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ENERGY CONSERVATION USING VFD

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Abstract— Many industrial applications require variable flow control of fluid (air, chemical gases, water and liquid chemicals). An automatic regulation water supply system based on PLC (Programmable Logic Controller) & VFD (Variable Frequency Drive) is proposed. The main aim of this paper is to reduce the energy consumption by the implementation of VFD and hence the proper control of fluid flows.

Keywords— PLC(Programmable Logic Controller),VFD(Variable Frequency Drive),Flow Control, Energy Consumption, Automatic regulation.

I. INTRODUCTION

With the rapid changes in industrial automation and information technologies in recent decades, the control of all equipments has been performed through the use of industrial computers. Most applications use PLCs to connect with computers for monitoring and controlling loads and electricity consuming devices. Programmable Logic Controllers (PLC) and Variable Frequency Drives (VFD) are commonly used **,** these days **,** in controlling the speed of induction motors in a wide range of industry and building automation because they are inexpensive , easy to install and very flexible in applications [1].

There is tremendous energy saving potential in pumps, fans, blowers & compressors. The saving potential varies from 20 % to as high 70 % of the energy consumption in the above equipments. One of the major methods for achieving this huge energy savings, is through the application of variable frequency drives (VFDs).

II. BLOCK DIAGRAM OF PROPOSED SYSTEM

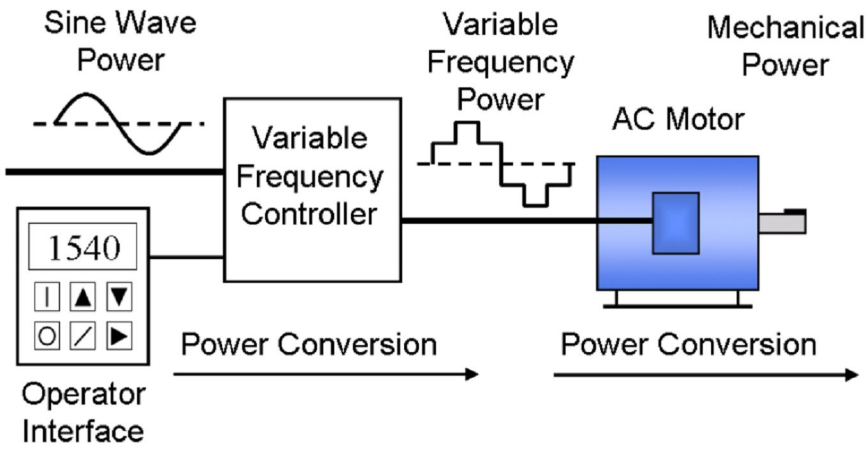

Fig.1 Block Diagram

III. VARIABLE FREQUENCY DRIVE

Variable speed drives are devices used for varying the speed of a driven equipment (such as pumps, blowers, compressors, conveyors etc.) to exactly match the process requirements and achieve energy saving as well.

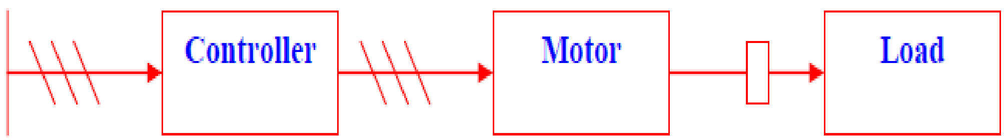

Fig. 2 Basic Components of VFD

Any variable frequency drive consists of three components as follows:

- *An electronic actuator – the controller.*
- *A driving electrical machine – Motor.*
- *A driven machine – Pumps, Fans, Blowers,Compressors*

The task of a variable speed electrical drives task is to convert the electrical power supplied by the mains into mechanical power with minimum losses. To achieve an optimum technological process, the drive must be variable in speed. The controllers are connected to mains supply and the electrical machines.

IV. BENEFITS OF VFD

The use of variable frequency drive control offers several advantages. The most significant benefit is its potential to reduce electrical energy consumption and demand from motor-driven processes.

Fig. 3 below compares the relative power requirements of a fan at different flow rates, using three types of throttling control: outlet damper control, variable inlet vane control, and VFD control. Although VFDs save far more energy than throttling, the technology has not yet achieved widespread adoption.

Variable frequency drives also have the potential to reduce system maintenance and related costs. Control with a VFD affords the capability to soft start a motor, which means the motor, can be brought up to its running speed slowly rather than abruptly starting and stopping. Similarly, running the motor at lower speeds extends the lifetime of other equipment components, including shafts and bearings.

In addition to enabling precise speed control of applications such as conveyors or winders, other parameters such as pressure, flow and even temperature may be accurately controlled. The efficiency of the electrical supply is increased and more of the electrical current drawn is used to drive the load. Hence the implementation of VFD improves the power factor of the system. In addition to this VFD provides good dynamic response. This can be achieved by rapid adjustment of speed, torque and power and hence gives better control in high speed applications. In some applications it is also possible to operate motors at higher speeds than their nominal speeds. The other advantage of VFD is that it is possible to interface VFDs to wider process control systems such as supervisory control, data acquisition (SCADA) systems and building management systems (BMS). Hence VFD is able to compute intelligence and communication systems.[2]

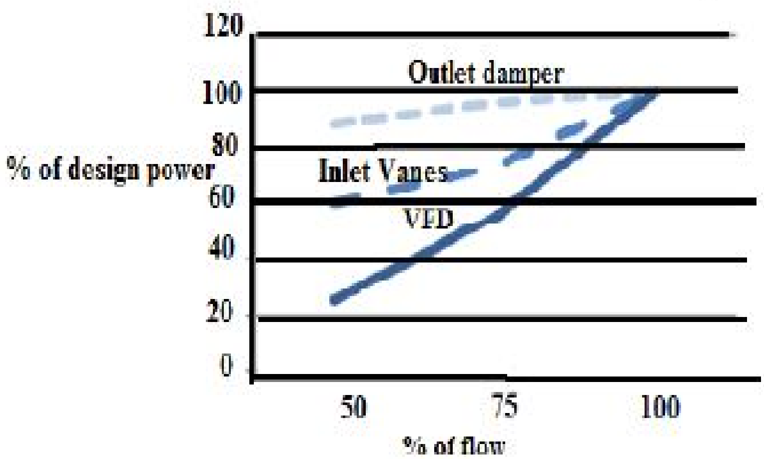

Fig.3 Comparison Between Power and Flow for Different Fan Control Types

IV.ENERGY CONSUMPTION FORMULAE

- Flow $\propto$ Speed
- Torque $\propto$ Square of Speed ($T \propto N^2$)
- $N \times T \propto N^2 \times N$
- Power $\propto$ Cube of Speed ($P \propto N^3$)
- 10 % Reduction of speed gives 25 % Power Saving

V.APPLICATION OF VFD FOR PUMPS AS LOAD

A. What is Pump?

Pump is a commonly used equipment finding application in varied types of industries such as chemical, paper, sugar, engineering, cement etc. On an average the power consumed by pumps vary between 5-30 % depending on the type of industry & applications. Pumps offer an excellent opportunity for achieving substantial energy savings through application of variable frequency drives.

Generally pumps are designed for maximum flow & process conditions. When the flow requirement varies in the process, pumps capacity utilization also changes. Whenever the process requires less flow, the capacity utilization of the pump will be less. In this condition generally re-circulation or valve throttling is practiced, which is energy inefficient. In these conditions, a variable speed system will be very useful. Whenever the flow requirement varies, speed of the pump can be increased / decreased automatically.

B. Potential Saving in Pump Using VFD

Hence the saving potential in pumps (by installing variable speed drives) can also be estimated by measuring the pressure drop across the valves.

- The pressure drop across the valve = P3 - P2
- The total pressure rise of the pump = P2 – P1
- Energy saving potential = (P3-P2) X Input KW / (P2-P1)

Out of this saving potential, at least 90 % of the saving can be achieved with a VFD. The pressure measurement may not be feasible in all the cases. In those cases the saving potential can be estimated based on the design head & flow, estimated drop in valves / control valves, actual flows during normal operation & the process application.

C. Pumping System

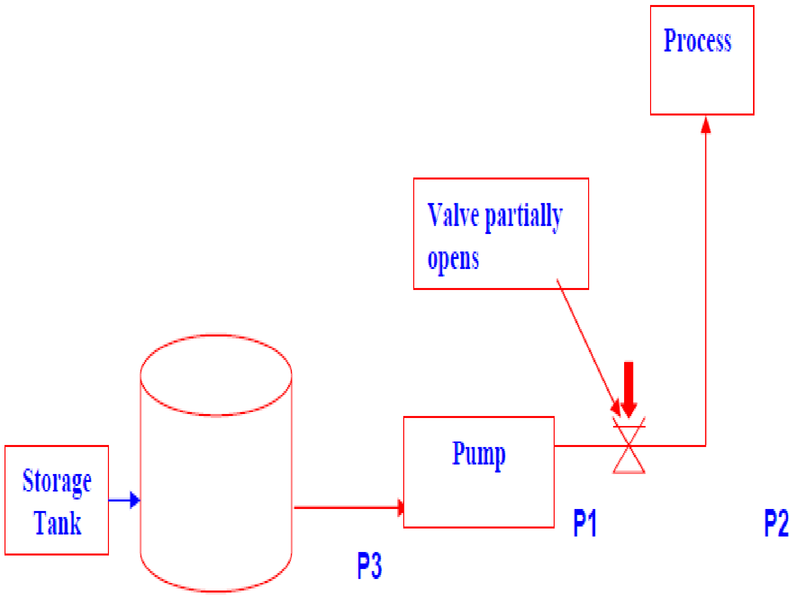

Fig.4 Saving Potential in Pumps Using VFD

VI. APPLICATION OF VFD FOR FANS AS LOAD

A. What is Fan?

Fans are used for ventilation, creating draught in boilers & furnaces, moving large volumes of air or gases through duct, supplying air for drying, conveying material suspended in the gas stream, removing dust, fumes or gases etc.

Fans are major consumer of energy and they offer excellent scope of energy savings through the application of variable speed drives. Generally there are two types of fans, centrifugal & axial fans.

B. Fan Performance

The performance of centrifugal fan varies with changes in condition such as temperature, fan speed, impeller size and density of the gas being handled.

These factors are to be considered and necessary correction made for variation from these standards, while designing a fan.

Parameter	RPM	Dia of impeller	Density of gas	Temp. of gas
Volumetric capacity	N	D3	-	-
Pressure rise	N2	D2	p	1/T
Power consumption	N3	D5	p	1/T

Fig.5 Performance Parameters.

C. Power Consumption of Fan with RPM

Volumetric flow = K (RPM)

Static pressure rise = K $(RPM)^{2}$

Power consumption = K $(Speed)^{3}$ = (Volumetric flow X static pressure rise)

D. Characteristic Curve

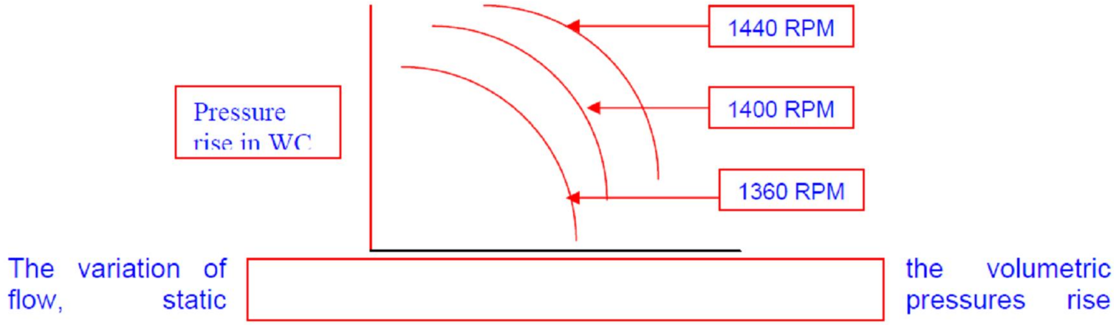

Fig.6 Characteristic Curve

E. VFD Offering Best Efficient Operation

The speed of the fans is varied to achieve different capacities.
(Graph between % flow & % KW demand for different types of capacity controls in fans)

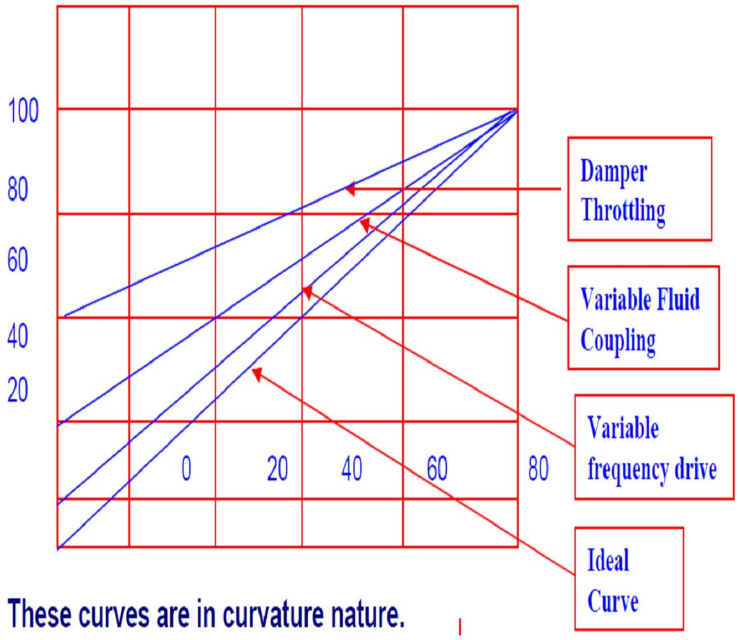

Fig.7 Graph Between Flow & Demand

VII. CONCLUSIONS

In this study it is found that, the speed control of induction motor using variable frequency drive can save energy. According to this assumption a small reduction in speed can save a large amount of energy.As use of VFD provides following advantages:

- *Significant energy savings*
- *Easy setup & programming*
- *Retrofits*
- *Space*
- *Better design*
- *Competitive edge*

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[2] www.jatit.org (Volume 51, No.1,10th May, 2013), "*Design and Implementation of PI Controller for an Automated Building Water Supply System using PLC Techniques*"

