Design and Installation of High Capacity Centralized Coolant Pump for Optimization of Power Consumption using VFD Controller

Ms. Asavari Jadhav[1], Ms. Mayuri Pawar[2], Ms. Shital Shingate[3], Ms. Komal Devakar[4], Dr. B. M. Nayak[5]
B.Tech Students, Department of Electrical Engineering[1,2,3,4]
Head of Department, Department of Electrical Engineering[5]
Arvind Gavali College of Engineering Satara, Maharashtra, India

Abstract: *This paper discuss the pumping system study involved detailed discussions with Maintenance Engineers. The flow, pressure and power measurements for the pumps were done with the advanced instruments available with GIN. A total of around 2 Pumps were studied during the audit period. We find that there is a good amount of saving potential available on replacement of the pumps with Energy Efficient pumps call it a variable speed drive, adjustable frequency drive, adjustable speed drive, AC drive, inverter drive or something else, a variable frequency drive (VFD) can reduce the energy usage of an electric motor up to 90%, extend motor life, deliver a payback in as little as 6 months and often qualify for energy-saving financial incentives. Since HVAC consumes the most energy in a building and motors account for the majority of HVAC energy usage, using VFDs on pump and fan motors can result in substantial energy cost reductions.*

Keywords: Centralized coolant system, VFD, Three phase AC motor, Transmitter.

I. INTRODUCTION

A centralized coolant system is the system in which a typical machining operation in CNC turning or CNC milling the heat is generated as a by-product of shearing off the work piece material and the friction of the chip sliding over the cutting tool. High temperature in the tool results in rapid tool wear, and high temperature in the work piece can change its metallurgical characteristics and hardness, create unwanted thermal expansion, or lead to unwanted chemical reactions such as oxidation.

In order to achieve this coolant pressure there is system which includes pumps, three phase ac motors and VFD. Variable Frequency Drives (VFD) change the speed of motor by changing voltage and frequency of the power supplied to the motor. In order to maintain proper power factor and reduce excessive heating of the motor. In general a VFD can be used in a variety of applications where the load is variable, such as fans, pumps, and compressors. There are several types of VFDs, but the most commonly used VFD is the Pulse-Width Modulation (PWM) type. Simplicity, reliability and value are the advantages of the PWM VFD. A variable frequency drive (VFD) can reduce the energy usage of an electric motor up to 90%, extend motor life and often qualify for energy-saving financial incentives .There is a transmitter is also used, A pressure transmitter is a mechanical device that translates the expensive force of a liquid sample into an electrical output. This device converts the pressure through a transducer into an electrical signal.

II. WORKING OF CENTRALIZED COOLANT SYSTEM

It is a centralized coolant system which is used in a industry for CNC and VMC machine operation. Functions of coolant in the machining process include: Reducing and removing the heat build-up in the cutting zone and work piece, Provides lubrication to reduce friction between the tool and removal of the chips, Flushes away chips and small abrasive particles from the work area, protects against corrosion. In our existing centralized coolant system there are two 30 KW motors and two pumps of capacity of 160 m3/hr are used for the flow of 261 m3/hr. But to achieving the flow of 261 m3/hr .We have to use two motors of 30 KW, due to this total 60 KW power consumed by the motor so the maximum power demand will shoot, so to optimize the power demand we use proposed system.

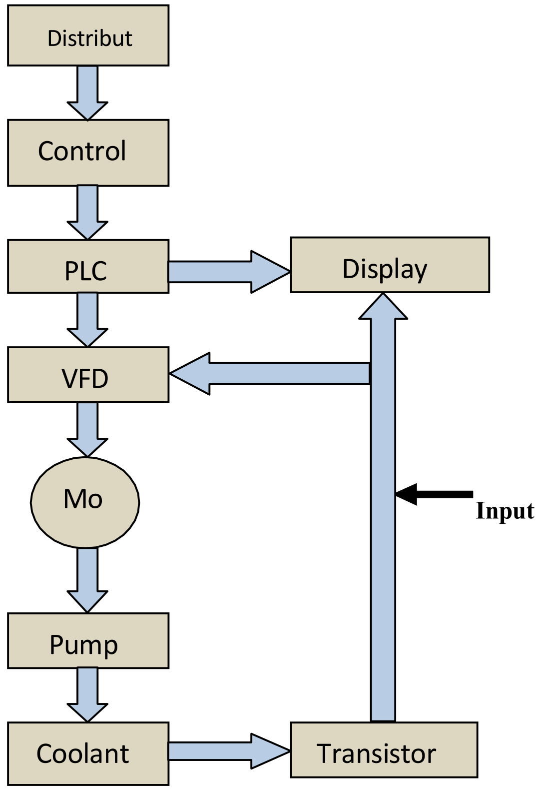

Fig 1: Working of centralized coolant system

In a proposed system there are two 55 KW motors, capacity of pump is 300 m3/hr and the VFD which are used to control speed of motors and frequency. Here for the flow of 303 m3/hr we use transmitter which sense the pressure of coolant after that transmitter gives signals through PLC (Programmable Logic Control) to the VFD, it is a variable frequency drive which is control the frequency and voltage of power supplied to the motor which is of 55 KW. So a variable frequency drive can vary the power supplied to match the energy requirement of driven system and this is how it saves the energy, optimizes the power.

This proposed system is design for the centralized coolant system which include machines for the desired coolant pressure and flow and for the optimization of power which was shoots maximum demand in existing system. In a proposed system power saved by system is 17 KW.

III. CENTRALIZED COOLANT SYSTEM CONTROL PANEL (CCS)

Fig 2: CCS control panel

3.1 Variable Frequency Drive (VFD)

The first stage of a Variable Frequency AC Drive, or VFD, is the Converter. The converter is comprised of six diodes, which are similar to check valves used in plumbing systems. They allow current to flow in only one direction; the direction shown by the arrow in the diode symbol. For example, whenever A-phase voltage (voltage is similar to pressure in plumbing systems) is more positive than B or C phase voltages, then that diode will open and allow current to flow. When B-phase becomes more positive than A-phase, then the B-phase diode will open and the A-phase diode will close. The same is true for the 3 diodes on the negative side of the bus. Thus, we get six current "pulses" as each diode opens and closes. This is called a "six-pulse VFD", which is the standard configuration for current Variable Frequency Drives.

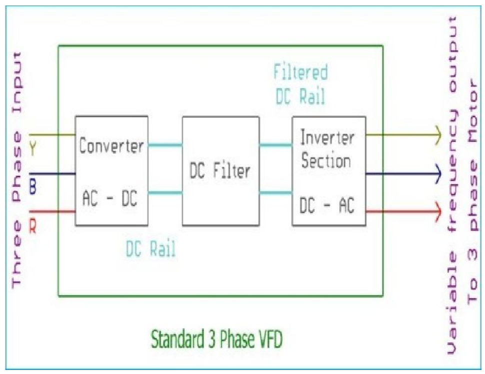

Fig 3: Three phase VFD

IV. CENTRIFUGAL PUMP

Are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor. They are a sub-class of dynamic axis symmetric work- absorbing turbo-machinery. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller flowing outward into a diffuser or volute chamber (casing), from which it exits.

Centrifugal pumps are hydraulically operated machines characterised by their ability to transmit energy to fluids (in particular to liquids) through the work of a field of centrifugal forces. Their main purpose is to transfer fluids through an increase in pressure.

Fig 4: Centrifugal Pump

V. MOTOR

When the 3-phase stator winding is fed from a balanced 3-phase supply, a rotating magnetic field (RMF) is produced in the motor. This RMF rotates around the stator at synchronous speed. The RMF passes through the air gap and cuts the rotor conductors, which as yet are stationary. Due to the relative motion between the RMF and the stationary rotor conductors, EMFs are induced in the rotor conductors. As the rotor circuit is closed with short-circuit so currents start flowing in the rotor conductors.

Since the current carrying rotor conductors are placed in the magnetic field produced by the stator winding. As a result, the rotor conductors experience mechanical force. The sum of the mechanical forces on all the rotor conductors produce a torque which moves the rotor in the same direction as the rotating magnetic field. Hence, in such a way the three phase input electric power is converted into output mechanical power in a 3-phase induction motor. According to Lenz law the rotor should move in the direction of the stator field, i.e., the direction of rotor currents would be such that they tend to oppose the cause producing them. Here, the cause producing the rotor currents is the relative speed between the RMF and the rotor conductors. Thus to reduce this relative speed, the rotor starts running in the same direction as that of the RMF.

Fig 5: Three Phase Motor

VI. TRANSMITTER

6.1 Mounting

1. The pressure and characteristics of the fluid to be measured must be compatible with the transmitter (to eliminate all risk of damage or explosion) the fluid must be compatible with 1.4404 stainless steel (AISI316L)AL203 ceramic material and the type of gasket the fluid may not contain solid fractions(bigger than 80micrometer)
2. The use of a transmitter with fluid for which it has not been designed is strictly prohibited the operating temperature must lie between -25degree and 85 degree celsious (-13 degree and 185 degree faraday) the temperature of the process must not give rise to a temperature in the transmitter higher than the allowed maximum for other values see baumer bourdon-haenni
3. The fluid must not freeze inside the transmitter nothing rigid must be allowed to enter the pressure port opening as it may destroy the diaphragm the mounting or dismounting operations must be carried out with the power switched off and at zero pressure note when the liquid is compressed during mounting it may result in over pressure
4. Mounting must be carried out in compliance with current regulations leave all labels and marketing visible The mounting positions does not affect measurement it is nonetheless recommended to place the transmitter away from all severe environmental conditions (throbbing, hammer-blow in pipes, vibrations, jolts, sources of heat, electrical and magnetic fields, lighting humidity and atmospheric influences).The operator must ensure that the connections is sealed. The sealing surface must be clean and an appropriate gasket used use 23mm(15/16*) wrench on the hexagon (G1/2 ½ NPT) to tighten to the appropriate torque (50nm maximum) reduce this torque for smaller threads

Fig 6: Transmitter

VII. RESULTS

7.1 Existing System

This existing system result is for two motors each motor of 30KW so the total power consumed by the system is 60KW for the pressure of 2.2kg/cm^{2}.

Sr. No.	Current	Pressure	Frequency	Power
1	34 A	0.4 kg/cm^2	50 Hz	30 KW
2	68 A	2.2 kg/cm^2	50 Hz	60 KW

Table 1: Result

7.2 New System

In Existing system total power consumed is 60 KW and in proposed system total power consumed is 43 KW. Therefore total power saving by the system is 17 KW.

Sr. No.	Current	Pressure	Frequency	Power
1	39 A	0.2 kg/cm^2	30 Hz	26.4 KW
2	46 A	1 kg/cm^2	35 Hz	31.1 KW
3	54.5 A	1.9 kg/cm^2	40 Hz	36.9 KW
4	58 A	2 .2kg/cm^2	42 Hz	43.6 KW

Table 2: Result

VIII. CONCLUSION

A centralized coolant filtration system is a common system for a group of machines. Coolants are an instrumental part of machining, including grinding, milling, and turning. They help extend tool life and provide an improved surface finish of the parts being machined. Functions of coolant in the machining process include: Reducing and removing the heat build- up in the cutting zone and work piece, Provides lubrication to reduce friction between the tool and removal of the chips, Flushes away chips and small abrasive particles from the work area, Protects against corrosion.

VFD helps to save energy in many applications. It is a power conversion device. It converts a basic fixed frequency to a variable frequency, variable voltage output. This fixed output voltage is used to control the speed of induction motors. Primary function of a VFD in a aquatic application is to provide energy savings. By controlling speed of a pump rather than controlling flow through use of throttling valves, energy savings can be substantial. A VFD is used for control of process temperature, pressure or flow without use of a separate controller, Suitable sensors and electronics are used to interface driven equipment with it. Also maintenance costs can be lowered, since lower operating speeds result in longer life for bearings and motors.

REFERENCES

[1]. Design and implementation of advance harmonic filter for variable frequency derive (2020). L.Ashok kumar,V.inditra Gandhi,Steffi Pius

[2]. Variable frequency device (Jan 2017). Prof. Ankita A. Yeotikar,Mr. Amit Kale, Mr. Nikhil R. Kamdi, Ms. Priya Kale

[3]. Application of variable frequency drive on the condensate pump motors of APR1400 nuclear power plants for energy savings (Oct 2017). Zakaria Barie and Choong-koo Chang.

[4]. Speed control of AC motor using VFD. (2015). Sumedh Tonapi,Piyush chopade.

[5]. Use of the VFD to minimize the throttling effect of water supply by the automation of the system (Feb 2015). Sumedh Tonapi,Piyush chopade.

[6]. Variable frequency drive for induction motor(Nov 2015) . Krutika Mokashi,MS. S.V Morge.

[7]. Energy Efficiency in Industrial Process Cooling Systems (2003). Michael M. Tillou,Mark E.,Patti Lynn .