### 8.1 Introduction

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8.1 INTRODUCTION

In this Chapter, the DC motor pump is directly connected to PV module. The simulations curves are found out in the MATLAB. The efficiency and water pumped per day are calculated by the simulation curves.

8.2 DIRECT-COUPLED METHOD

In this method, the DC motor pump Kyocera SD 12-30 is directly coupled with PV module BP SX 150S without MPPT as shown in the figure 8.1. When a PV module is directly coupled to pump load, the operating point is seldom at the PV module’s MPP, thus it is not producing the maximum power. A study shows that a direct-coupled system utilizes a very less of the PV capacity [11].

![Figure 8.1: PV module is directly coupled to a DC solar water pump.](image)

8.3 SIMULATION CURVES OF DIRECT COUPLE SYSTEM

In this method the DC motor pump is directly connected with PV modules without using MPPT. The results are shown in Figure 8.2. This method has a severe disadvantage because the flow rate of water is lower throughout the operating period.
(c) Direct-Coupled System

Output Voltage (V) vs. Output Current (A)

Output Voltage: 26.48 V
Output Current: 4.722 A

(d) Direct-Coupled System

Flow Rate (L/min) vs. Hour

Flow Rate: 10.84 L/min
Hour: 0.9017 hours
Figure 8.2: Simulation curves of direct-coupled method with DC motor pump without using MPPT.
8.4 ENERGY UTILIZATION EFFICIENCY OF PV MODULE

Energy utilization efficiency of the PV module is the ratio of utilization energy of the PV module to the theoretical energy (total maximum power points energy) of the PV module. Here in this chapter, The DC motor pump is directly coupled with the PV module without using MPPT, so the utilization power of PV module is the power consumed by the DC motor pump. The utilization energy (utilization energy = utilization power \times \text{time}) of the PV module from the simulation curve (Figure 8.2f) can be calculated as:-

\[
\text{Utilization energy of PV module for a day (12 hrs)} = 0.5 \times 122.91 \times 0.4892 + 125 \times 11.0975 \\
= 30.063786 + 1387.1875 \\
= 1417.25\text{Wh} \\
\sim 1411.7\text{Wh (by simulation program)} \tag{8.1}
\]

The Theoretical Energy of the PV module = 1732.3Wh (from section 2.9).

\[
\text{Energy Utilization Efficiency} = \frac{\text{Utilization Energy}}{\text{Theoretical Energy}} \\
\frac{1411.7}{1732.3} = 81.49\%
\]

<table>
<thead>
<tr>
<th>Theoretical Energy of the PV module</th>
<th>1732.3Wh</th>
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<tbody>
<tr>
<td>Utilization Energy of PV module</td>
<td>1411.7Wh</td>
</tr>
<tr>
<td>Energy Utilization Efficiency of PV Module without using MPPT</td>
<td>81.49%</td>
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The result shows that the PV water pumping system without MPPT has poor energy utilization efficiency because of mismatching between the PV
module resistance and the DC pump motor load. The system with MPPT is discussed in the next chapter.

8.5 WATER PUMPED PER DAY

The flow rate of DC motor pump is 10.84 litre/minute is found out by the above simulation curve (Figure 9.2d). The total water pumped by the DC motor pump in a day (12 hrs.) can be determined by the simulation curve (Figure 9.2d) is given below:-

Total Volume of Water Pumped in a day (12 hrs)

\[ = 0.5 \times 10.7318 \times 0.53 \times 60 + 11.0983 \times 10.84 \times 60 \]

\[ = 171.215 + 7218.334 \]

\[ = 7389 \text{ litres} \]

\[ \sim 7340.7 \text{ litres (by the simulation program)} \] (8.2)

Please refer Appendix 1.9 for this MATLAB program

8.6 CONCLUSION

As shown in simulation results of direct-couple system without using MPPT. The energy utilization efficiency without using MPPT is 81.49% and the total volume of water pumped per day is 7340 litre. So for increasing the energy utilization efficiency and total volume of water the MPPT is used in the system which is explained in the next chapter.