Energy Conservation in Solar PV Pumping System using BLDC Motor

N. D. Perane[1] N. H. Mate[2]
[1,2]Department of Electrical Engineering
[1,2]S.N.D.COE & RC Nasik, Maharashtra, India

Abstract— The demand of electricity is increasing day by day, the demand gap of energy is also increasing drastic change simultaneously and also generation control is also a big problem this gap in demand energy is responsible for energy crisis which we face today. Due to this there is a vast need for energy efficient technologies. So we can mitigate this energy gap by shifting towards Renewable energy sources coupled with some energy efficient systems. According to literature survey the PMBLDC (Permanent magnet Brushless DC motor) based pump sets are found to be more efficient and reliable than the other conventional pump sets. So this paper is an effort to show solar powered PMBLDC pump set is more efficient than conventional pumping system for energy conservation and utilization.

Key words: Alternative Energy Sources, PV Panels, PMBLDC Pump System

I. INTRODUCTION

The demand of energy is increasing with increase in population, due to it the energy consumption is also increasing simultaneously. Thus due to this energy deficiency ,the energy crises issue also arises, To mitigate this energy consumption there is burning of fossil fuels at great extent. Which is not only creating the global issues like global warming but also it is depleting the natural resources(fossil fuels).Thus it has become very much necessary to find an alternatives. Renewable sources can be the best alternative to fulfill the energy gap, while using it with more energy efficient technology can further improve the results. Solar energy is a form of eco-friendly type of energy i.e. harnessing this energy does not create any damage to the environment. Solar energy is an everlasting i.e. never ending source of energy.

Industry contributes for nearly 49% of total energy consumption in India. Thus by utilizingsolar system with proper energy efficient system can help in reducing the burden on the generating stations. As water is a basic need for everyone may it be industry as well as agriculture field, water pumps are widely used in all industries which contributes to around 10% of total energy consumption in a industry. Usually pumps are coupled to various types of electrical motors like 3 phase squirrel cage induction motor, dc shunt motor, PMBLDC motor etc. Each motor contributes for different efficiency. Thus pumps using the solar powered PMBLDC motor drive can help in reducing this 10% energy consumption of an industry. These solar powered PMBLDC pump set are have longer life, less bulky and maintenance free.

II. SYSTEM DESIGN

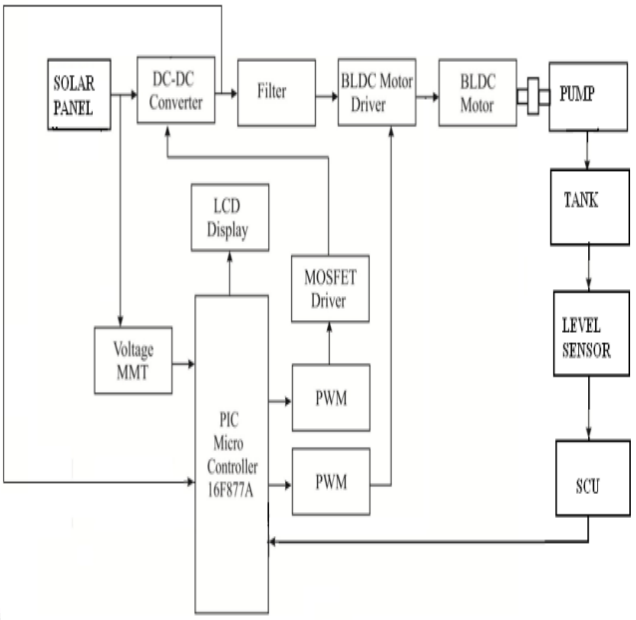

Fig. 1: Block Diagram of the System

A. PV-ARRAY:

The solar cells are connected in series and parallel combinations in order to get the desired level of voltage and current. The equivalent circuit of PV array as indicated.

B. DC-DC Converter:

These converters used in this system works as a boost converter, which are selected on the basisof ratings of the PV array and the inverter voltage the main function of this boost convertors is to step up the output voltage to the voltage required by the BLDC Drive. Irrespective of the variations in the PV output voltage, the boost converter output voltage is kept constant by a control circuit which utilizes a PIC controller. A switching frequency of 1 kHz is chosen for the design and a MOSFET of appropriate rating is selected as a switch.

C. Inverter and BLDC:

In a conventional DC motor, current polarity is changed by using commutator and brushes. In the brushless DC motor, polarity is reversal action is performed by power transistor switching in synchronization with the rotor position. To accomplish this, the input of PMBLDC motor is connected to inverter. Inverter is designed in such a way that, its output frequency is a function of instantaneous rotor speed and its phase control will correspond to actual rotor position. Typically a BLDC motor is driven by 3 phase inverter with six step commutation Here the conducting interval of each phase is 120° electrical angle. In order to produce maximum torque, inverter should be commutated every 60°, so that current is in phase with the back EMF.

D. PUMP:

The Two types of pumps are generally deployed for water pumping applications: positive displacement and centrifugal. Positive displacement types are used in low-volume pumps and cost-effective. Centrifugal pumps have relatively high efficiency and are capable of pumping a high volume of water. It is found that PV energy utilized by centrifugal pump is much higher than volumetric pump the pump used is of centrifugal type which can be described by an aerodynamic load and is characterized by the following equation

E. Level Sensing Mechanism:

Sensors are been used to indication of water level. When the lowest level is reached the signals are given to the BLDC driver which starts the BLDC motor thereby initiating the pumping process. When the medium level is reached the duty cycle is reduced to run the drive at a relatively low speed. When the highest level is reached i.e. when the tank is full the controller provides the brake signal to the BLDC motor thereby stopping the pumping operation.

F. PIC Controller:

PIC microcontroller is the RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques. PIC microcontroller performs the following three prime functions: It receives solar panel output voltage and boost converter output voltage as input and based on these inputs it generates PWM signals to MOSFET (in boost converter). It generates PWM signals for the MOSFET switches in the inverter. It receives input from the water level sensor based on which it automates the drive operation.

III. ANALYSIS

Small Scale chemical Industry with Annual turnover of Rs 1.5 Crore per year from Bhosari Industrial area,Pune in Maharashtra State was selected by MSEDCL Company. The electric motors used for each drive is a 3 phase induction motor. As the industry main product was chemicals, surplusquantity of water was required by the industry. The water used in the industry average around 1 lakh liters per day. The main operation time of the company was from 08:00 hours to 18:00 hours. The water pumps shares around 30% share of total consumption i.e. 81 kW.And the total energy units consumed by the company were 40000 units per month. The water head required was 20 meters.

Sr. No	Particular	Motor rating (kW)	Quantity	Total Load(kW)
1.	Drying machine	3	3	9
2.	Mixer	2.5	3	7.5
3.	Water Pump	20 5	1 1	25
4.	Cold Storage	5	2	10
5.	Lighting	--	--	15
Total				66.5

Table 1: Indicates the Load Profile of an Industry

Sr. No	Particulars	Units consumption /month	% of total consumption
	Drying machine	5000	12.5
	Mixer	8000	20
	Water Pump	12000	30
	Cold Storage	5000	12.5
	Lighting	3000	7.5

Table 2: Indicates Percentage Share of Energy Consumption of Different System

Thus One 10kW rating pump was selected for replacing with one Solar based BLDC pump set. The pump selected previously used to contribute 4000 units of energy consumption per month and taking into consideration the duty cycle of pump set is 10 hours per day during daytime (sunlight).

So energy consumed per day by electric pumps sets = 10(kW) x2x10(hrs.) =200 kWhr (units) per day.
Thus the solar based BLDC Pump Set , having capacity of 225 kW is selected which has the ability of water discharge 30000 liter. Per day. For more effective operation the system was installed with a Solar tracking system.

Thus the energy consumption by a single electric pump for one month of operation and with 10 hour duty cycle per day was 4000 units. But by using the solar based PMBLDC Pump set water was efficiently pumped for 10 hours. So around 3000 units were saved for a single month it contributed for around 10% of total monthly consumption.
And also by using this Technology following benefits were also obtained significantly:

- This type of sets is independent on fuel other than sunlight
- These sets are ecofriendly as there are no harmful bi products
- Solar PV cells are arranged in this way having self-draining and self-cleaning ability.
- These system are having less wear and tear due to brushless structure so less downtime and maintenance.
- Maximum reliability is obtained due to no longer transmission wires, no oil etc. thus it is a very reliable system.
- Easily expandable, as solar PV panels can be added whenever it is required to enhance its capacity.
- DC-DC convertors are employed thus the operation of PMBLDC Motor is not affected due to poor sunlight.
- Overall efficiency of system is maximum so it helps in energy conservation.
- payback period is also very less

1) Payback calculations:

Units savings = 4000 (units)
Savings (Rs) = 4000 X 5 = RS 20000
Cost of System = 380000
Subsidies = 120000 (from MNRE 30% of the cost)

Total cost of installation = cost of system - subsidies by MNRE
= 380000 -120000 = 260000
Payback period = Cost of installation/total monthly savings
= 260000/20000 = 13 months ~ 1year and 1 month

IV. CONCLUSIONS

As in India Nearly 67% of energy is generated using coal based power plants i.e. Thermal Power Plants. As population is increasing the load demand is increasing simultaneously. That is causing the energy shortage problem which contributes to energy crisis. Thus it had become very much necessary to find alternatives. And renewable energy sources are found to be the best alternatives for the same. So shifting towards these sources is becoming very much vital.

Industry contributes to nearly 49% of energy consumption of total generation. Thus the industrial sector has a lot of potential for saving of energy. Thus in industry switching towards energy efficient technologies coupled to renewable energy sources can be very much effective solution. By following this industry can not only save energy but can reduce the cost of production of particular product. That can help them in surviving competition in markets. It also helps the environment in reducing the CO2 emission.

From the above case analysis the use of solar based PMBLDC pump sets are found to have saved around 4000 units of energy that is around 10% of total consumption. The system also has an effective payback period i.e. 1 year 1 month (13 months).So it is very much beneficial for industry as well as the environment.

REFERENCES

[1] V A Kulkarni and Dr. P K Katti "Energy Conservation in Industries by PV Solar Pump as Renewable Energy Source "
[2] Ministry of New and Renewable energy GOI. www.mnre.org
[3] S.Karthikeyan, B.Kavitha, B.Iswarya "Design of solar PV water pumping system using BLDC driveUsingsensor less method"
[4] Solar Lighting Systems Module Ministry of New and Renewable Energy Govt. of India, Trainers Textbook
[5] T. D. Short, R. Oldach, Solar Powered Water Pumps: The Past, the Present—and the Future?, Transactions of the ASME,Vol. 125, FEBRUARY 2003.
[6] V A Kulkarni and Dr. P K Katti, "Efficient utilization of energy in industry- energy management perspective"IEEE Int Con. on Power Technology. (POWER CON 2010) Oct 2010, China.
[7] Mohanlal Kolhe , J. C. Joshi, and D. P. Kothari, Senior Member, IEEE, Performance Analysis of a Directly Coupled Photovoltaic Water-Pumping System, IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 19, NO. 3, SEPTEMBER 2004.

