Study & Analysis Of Conservation Of Energy With VFD

*Nisha M.Shrirao[1] , Tomesh T. Sahu[2]

1Yeshwantrao Chavan College of Engineering,Nagpur,Maharashtra,India

2*GayatriInfotech,Mumbai, Maharashtra,India*

Abstract:

Booming demand for electricity, especially within the developing countries, has raised power generation technologies. At the same time the discussion about causes of global warming has focused on emissions originating from power generation and on CO2 reduction technologies such as Alternative primary energy sources, Capture and storage of CO2, increasing the efficiency of converting primary energy content into electricity.Concerning the third focus point, relatively little attention has been paid to the efficiency of auxiliary processes in thermal power plants, which account for about 5-8% of the gross generating capacity. Examples of auxiliary processes in thermal power plants are Conveying and preparing the fuel, Moving the necessary air into the furnace, Moving the fuel gases from the furnaces, Returning the condensed water heater to the steam generator, Maintaining the required cooling effect within the condenser and Operating various emission cleaning processes.A majority of these processes are run by centrifugal pumps, fans and compressors driven by electrical motors.This paper presents the implementation of variable frequency drives for the Induced draft fan. It is a case study on energy conservation by using variable frequency drive at Thermal Power station

Keyword: ID fan, VFD, Blowers, power plant, Energyconservation

1. Introduction

The control industry may be a strong aggressive sector. Each industry to stay competitive must reduce costs but also has got to answer to power consumption reduction and electromagnetic interference (EMI) radiation reduction issues imposed by governments and power station lobbies. To preserve the environment and to reduce greenhouse effect gas emission, governments around the world are introducing regulations requiring white good manufactures and industrial factories to produce more energy efficient appliances, which is very much essential not only to electrical systems, it require all the systems to get beneficial in terms of money and also to reduce the global warming. This is the rationale why appliance designer's and semiconductor suppliers are now inquisitive about the planning of low cost and energy efficient variable speed drives.In the present time, in the most of the applications, alternating current (AC) machines are preferable to direct current (DC) machines due to their simple and most robust construction without any mechanical commutator.These motors haven't any brushes to wear out or magnets to feature to the value . The rotor assembly is a simple steel cage. Squirrel cage are rugged, cheaper, lighter, smaller, more efficient, requires less maintenance and can operate in dirty and explosive environment. With this induction motors are the most widely used motors for appliances, industrial control, fans, blowers, cranes, conveyers, traction, underground and 3 underwater installation and automation.A variable frequency drive (VFD) is an electrical variable speed drive that's added to motor-driven systems to assist save energy. Motor-driven systems are designed to handle peak loads. When these operating systems work for extended periods of your time at a reduced load, it wastes energy. Adding a VFD allows you to regulate the motor-speed capability and match it

with motor-output load. This is how it saves energy. The motor-driven system is connected to the VFD and allows us to possess speed control by changing the frequency of the motor-supply voltage. Variable frequency drives allow reducing power consumption up to 30% or more and obtaining a payback time on the investments often less than 1 – 2 years. Moreover, the quality of the equipment's and the lower mechanical stress on the installed machinery guarantee it a longer life time and a substantial cut on its maintenance cost In the present time, in most of the applications, alternating current (AC) machines are preferable to direct current (DC) machines due to their simple and most robust construction without any mechanical commutator. These motors haven't any brushes to wear out or magnets to feature to the value . The rotor assembly is a simple steel cage. Squirrel cage are rugged, cheaper, lighter, smaller, more efficient, requires less maintenance and can operate in dirty and explosive environment. With this induction motors are the most widely used motors for appliances, industrial control, fans, blowers, cranes, conveyers, traction, underground and 3 underwater installation and automation.A circuit/device which converts the energy from one form to a different form are called converter .a device that converts alternating power to direct power is named rectifier obtaining dc link input voltage to inverter, a diode bridge rectifier is employed for a pulse width modulated inverter, an easy bridge rectifier is enough the utilization of straightforward and economical bridge rectifier within the front improves the distortion, power factor, reduces the filter size and improves the reliability of operation. an outsized filter capacitor provides a stiff voltage supply to the inverter and its output waveform isn't suffering from the character of the load. The inductor smoothens the dc current. the choice of filter component values has a crucial effect on the performance and stability of the drive system. Inverter converts DC power to AC power. The input to the inverter could also be DC voltage source or DC current source. Depending upon the character of input power source to the inverter; they're classified in to 2 types; Voltage source inverter (VSI) and Current Source inverter (CSI). the present source inverters, due to their simplicity are gaining importance in speed drive systems, moreover they need the restrictions of torque pulsation at low frequencies resulting in cogging of the shaft, which needs a high value reactor within the dc link and also it needs high value of commutation capacitors. The CSI feed drive systems are generally unsuitable for multi-motor drive system. On the opposite hand, voltage source inverters don't have these problems, but they're considered to be complex from the purpose of view of control circuitry and power circuit. the most purpose of control unit is control the speed also as torque of the driving force . The closed-loop system control of induction motor is important to take care of the speed constant regardless of the change within the load and provide voltage conditions. generally , the control scheme should provide for constant torque operation up to base speed and constant power operation at higher speeds. Generally the speed of the drive drops thanks to variation within the load. so as to take care of constant speed and torque, the closed system is required. The closed system is obtained by a feedback voltage proportional to the motor speed. This voltage is usually obtained by using additional components just like the speed sensor. The sensor senses the particular speed of the drive and sends to regulate unit. The control unit compares this particular speed with the reference speed, depending upon the difference a mistake signal is generated. The generated error signal of the controller controls the width of pulses given to the switching devices. supported the switching action, the voltage and frequency of the inverter changes. The implementation of controllers and inverter switching strategy shouldn't be complex. Too complexity of a system will bring down its reliability and hence that of the entire system. The implementation by dedicated VLSI circuits and microcontrollers gives superior performance with less hardware and more flexibility.The variable speed drive system are classified into electrical, hydraulic and mechanical system. Fig .1.1 shows the block diagram of a typical variable drive system. It consists of rectifier unit, DC link filter, inverter power circuit feeding the motor and feedback control unit/system. The details of each block are given below. A circuit/device which converts the energy from one form to another form are called converter .a device that converts alternating power to

direct power is called rectifier obtaining dc link input voltage to inverter, a diode bridge rectifier is used for a pulse width modulated inverter, a simple bridge rectifier is enough the use of simple and economical bridge rectifier in the front end improves the distortion, power factor, reduces the filter size and improves the reliability of operation.A large filter capacitor provides a stiff voltage supply to the inverter and its output waveform is not affected by the nature of the load. The inductor smoothens the dc current. The selection of filter component values has an important effect on the performance and stability of the drive system Inverter converts DC power to AC power. The input to the inverter may be DC voltage source or DC current source. Depending upon the nature of input power source to the inverter; they are classified in to two types; Voltage source inverter (VSI) and Current Source inverter (CSI). The current source inverters, because of their simplicity are gaining importance in speed drive systems, moreover they have the limitations of torque pulsation at low frequencies leading to cogging of the shaft, which needs a high value reactor in the dc link and also it needs high value of commutation capacitors. The CSI feed drive systems are generally unsuitable for multi-motor drive system. On the other hand, voltage source inverters do not have these problems, but they are considered to be complex from the point of view of control circuitry and power circuit. The main purpose of control unit is control the speed as well as torque of the driver. The closed loop control of induction motor is necessary to maintain the speed constant irrespective of the change in the load and supply voltage conditions. In general, the control scheme should provide for constant torque operation up to base speed and constant power operation at higher speeds. Generally the speed of the drive drops due to variation in the load. In order to maintain constant speed and torque, the closed system is required. The closed system is obtained by a feedback voltage proportional to the motor speed. This voltage is generally obtained by using additional components like the speed sensor. The sensor senses the actual speed of the drive and sends to control unit. The control unit compares this actual speed with the reference speed, depending upon the difference an error signal is generated. The generated error signal of the controller controls the width of pulses given to the switching devices. Based on the switching action, the voltage and frequency of the inverter changes. The implementation of controllers and inverter switching strategy should not be complex. Too complexity of a system will bring down its reliability and hence that of the total system. The implementation by dedicated VLSI circuits and microcontrollers gives superior performance with less hardware and more flexibility.

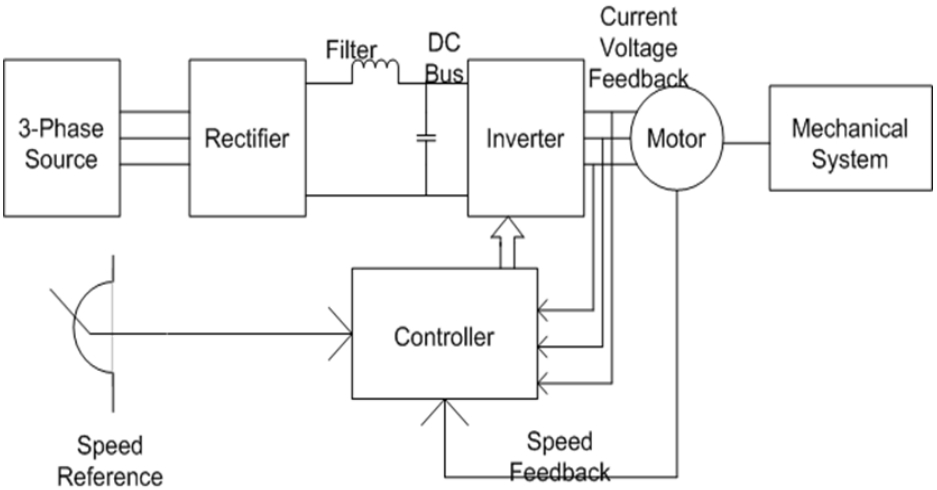

Figure 1. Block Diagram of VFD

2.Methdology

Case Study: Induced Draft Fan, Khaparkheda Thermal Power Plant

Induced Draft Fan

Large AC variable frequency drives (VFDs) provide significant benefits when applied to induced-draft fans (IDFs) electric generating stations. IDFs are located on the exhaust gas side of a balanced draft boiler and are usually controlled to take care of a rather negative pressure within the boiler. If a flame collapse occurs within the boiler, or if there's a sudden loss of air entering the boiler, the IDFs will evacuate the gas from the boiler and make a vacuum. If the fans have sufficient capability, a boiler implosion might occur.Application of VFDs to IDFs can reduce the danger of implosion during one among these events. the power of an IDF to make a vacuum during a boiler depends on the pressure the fan develops when the boiler has been evacuated and therefore the flow is low or non-existent. Until the mechanical guide vanes or dampers are closed, IDFs with constant-speed motors still pull a vacuum with the pressure associated with full speed.When minimizing the danger of boiler implosion, there are two significant advantages to VFDs: normal operating speeds are usually lower compared to constant-speed motors and a VFDs control response is far faster. The pressure developed by the fan is proportional to the square of the speed. Since fan motors powered by VFDs normally operate at but full speed, this is often a big benefit. With typical fan application margins, IDFs operate at but full speed even when the generating unit is working at full load. Consequently, the pressure developed by the fan during a possible implosion condition is a smaller amount when operating on a VFD.

Table 1. Test Result Obtained On ID Fan

Frequency(Hz)	Speed (RPM)	Excitation panel		KW	Contactor panel		Field current	Field voltage
		V (volts)	I (amps)		V (volts)	I (amps)		
10	150	200	95	30	200	60	12.4	166
13.33	200	275	100	50	275	80	11.2	166
22	300	400	200	180	400	200	13.7	166
33.33	500	850	260	480	850	260	17.4	166
40	600	1200	300	810	1200	310	22.5	166
46.66	700	1200	450	690	1225	450	28.9	166

3.Findings & Analysis

Energy saving calculations:

Power saving with VFD = 297KWh

Operation of system is considered for 300 days in year.

Average generation cost of Rs. 1.25/KWh

For one day total cost= 1.25×24 hr = 30Rs

For 300 days net saving= 30×300×474 = 42.66 lakhs per year

The extra capital expenditure towards installation of VFD will be approximately Rs 165 lakhs based on the present day cost.

Payback period=165/43

=3.8 years

The implementation of variable frequency drive for ID fan in a power plant reduces the power consumption. The drive pay back periods for the additional investment are quite attractive. From the above we can arrive at decision that the VFD is most suitable and economical solution for energy savings for ID fan. From the results, the use of variable frequency drive for cooling tower fan in power plant reduces the power consumption. If the motor has to run without variable frequency drive then the motor will consume more power and cannot be controlled and regulated as per the load demand and requirement.

Table 1. Energy Saving Calculation on ID Fan

Power consumption in KWh		Power saved with VFD in KWh	Cost savings in Lakhs per year	Cost of the drive in Lakhs	Pay back in years
Without VFD	With VFD				
2319	1845	474	43	165	3.8

4.Simulation and Result

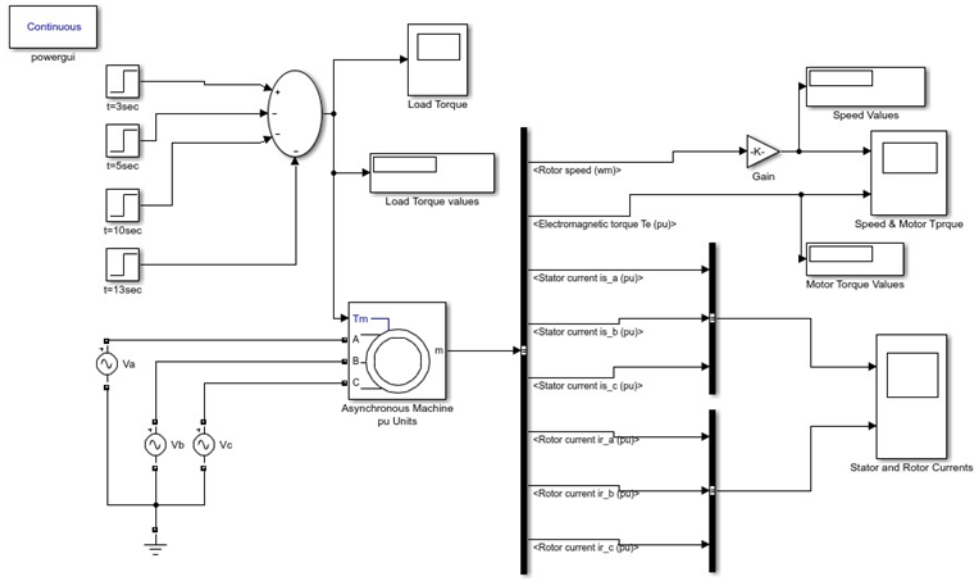

Figure 2. ID FAN Simulation without VFD

The above simulation model is based on a system with ID Fan which is without variable frequency drive. Variable load is supplied to the asynchronous motor by the use of step input of different frequency, for different time interval. The output of the motor, i.e. its stator and rotor current is measured by the current measurement and voltage measurement block. Further for the measurement of motor torque and the speed, measurements block are added, so as to get the required graphical output.

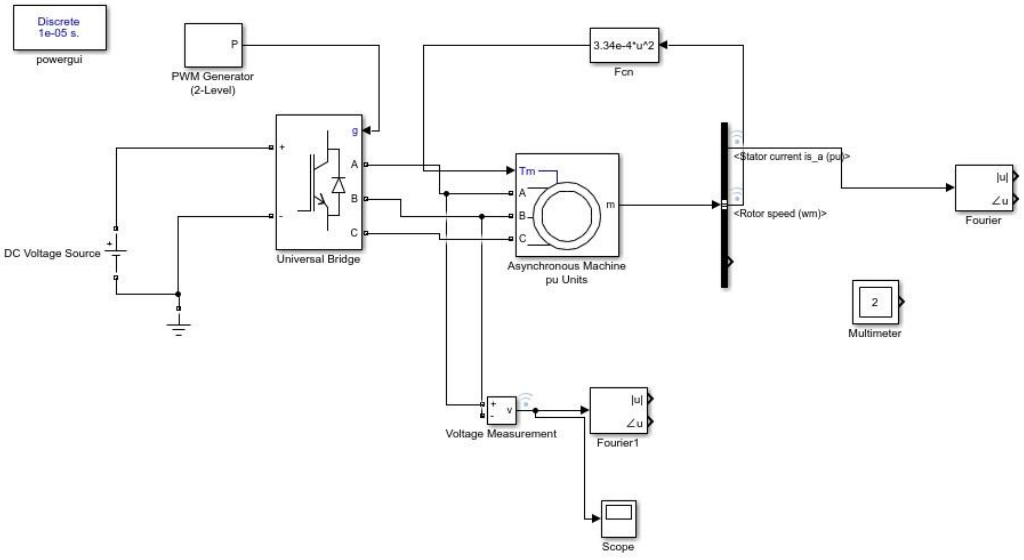

Figure 3. ID FAN Simulation With VFD

The above simulation model is based on a system with ID Fan which is equipped with variable frequency drive. Variable load is supplied to the asynchronous motor by the PWM Generator (2 level). The VFD is created by using inverter stage, which converts the input into required arc. output of suitable frequency.

The fan system is connected in a close loop with the motor to minimize the error. The output of the motor, i.e. its stator and rotor current is measured by the multimeter block. Further for the measurement of motor torque and the speed, measurements block are added, so as to get the required graphical output.

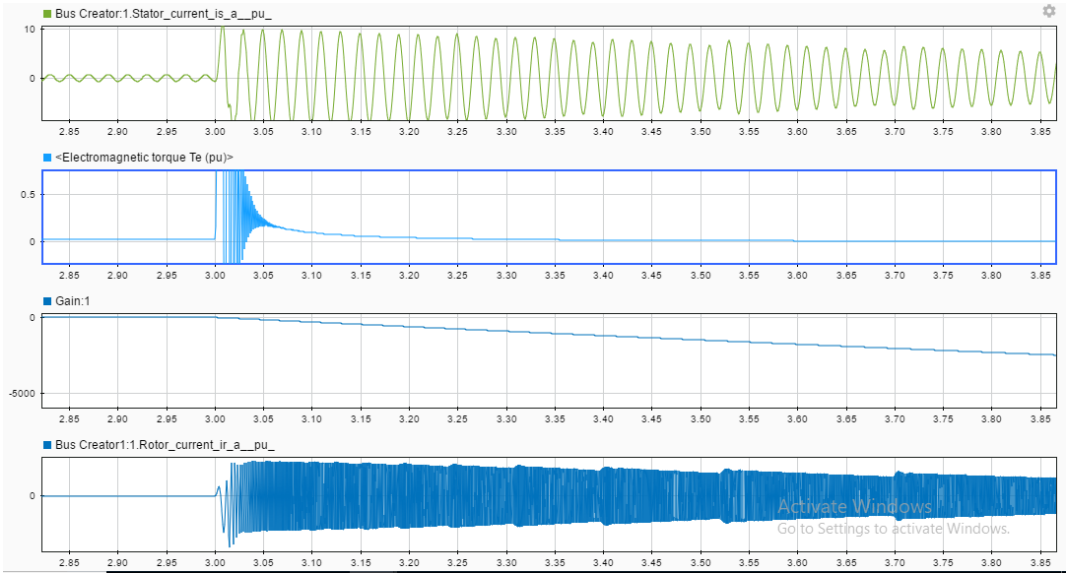

Figure 4. Graph of ID Fan without VFD

Graph no.1 shows variation of stator current w.r.t. time. As in the system the load is changes after 3 seconds of interval due to which fluctuations are seen in the graph hence due to variation of load the stator current also changes.

Graph no.2 shows the variation of electromagnetic torque w.r.t time. We can see after 3 seconds there is sudden increase in the torque which has further become steady this increase in the torque is due to variation of load

Graph no.3 shows the speed of the motor w.r.t. time. As seen from the graph, with the increase of load the speed is decreasing

Graph no.4 shows the variation of rotor current w.r.t. time. After 3 seconds there is sudden increase in the current as the load is increasing.

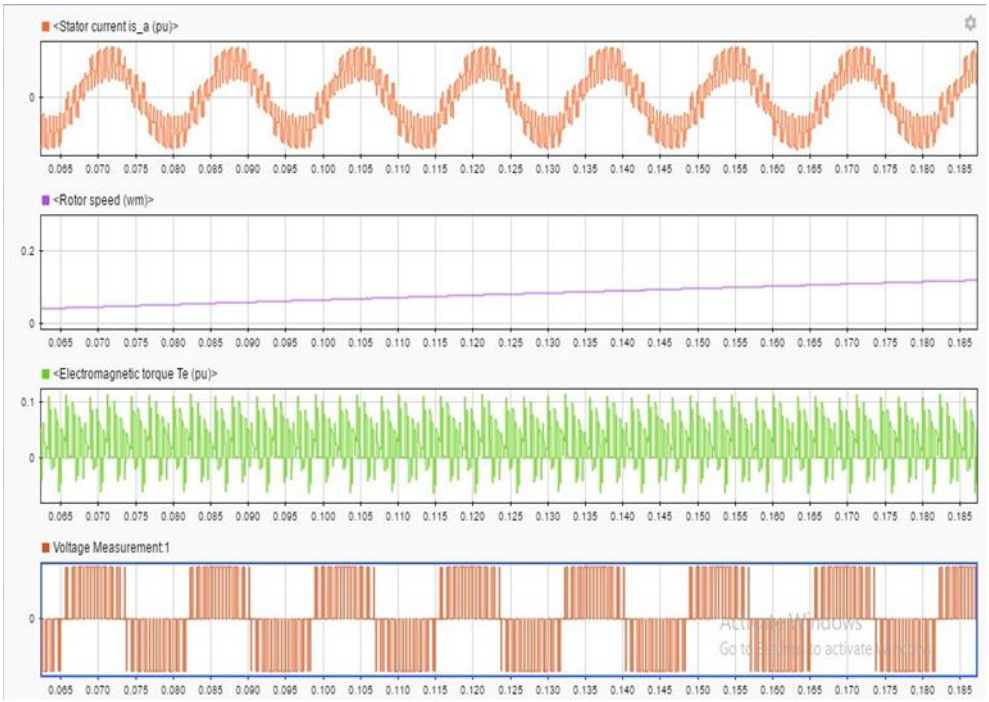

Figure 5. Graph of ID Fan with VFD

Graph no.1 shows the variation of stator current w.r.t. time. In this graph with the variation of load there are not much fluctuation in the stator current.

Graph no.2 shows the variation of stator speed w.r.t. time. With the increase in the load the speed of the motor also increasing

Graph no.3 shows the variation of electromagnetic torque w.r.t. time. There are not much variation on the torque with the varying load.

Graph no.4 shows the variation of voltage w.r.t. time.

5.Conclusion

After the detailed study of Variable Frequency Drive, it becomes possible to control the speed of electric motor as well as to conserve the electrical energy, as we know that the energy conservation has become a crucial subject to all or any over the planet . Increase in efficient energy use, decrease in energy consumption and/or consumption from conventional energy sources is reduced that results in the conservation of energy.For high performance provided by the Variable Frequency Drive for maximum process productivity always required a complex engineering consideration. However rapid improvements in AC control technology combined with ready availability of ordinary fixed frequency of AC motor have increased the amount of possible solution. With the method of pulse width modulation, the frequency given to the induction motor are often set so as to regulate the speed of the induction motor. Thus the consumption of electricity is depends on the load requirement. However the variation of frequency results in the harmonics distortion which may be mitigate by several techniques of harmonics mitigation.At last the conservation of energy may end in increase in financial, capital, environment quality, national security, personal security and human comfort. The individual and commercial user can increase energy use efficiency to maximum profit

which leads to help for the individual and organization that are direct consumer of energy security.

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