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Motor-pump system modelization

A. Hadj Arab[a,*], M. Benghanem[b], F. Chenlo[c]

[a]*Centre of Development of Renewable Energies, BP 62 Bouzaréah, Algeria*
[b]*Institute of Electronics, University of Sciences and Technology Houari Boumediene, BP 32, El-Alia, Bab-Ezzouar 16111, Algiers, Algeria*
[c]*Departamento de Energías Renovables-CIEMAT. Avda. Complutense 22, Madrid 28040, Spain*

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Abstract

This paper presents two mathematical motor-pump models for photovoltaic (PV) applications. These models will allow us to obtain the operating point with the PV array and the flow rate of the pumped water. The modelled motor-pump characteristics are current–voltage and flow–voltage. The models are established for centrifugal and positive displacement pumps coupled to DC motors. The experimental data is obtained in our pumping test facility. A simplified method is proposed to obtain the parameters of these models in order to reduce the number of experimental measurements to the minimum.

Keywords: Motor-pump; PV pumping; Modelization

1. Introduction

Photovoltaic (PV) water pumping is one of the most typical PV application in developing countries and has the potential to become a major force for social and economic development. In Algeria many remote villages are not yet connected to the electric grid and face severe problems of water for drinking and irrigation purposes [1].

There are several theoretical models of pumps and motors [2,3]. Nevertheless, to obtain the parameters of the models applied to concrete motor-pumps, we need to separate

* Corresponding author. Tel.: +213 21 901503; fax: +213 21 901654.
E-mail address: hadjarab@hotmail.com (A. Hadj Arab).

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physically the motor from the pump and to measure their current–voltage (I–V) and flow–voltage (Q–V) characteristics in relation to the torque and the velocity.

For these reasons, we have decided to use an empirical model for the complete motor-pump system in which parameters are obtained in a pumping test facility, built for this purpose. It allows us to characterize any pumping system in the ranges from 0 to 100 m for the pumping head and from 0 to 30 m^3/h for the flow rate and from 0 to 50 A and from 0 to 250 V for the PV array [4].

In this pumping test facility we obtain, for each fixed pumping head, the pumped flow versus input voltage, simultaneously we measure the consumed current and therefore, we get the relation between the curves I–V and Q–V.

2. Motor-pump modelization

2.1. Modelization for each pumping head

The experimental part is based on the measurements of two centrifugal pumps and two positive displacement pumps CP1, CP2, DP1 and DP2. The characteristics of these pumps are summarized in Table 1. These pumps have been completely characterized in the pumping test facility in order to proceed to their modelization. To obtain these curves, we have fixed the pumping head, varying the input voltage, and we measured the following parameters:

- The input DC voltage and current
- The output flow rate and pumping head

Then we fixed another head and we repeated the same process of measurement. In this way, we obtained two measured curves I–V and Q–V of the motor-pump assembly of each head.

Figs. 1 and 2 show an example of the experimental values obtained with DP1, which represents the dependence of the current and the pumped flow versus the voltage for each head. From these results, we have tried to find simple mathematical expressions, which allow us to adjust these experimental values. In the case of the current versus the voltage, we found that it is linear. In the case of the flow, the experimental points present a certain curvature, therefore it seems more suitable to use a second-degree equation. For this

Table 1
Technical characteristics of the modelled pumps according to the manufacturer data

Type	Floating centrifugal and single stage	Floating centrifugal and multistage	Positive displacement and submersible	
	CP1	CP2	DP1	DP2
Motor	Brushless DC	DC	DC	DC
Nominal power (W)	450	400	120	300
Range voltage (V)	0–100	0–48	24	12–45
Maximum current (A)	8.4	13	4	10