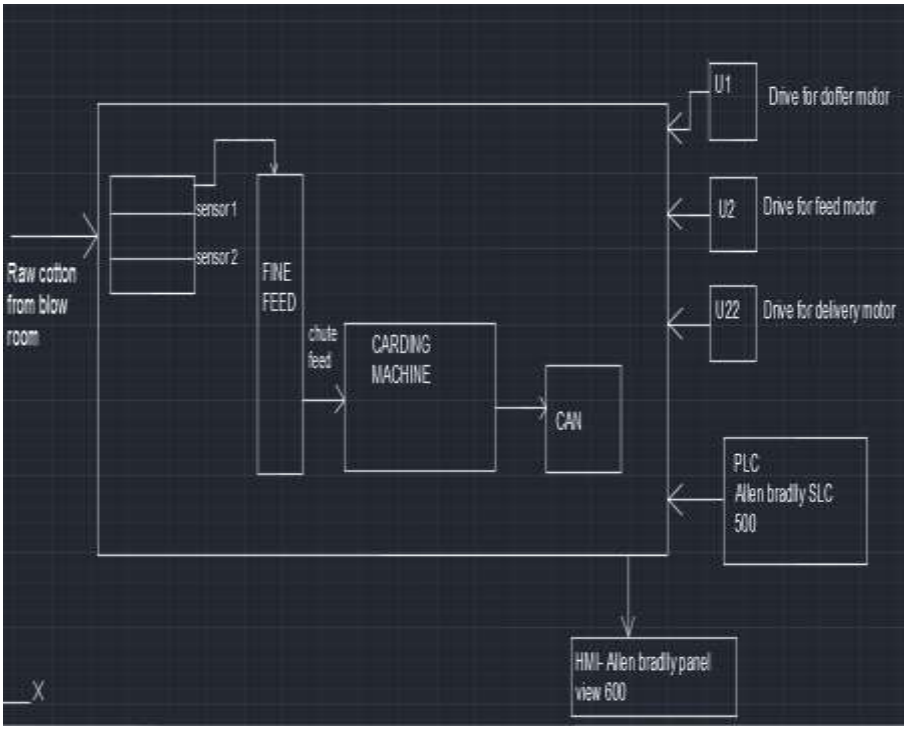

Figure 4: Block diagram of Automation of Carding Machine

Results

Energy Saving in Cylindrical Grinder

- In manual operation energy consumed by the machine = 9.30 kWh
- After automation energy consumed by the machine = 7.00 kWh
- Energy save = reduction in units= 9.30-7.00=2.30kWh
- If commercial rate of a unit is 7.20 Rs and machine is operated for 14 hours in a day then
- Annual saving= annual loss reduction in units × unit price = 7.20 ×2.30 × 14 ×365

  =Rs 84,621.60.

Energy Saving in Carding Machine

- In manual operation energy consumed by carding machine in one hour = 13 kWh

- In automation mode energy consumed by carding machine in one hour= 11.10 kWh
- Reduction in energy consumed in one hour= 13-11.10= 1.90 kWh
- If commercial rate of unit is 7.20Rs, Machine works for 24hours a day. It is turned off for one day in a week. Therefore machine is ON for 312 days in a year.
- Annual saving= Annual loss reduction in units × Unit price = 1.90 × 7.20 × 24 ×312

  = Rs 102435.84

Conclusion

Industrial automation results in great amount of energy saving by the use of electric drives in electric motors which improves the efficiency, reliability and life of machine. Overall production cost is reduced. Moreover machine control and monitoring is easy. Absolute control of speed of motor and position is there.

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