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VFD Based Performance Analysis of the Pump

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Abstract*: Electric power conservation is important in the induction motor field because two-thirds of the earths electricity is being consumed by induction motors. AC motors are said to consume more energy in the industry. The main problem with these induction motors are they consume very high power consumption. The use of variable frequency drives (VFD's) has reduced this current. Variable Frequency Drive is a common technique used to vary the speed of AC impulse motor by changing their input frequency. These drives use large motors to start smoothly and constantly adjust the speed. With the use of VFD's, energy cost savings are particularly important in pump applications where the load torque and power vary with respect to the induction motor speed. With that system it helps to reduce the operating cost of the whole system, which provides operational benefits and improves the system. Life. This paper contains experimental studies of induction motors with VFD and VFD for pumps. With that study's analysis, this paper reflects a review on the stimulus and performance analysis of the induction motor with and without VFD.

***Keywords:* Pulse Width Modulation. Alternating Current, Variable Frequency Drives, Induction Motor**

I. INTRODUCTION

Energy conservation is an efficient way to reduce total energy consumption. Since India saves 23 percent of its total energy consumption, it can transform the power situation from a deficit to an energy surplus country. Induction motors are used in most industries. There is a large scope for energy savings, so variable frequency drives are one solution to reduce energy consumption in the industry. In many industries, electric motor drives are used in press and auxiliary systems for major industrial processes such as compressed air generation, ventilation blowers and pumps.

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In industries, electric motors are the main source of mechanical power supply with few exceptions. Horsepower can vary in size between motors of less than 1HP. In recent years, a number of studies have identified a large range of electric protection in electric motors, especially induction motors.Pump systems with induction motors consume more energy in the industry. One fourth of the electricity utility industry is the pump system. Use a frequency converter to adjust the motor speed according to requirements, which greatly improves the efficiency of the motor system. In variable speed drive flow systems, such as pumping or ventilation systems, they have a high energy savings range with high production variations. Pumping systems are traditionally controlled by valves. Traditionally, in control mode, the motor has reduced the output current, but the motor is still running at full load and thereby releasing large amounts of energy, which can be frictional. Variable speed drives vary in input frequency and voltage to adjust the motor speed as needed.As a result, the pump load or water flow is adjusted without using an inefficient valve.

II. VARIABLE FREQUENCY DRIVE

It is a power electronic device which converts constant frequency and voltage to variable frequency and variable voltage output which can be used to control the speed to the Induction motors.[1]

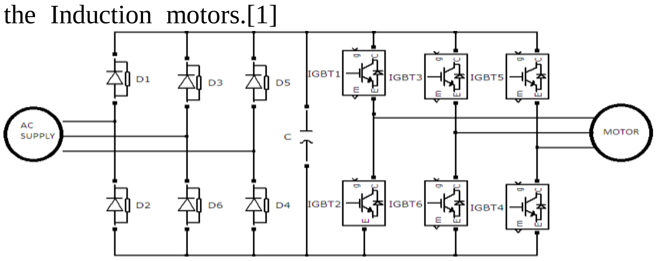


Fig.1 VFD Block diagram

There are various methods of speed control in an Induction Motor such as varying voltage supply, Changing the number of stator poles, adding resistance externally on the rotor side and variable frequency control method [2]. Variable Frequency control method is widely used as it is more efficient as it varies the input frequency of the supply and hence varies the speed of the IM.

$N_s = (120*f)/p$

Where,

N_S = Synchronous Speed of the Induction Motor

F = Supply Frequency to Induction motor

P = No. of Pole in the Induction motor

III. PUMP

A Pump is a mechanical Device which helps in the movement of Fluids from one place to other. The Pumps can be classified as Direct lift, Gravity Pumps and Displacements [3]. Pump mechanism is based on either reciprocating or rotary method. They consume a Significant amount of energy to transport the fluid. Mechanical Pump and they have a vast range of application in pumping water from bore well, Sumps, in generation plants they are used to transport coolant.

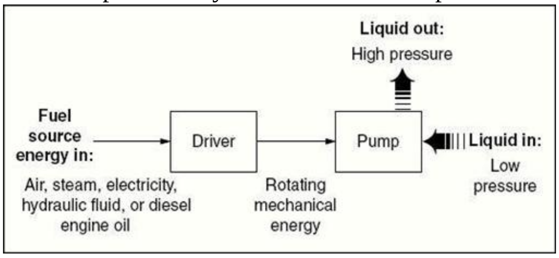


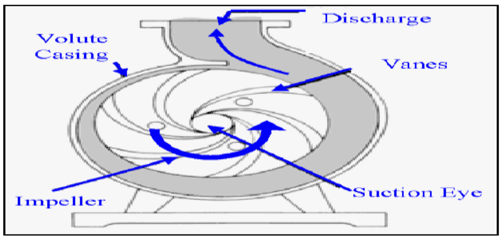
Fig.2 Working of Pump

The Fuel used in this method is the Electrical Energy and the driver is an Induction Motor used to mechanically drive the Pump for the transportation of fluid from one place to other.The Pump Used here is a Centrifugal Pump connected to an Induction Motor as a Driver.

TABLE I. Induction Motor Specifications

INDUCTION MOTOR NAME PLATE DETAILS	
PHASE	3
FREQUENCY	50
VOLTAGE	415
RPM	1425
CURRENT	1.19
EFFICIENCY	83.3

Centrifugal Pumps are commonly used to transport fluids by converting rotational kinetic energy into hydrodynamic energy with the fluid flow.The Rotational kinetic energy is provided by an Induction motor.The fluid enters the Pump



Impeller near or along the rotating axis and its speed is increased by the impeller, radially flowing outward into a volute chamber from where it comes out.

Fig.3 Liquid Flow Inside a centrifugal pump

IV. PERFORMANCE ANALYSIS

The performance of the Pump can be Observed with certain Test such as measuring the Electric Power, Motor Efficiency and Pump efficiency with respect to the flow rate.Initially The set of experiments are done at 50 Hz and once more the set of experiment is repeated at 40 Hz of supply frequency.The 50 Hz Input Supply is reduced to 40 Hz with the help of the Variable Frequency Drives.

TABLE II. DATA COLLECTED WHEN PUMP RUNNING AT 50 HZ FREQUENCY

PUMP AT 50 HZ										
SL.NO	A	B	C	D	E	F	G	H	I	J
	ELECTRIC POWER KW	FLOW RATE M3/hr	SUCTION PRESSURE kPa	DISCHARGE PRESSURE kPa	FLOW RATE M3/min	TOTAL HEAD (D-C)/9.8	MOTOR EFFICIENCY	SHAFT POWER KW A*G/100	THEORITICAL POWER 0.163*E*F	PUMP EFFICIENCY (I/H)*100
1	4.6	25	16.68	322	0.41666667	31.155102	83.3	3.8318	2.11595068	55.22080172
2	4.35	20	17.94	331	0.33333333	31.944898	82.9	3.60615	1.735672789	48.13090939
3	4	15	19	339	0.25	32.6530612	82.5	3.3	1.330612245	40.32158318
4	3.72	10	19.73	345	0.16666667	33.1908163	81.9	3.04668	0.901683844	29.59562027
5	3.45	5	20.21	351.2	0.08333333	33.7744898	81.2	2.8014	0.458770153	16.37646009
6	3.2	0	20.94	355	0	34.0877551	80.4	2.5728	0	0

TABLE III. DATA COLLECTED WHEN PUMP RUNNING AT 40 HZ FREQUENCY

PUMP AT 40 HZ										
SL.NO	A	B	C	D	E	F	G	H	I	J
	ELECTRIC POWER KW	FLOW RATE M3/hr	SUCTION PRESSURE kPa	DISCHARGE PRESSURE kPa	FLOW RATE M3/min	TOTAL HEAD (D-C)/9.8	MOTOR EFFICIENCY	SHAFT POWER KW A*G/100	THEORITICAL POWER 0.163*E*F	PUMP EFFICIENCY (I/H)*100
1	2.9	25	16.65	208.8	0.41666667	19.6071429	83.3	2.4157	1.33165179	55.1248825
2	2.7	20	17.93	217.3	0.33333333	20.3438776	82.9	2.2383	1.10535068	49.3834911
3	2.5	15	19	224	0.25	20.9183673	82.5	2.0625	0.85242347	41.3296228
4	2.3	10	19.7	229	0.16666667	21.3571429	81.9	1.8837	0.58020238	30.8012094
5	2.1	5	20.24	234.3	0.08333333	21.8428571	81.2	1.7052	0.29669881	17.3996487
6	1.9	0	20.8	238	0	22.1632653	80.4	1.5276	0	0

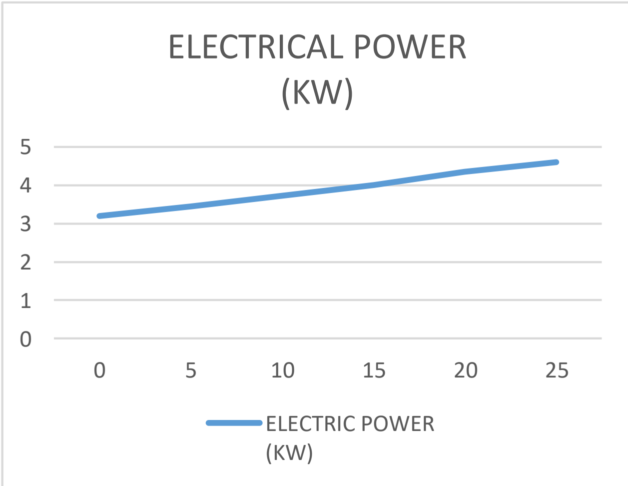


Fig.4 Electric Power Vs Flow Rate at 50 Hz Frequency

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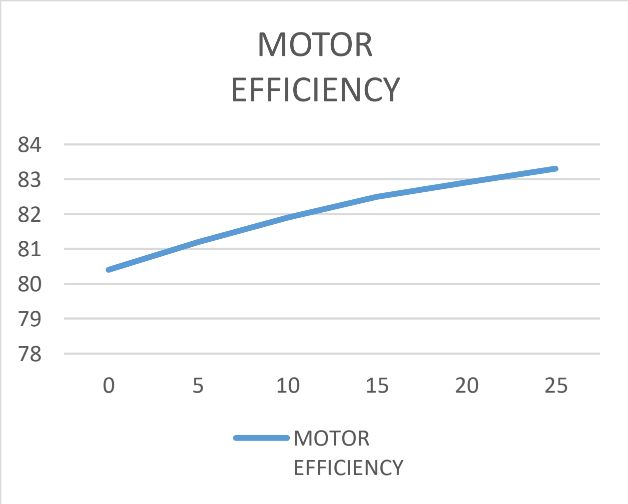

Fig.5 Motor Efficiency Vs Flow Rate at 50 Hz Frequency

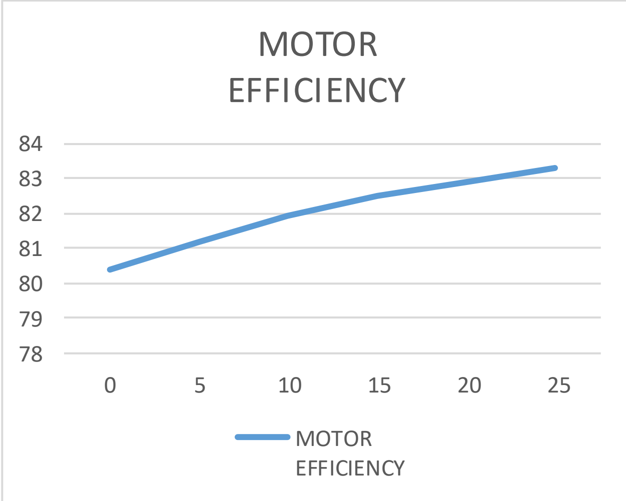

Fig.8 Motor Efficiency Vs Flow Rate at 40 Hz Frequency

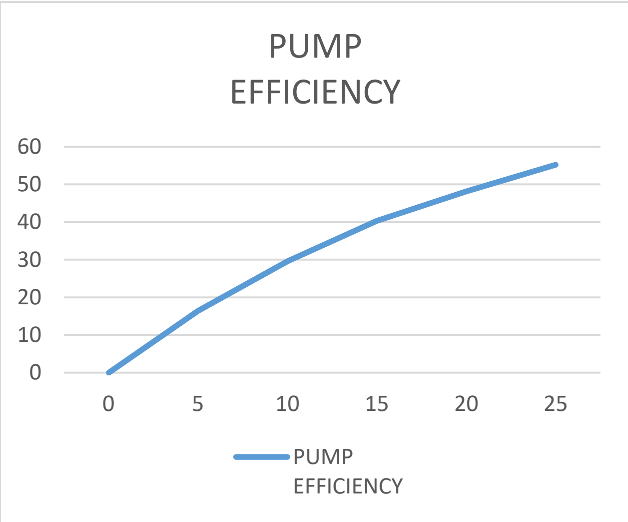

Fig.6 Pump Efficiency Vs Flow Rate at 50 Hz Frequency

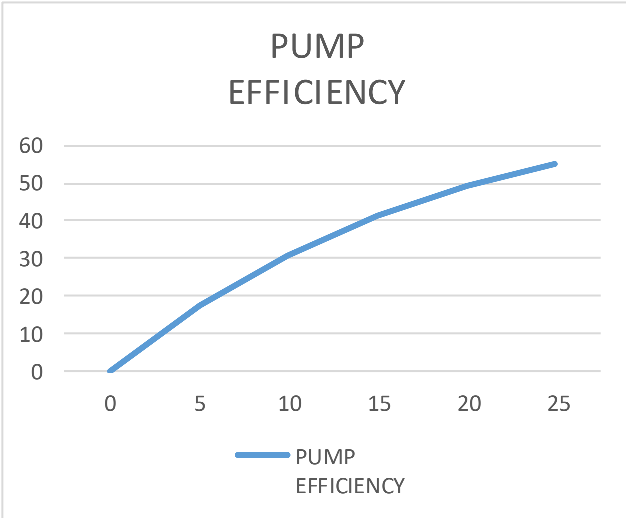

Fig.9 Pump Efficiency Vs Flow Rate at 40 Hz Frequency

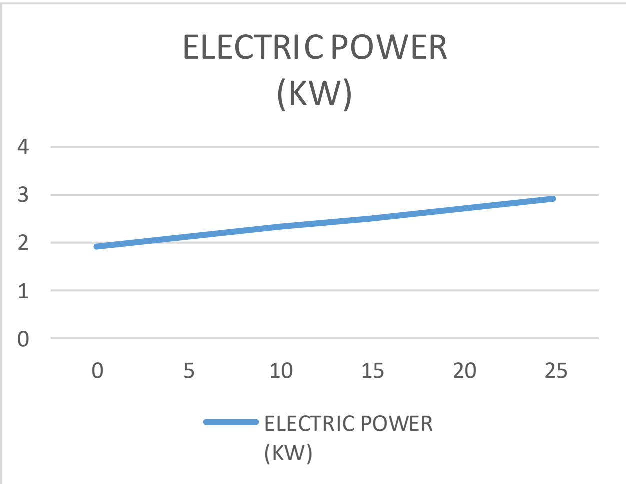

Fig.7 Electric Power Vs Flow Rate at 40 Hz Frequency

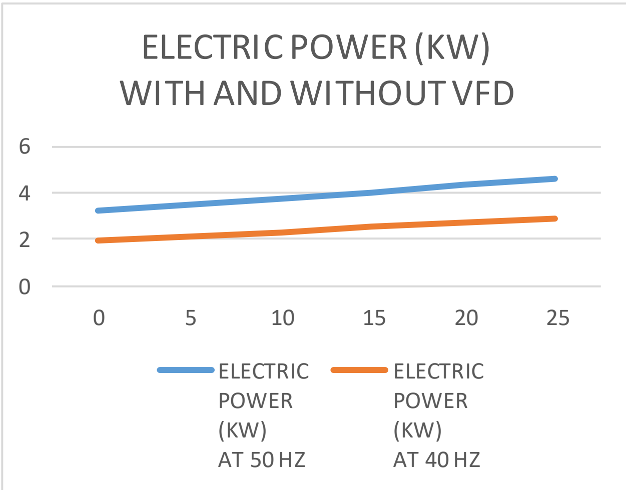

Fig.10 Comparative Electric Power at 50 Hz and 40 Hz

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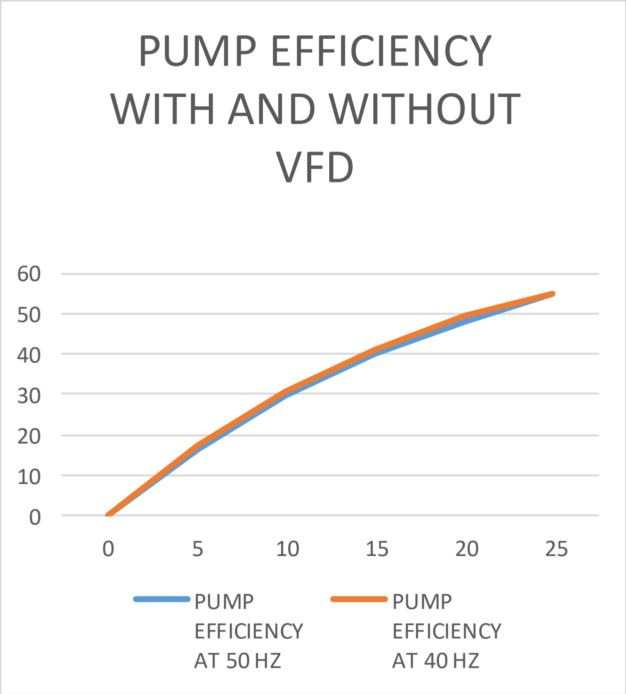

Fig.11 Comparative Pump Efficiency at 50 Hz and 40 Hz

V. CONCLUSION

Hence a Variable Frequency Drive Can be Used in a small day to day application such as pumps. We can infer that a significant amount of Energy is Saved and the Electric power Used in the presence of Variable frequency Drive is nearly Half of the amount of electrical power used in the absence of Variable Frequency Drive. These Applications can be very much useful in large scale integration and in factories which are dependent on pumps

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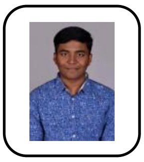

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