PERFORMANCE ANALYSIS OF PV FED SEPARATELY EXCITED DC MOTOR PUMP SYSTEM WITH AND WITHOUT MPPT USING MATLAB/SIMULINK

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Abstract- Photovoltaic (PV) water pumping systems have been increasingly popular in remote areas where grid is not accessible or is too costly to install. These systems are mostly used for agriculture and household purposes. Solar energy has the greatest potential of all the sources of renewable energy. In order to make solar energy competitive with the other forms of renewable energies, a better exploitation of its advantages especially environmental side, this will be possible only with the development of the less expensive and high output efficiency systems. This paper focused on PV-powered water pump using Separately Excited DC Motor is taken into account. The modeling of PV cell, Buck-Boost converter and Separately Excited DC motor with and without MPPT has been studied and developed. For MPPT hill climbing method is implemented and PV-powered water pump using separately excited DC motor pumping system fed by solar cell are simulated and their results for maximum mechanical output power are obtained and compared.
Keywords: SEDCM, PV, PUMP, MPPT, PWM, LPF, MATLAB/ SIMULINK.

1. INTRODUCTION

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. The Earth receives 174 peta watts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near infrared ranges with a small part in the near-ultraviolet.

Solar-powered pumping systems can be configured to meet a wide variety of demands. The amount of water a solar powered pump can deliver is a function of how far the water has to be lifted, the distance it has to travel through a delivery pipe (and the size of pipe), the efficiency of the pump being used, and how much power is available to the system. Power can be increased by adding more solar panels. One of the main advantages of a solar-powered pumping system is its simplicity and durability. The pump is the only part of the system having any moving parts, and it comprises a relatively small portion of the total system cost.

In this paper, a simple but efficient photovoltaic water pumping system is presented. It provides theoretical studies of photovoltaics (PV) and its modelling techniques. It also investigates in detail the maximum power point tracker (MPPT), a power electronic device that significantly increases the system efficiency. At last, it presents MATLAB simulations of the system and makes comparisons with a system without MPPT.

2. PROPOSED SYSTEM

The experimental water pumping systems proposed in this paper are stand-alone type without backup batteries.

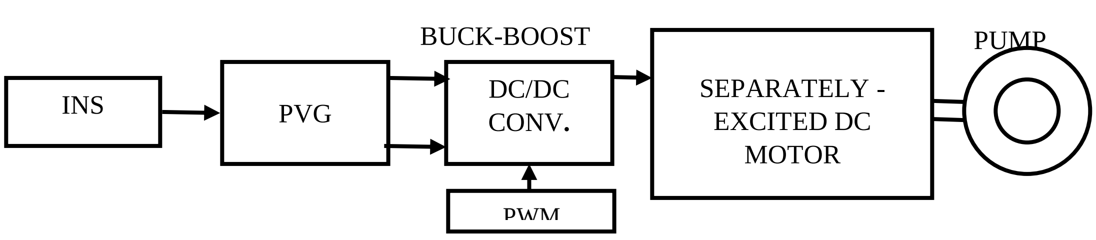

Fig. 2.1 PV fed Separately Excited DC Motor Pump System without MPPT

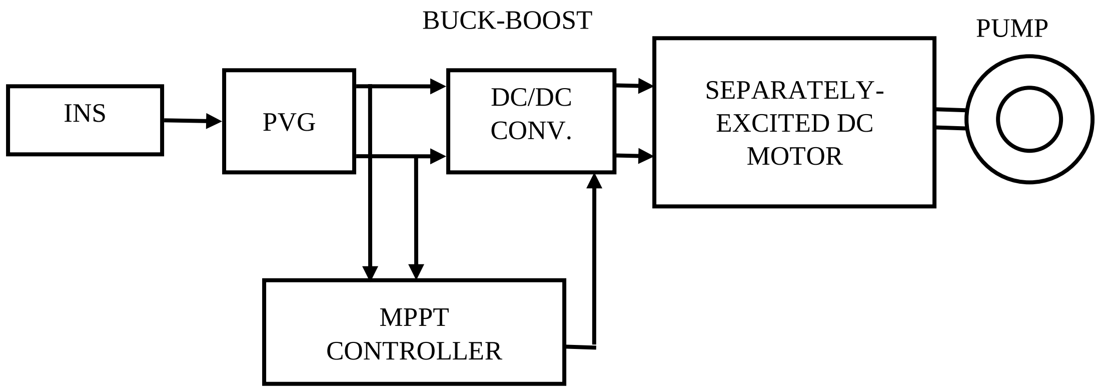

Fig. 2.2 PV fed Separately Excited DC Motor pump system with MPPT

3. GENERALIZED PV MODEL BUILDING AND SIMULATION

A model of PV module with moderate complexity which includes the temperature independence of the photocurrent source, the saturation current of the diode, and a series resistance is considered based on the Shockley diode equation. It is important to build a generalized model suitable for all of the PV cell, module, and array, which is used to design and analyse a maximum power point tracker. Bing illuminated with radiation of sunlight, PV cell converts part of the photovoltaic potential directly into electricity with both I-V and P-V output characteristics. A generalized PV model is built using MATLAB/Simulink. The proposed model is implemented and shown in fig. 3.1, in which the parameters of PV module can be configured in the same way for the Simulink block libraries.

A detailed block diagram of Simulation Model of PV Fed Separately Excited DC Motor Pump System without MPPT is shown in fig. 3.2. A solar array model is used to simulate the behaviour of solar panel (of 100 cells in series & 50 in parallel) & step input is applied to it showing the radiation intensity to the panel. Then according to the PV model it generates some power at particular terminal voltage now the output is connected to the input of the DC to DC converter and is also sensed by the current and voltage sensors, now the sensed values of current and voltage is used for estimating the power supplied by the PV panel to the load. The duty cycle of the buck boost converter is fixed to 0.8. Since the output of the DC to DC converter contains lots of spikes and ripples it is filtered by the next block. After filtering we get relatively smooth DC voltage which is now applied to the separately DC motor (of 240V, 5HP, 1750rpm).

A detailed block diagram of Simulation Model of PV Fed Separately Excited DC Motor Pump System with MPPT system is shown in fig. 3.3. A solar array model is used to simulate the behavior of solar panel (of 100 cells in series & 50 in parallel) & step input is applied to it showing the radiation intensity to the panel. Then according to the PV model it generates some power at particular terminal voltage now the output is connected to the input of the DC to DC converter and is also sensed by the current and voltage sensors, now the sensed values of current and voltage is used for estimating the power supplied by the PV panel to the load. After calculating the power it is compared with its previous value to calculate the sign of slope then the output is converted into binary number zero or one which is feed to the next section which is basically an up down counter it counts up for logic 1 input and counts down for logic 0 input. The counters output is used to control the duty cycle of the buck boost converter. Since the output of the DC to DC converter contains lots of spikes and ripples it is filtered by the next block. After filtering we get relatively smooth DC voltage which is now applied to the separately DC motor (240V, 5HP, 1750rpm).

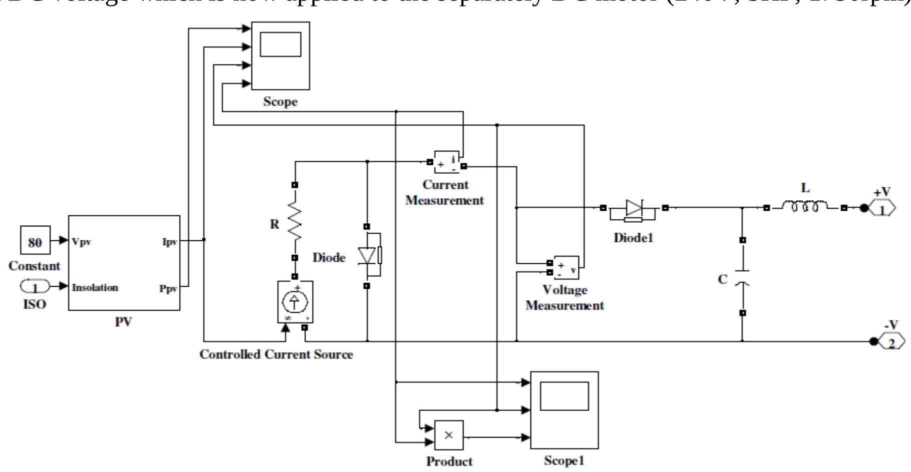

Fig. 3.1 Implementation of Generalized PV Model

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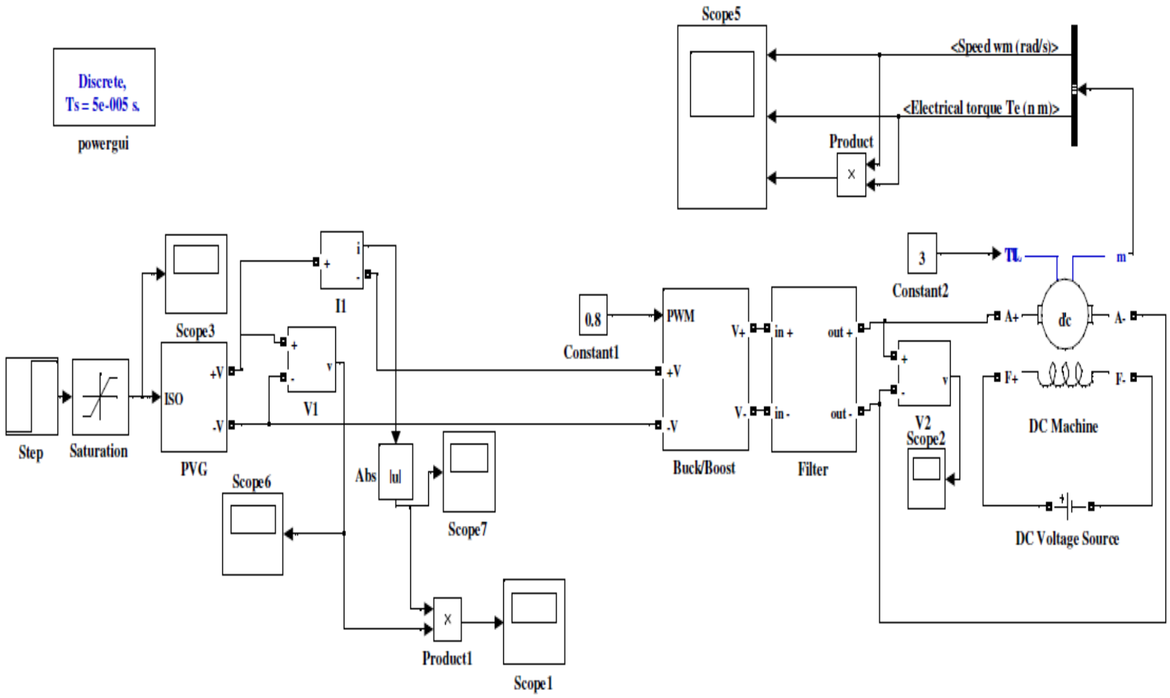

Fig. 3.2 Simulated Model of PV fed Separately Excited DC Motor Pump System without MPPT

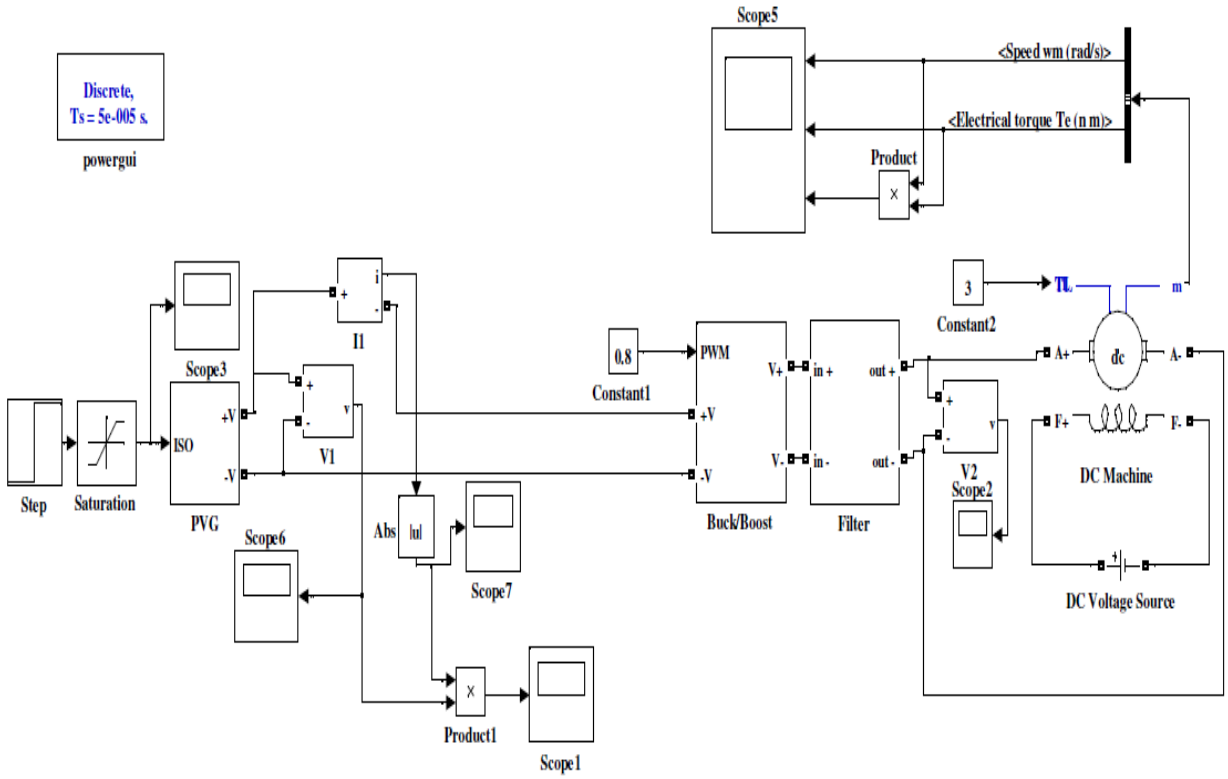

Fig. 3.3 Simulated Model of PV fed Separately Excited DC Motor Pump System with MPPT

4. SIMULATION RESULTS

The Simulation result analysis is a method, wherein the infinite calculations are made to obtain the possible outcomes and probabilities for any choice of action. It explore the behavior of the model by running a simulation. The simulation results for above Simulink model using different controlling topology are demonstrated by MATLAB R2014 a software module.

Simulation results at radiation level 400W/m^2 for PV fed separately excited dc motor pump system without MPPT are shown in fig. 4.1.

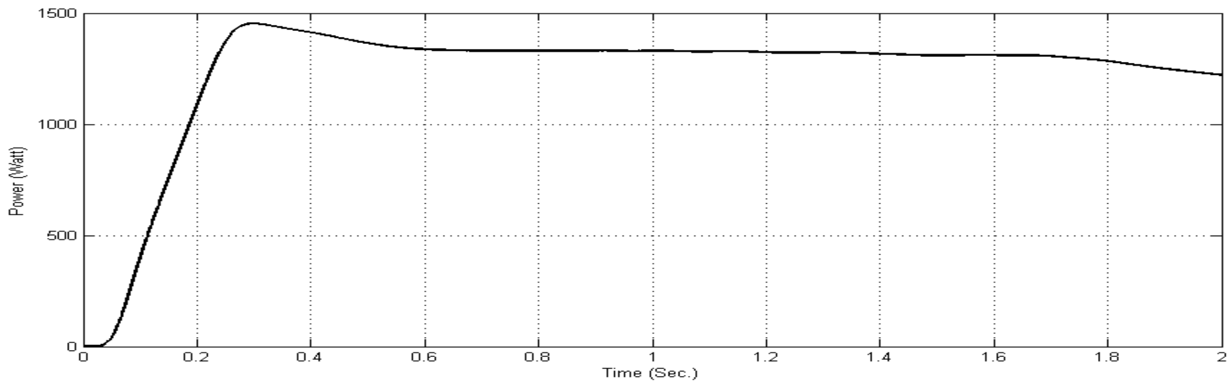

Fig. 4.1 PV Power Supplied by the PV Panel

Fig. 4.1 shows the simulated waveform of PV panel power delivered to PV fed separately excited DC motor pump system without MPPT with respect to time. PV panel delivered 1250 Watt power at radiation level 400 Watt/m^2.

Fig. 4.2 and fig. 4.3 shows the speed of motor in rad/Sec. of PV fed separately excited DC motor pump system without and with MPPT.

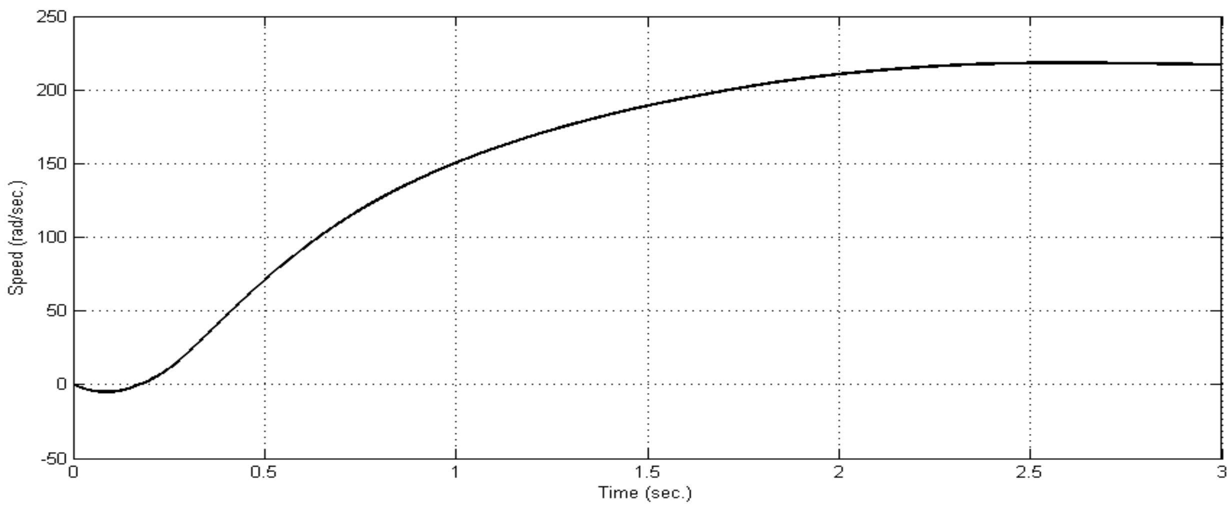

Fig. 4.2 Speed of Separately Excited DC Motor without MPPT

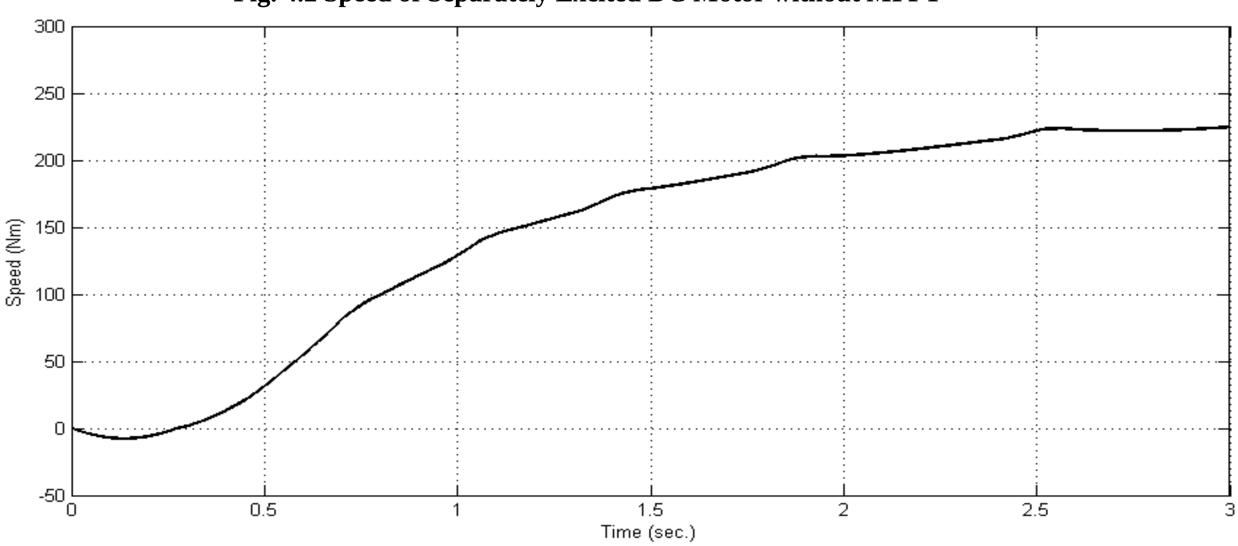

Fig. 4.3 Speed of Separately Excited DC Motor with MPPT

PV fed separately excited DC motor pump system with and without MPPT had been simulated for 200, 400, 600, 800 and 1000 W/m^2 radiation level and the results are listed in table 4.1.

Table-4.1 Comparison of Buck-Boost Converter Output Voltage for PV fed Separately Excited DC Motor Pump Systems with and without MPPT

Solar Radiation (W/m^2)	Voltage after buck-boost converter (without MPPT) (in Volts)	Voltage after buck-boost converter (MPPT) (in Volts)
200	125	100
400	225	240
600	225	250
800	225	265
1000	225	270

Table 4.1 shows comparison of buck-boost converter output voltage at different radiation level for PV fed separately excited dc motor pump system with and without MPPT.

The comparison of output mechanical power of motor at different radiation for comparison of output mechanical power of motor for PV fed separately excited DC motor pump systems with and without MPPT is shown in fig. 4.4 and also shows the graphical representation of Solar radiation V/S output mechanical power of PV fed separately excited dc motor in both cases.

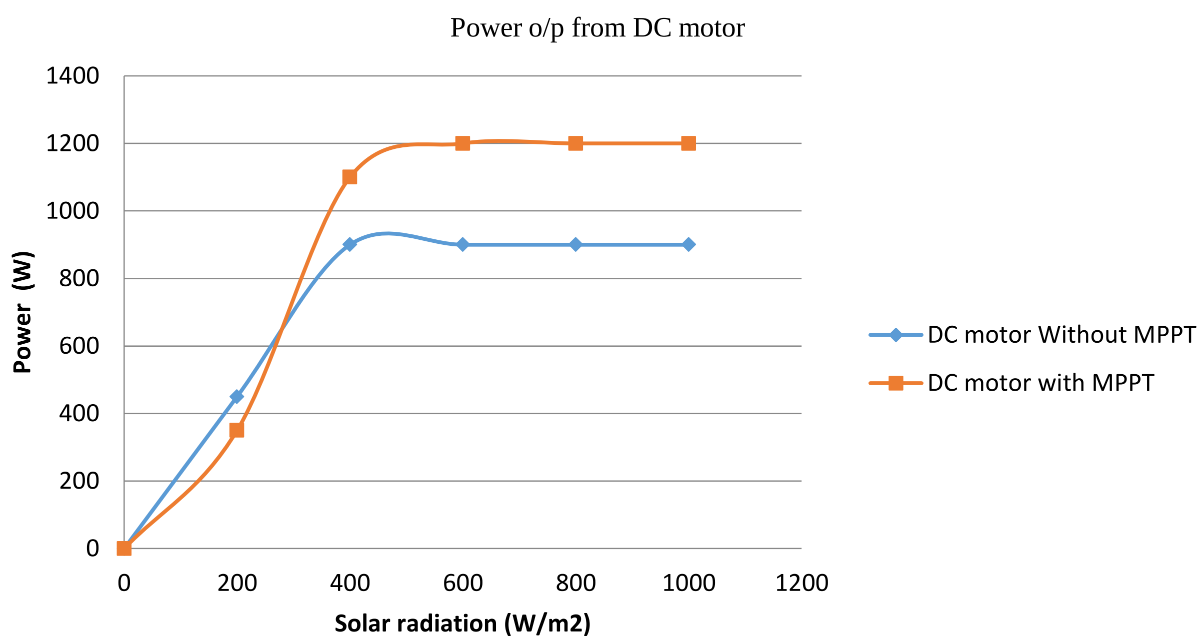

Fig. 4.4 Solar Radiation Vs Output Mechanical Power of Separately Excited DC Motor

CONCLUSIONS

The results obtained from the simulation of the system are satisfactory. This work will be a contribution to the analysis of the photovoltaic pumping system with regards to the results of simulation of the model. Simulations perform comparative tests for output mechanical power of photovoltaic motor pump systems using separately excited DC motor with and without MPPT. It performs simulations of the whole system and verifies functionality and benefits of MPPT. Simulations also make comparisons with the system without MPPT in terms of total mechanical power output of motor. The results validate that MPPT can significantly increase the efficiency of energy production from PV and the performance of the PV water pumping system compared to the system without MPPT.

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