

A Simplified but Accurate Prevision Method for A Stand-Alone Photovoltaic Pumping System using Linear Interpolation/Extrapolation

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Abstract: The Saharan medium by its arid nature and the availability of solar immense in our country, 7.8 kWh/m²/day can return the application of the water pumping via photovoltaic (PV) pumping system. However, due to their relatively high cost, the sizing of these systems implies the use of an accurate tool. In this paper, a new practical formulation is proposed, in order to predict the daily pumped water quantity (Q_d) for a given daily array energy output (E_{pv}) profile and any total manometric head (H). The model based on the linear interpolation/extrapolation, called: translation of the E_{pv} - Q_d characteristics of pumps. This technique has been developed based on experimental study. This makes practical translation procedure much easier; only four E_{pv} - Q_d characteristics measured at any E_{pv} and H can be used as the reference E_{pv} - Q_d characteristics. The calculated the Q_d over a wide range of E_{pv} and H well agree with experimental results of PV pumping system. These results indicate that the translation of the E_{pv} - Q_d characteristics based on this method is effective for estimating the performance of the PV pumping system under various climatic conditions.

Keywords: PV pumping, (E_{pv}, Q_d) characteristic, Translation, Array energy output, daily pumped, Head.

1. Introduction

During the day, the speed of the brushless DC motor-pump depends on the temperature (T_c) and the quantity of the solar irradiance (G) that is fallen on the photovoltaic panels to extract the maximum power. This latter, is obtained by the proper adjustment of the inverter frequency (by increase or reduction) instead of the MPPT circuit (maximum power point tracker), inducing a total improvement of the efficiency of the system. On the other hand, the flow rate (Q) and the efficiency of the motor-pump for a total head (H) depend on the speed (related to the irradiance) if we considered that the number of stages is fixed (i.e Standard Centrifugal Pump, SCP) [1, 2].

The variation of the pump's speed can give us numerous charts Q-H. The use of a centrifugal pump needs a preliminary study of the most important charts that characterize it, where efficiency will be optimum with the total head and the speed envisaged by control the pumped water quantity to a desirable head. In addition, they are related to dimensions, kinds and speed of the pump. The Flow-Head characteristics of a centrifugal pump, Figure 1, driven at a rotor speed Ω can be approximated by quadratic form using Pfleider-Peterman model [3, 4]:

$$H = a_0 \cdot \Omega^2 + a_1 \cdot \Omega \cdot Q + a_2 \cdot Q^2 \quad (1)$$

a_0 , a_1 and a_2 are constants depending on the pump dimensions.

For the determination of the pump operating point it is required to know both the pump and pipeline characteristics. The piping system deals with the total head that must be overcome by the pump. The H-Q characteristic of the pipe network is given as a function of the geodetic head and head losses (as function of the flow-rate) [3]. Thus, it should at least equal the head corresponding the flow computed by the pump flow-head equation. It comes:

