Energy Conservation Using Variable Frequency Drive in Pumping Application

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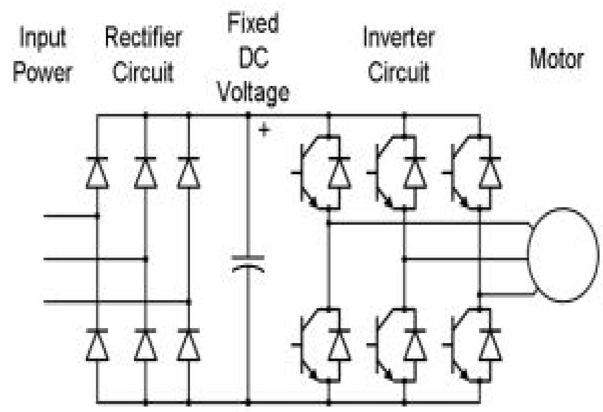
Abstract

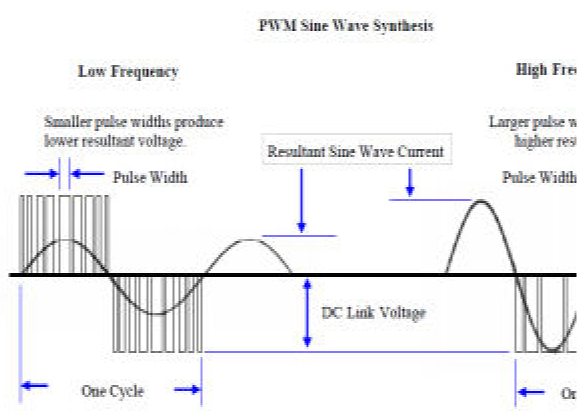
Pumping systems account for nearly 20% of the world's electrical energy demand and range from 25-50% of the energy usage in certain industrial plant operations[1].Pumping systems consume a significant portion of the electricity, Variable frequency drives (VFD's) are often recommended as a way to save pumping energy. Actual energy savings will vary greatly depending on how the discharge pressure of the constant speed pump is controlled and how it is operated after the VFD is installed. In the present work, the flow of pump has been controlled by two different methods, Matlab simulations and experimental work has been carried out and comparative statement is given in this paper. Index Terms - Centrifugal pump, flow control, throttling, variable frequency drive(VFD),Energy saving,Pulse Width Modulation(PWM).

INTRODUCTION

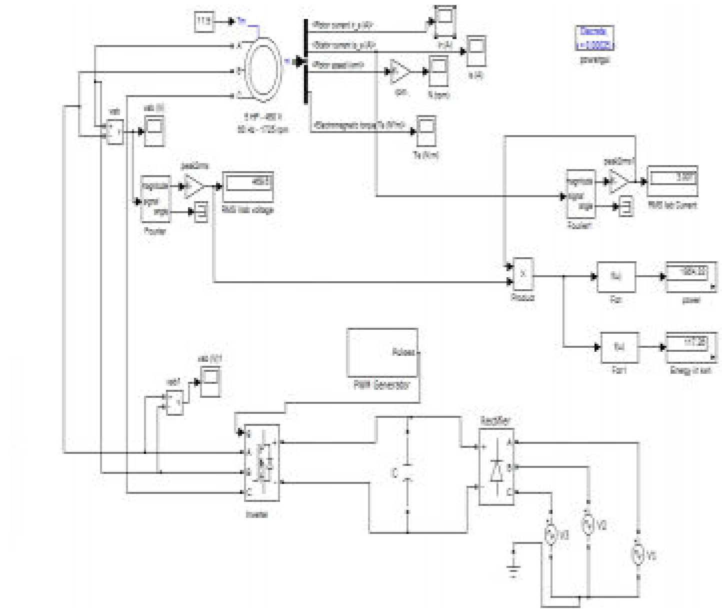
Now to save electricity for our future generation we should be aware of concept of energy conservation. With energy saving of 0.01% there is so much benefit to us [1]. So we have to be aware that where and when electricity should be conserve [2]. The cost of generation of 1 MW power is Many Crores of Rupees and takes longer years to generate. The cost of 1 MW power conservation is only less than Rs. 1 Crore. If Conservation done in morning of the day, the same evening the industry can reap the rewards of its conservation efforts. First step is to reduce the defects inside your system and automatically the Conservation happens to you [3]. Due to the renewed interest in energy saving, it has become more popular to utilize Electrical Variable Frequency Drives (VFD) to power pumps which results in significant energy savings versus mechanical means for adjusting the flow of the pumping system. Due to the characteristics of pumps it is easy to misapply motors in VFD pump applications



Variable frequency drives (VFD's) are often recommended as a way to save pumping energy. Actual energy savings will vary greatly depending on how the discharge pressure of the constant speed pump is controlled and how it is operated after the VFD is installed [12]. The speed of the motor can be changed by various methods such as hydraulic or eddy current coupling, variable pulley, gear box system etc.,



but most efficient one method is change the supply frequency and voltage to the motor. The variable frequency drive (VFD) varies the frequency and hence varies the speed of the motor as per the requirements by the load [13].

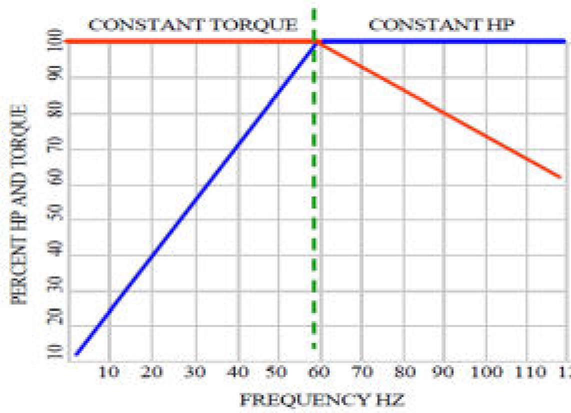


Speed control of AC/DC motors can be achieved by the variable speed drive (VSD) unit as shown in fig.2.1.

Torque (Nm)	Without VFD			With VFD			save
	Is Amp	P Watts	E kWh	Is Amp	P Watts	E kWh	
8	4.043	2337.04	140.22	2.614	1698.52	101.91	38.31
10	4.233	2535.05	152.10	2.785	1809.63	108.38	43.72
12	4.625	2814.76	168.89	3.02	1962.85	117.77	51.12
14	5.248	3087.35	185.24	3.306	2148.85	128.93	56.31
16	5.625	3263.22	195.79	3.631	2359.64	141.38	54.41

PULSE WIDTH MODULATION

VFD drive DC link voltage is constant. Pulse amplitude is constant over entire frequency range and equal to the DC link voltage as per above fig 4.1. Lower resultant voltage is created by more and narrower pulses. Higher resultant voltage is created by fewer and wider pulses. Alternating current (AC) output is created by reversing the polarity of the voltage pulses. Even though the voltage consists of a series of square-wave pulses, the motor current will very closely approximate a sine wave. The inductance of the motor acts to filter the pulses into a smooth AC current waveform. Voltage and frequency ratio remains constant from 0 - 60 For a 460 motor this ratio is 7.6 volts/Hz



TEST SETUP

The schematic diagram of test rig is shown in figure 6.1. It consists of a water tank, a centrifugal pump, magnetic flow meter, pressure gauges, and ball valve. The specification of parts is listed below Pump Description (Crompton Greaves minimaster• III) KW/hp :- 0.75/1.00• Head :- 6/45 m• Discharge :- 4000/900 lps• Pump No :- KFPM06914• Flow meter• Magnetic flow meter (ELMAG-200M)• HMI Panel (CVM-NRG96)• HMI panel is used for manual control of VFD drive. PLC• Siemens S7 200 PLC• PLC is used to control the whole pumping system, measure input parameters and compare it and give feed back to the SCADA system. Pressure Gauges•

Table 7.2 Observation Table (VFD)

Flow	Head	Active Power	Reactive Power	Apparent Power	Power Factor	RPM
m^3/hr	m	KW				
3.81	5.7791	0.1413	0.033	0.1451	0.97380	2919
3.50	5.1055	0.1183	0.02733	0.1214	0.97434	2703
3.20	4.8520	0.099	0.02266	0.1015	0.97477	2465
2.90	4.1120	0.082	0.01633	0.0836	0.98073	2235
2.50	3.8996	0.065	0.012	0.0661	0.98338	1933
2.12	3.5542	0.0526	0.01	0.0536	0.98244	1632
1.51	3.0254	0.039	0.006	0.0394	0.98837	1172

CONCLUSION

As by control the flow of pump with throttling, net head increases and to overcome this extra head motor draw extra power as shown in table no7.1 & 7.2. VFD offers a very good response to pumping system. Reduces the flow with VFD, motor consume very less power. So significant amount of power can be saved with the help of Variable Frequency Drive as table no7.1 & 7.2. As per Matlab Simulations Fig.5.1 (three phase Induction motor without VFD) and Fig. 5.2 (three phase Induction motor with VFD) as per result shown in fig.5.9 that electrical energy can be save by VFD in pumping application. Using VFD, there are harmonics introduced in above given simulation results but it can be removed by proper passive or active filters. VFD also serves as Soft Starter, during starting motor draws 6 times more current than rated current. While starting with VFD, motor draws very less current and also provide a smooth stopping of motor. So the losses occur in motor can be eliminated. VFD also improve the Power Factor, Form the table it can be clearly seen that while controlling the flow with Throttling, Power Factor remains very low compared to VFD which maintain the Power Factor near to unity and because of this the losses regarding to low Power Factor like Increase the I2R and I2X losses, Increase thermal stresses, increase size of conductor, circuit breaker etc. reduces.

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