ABSTRACT

In view of the tremendous potential for wind-powered shallow-water pumping and technical limitations of the conventional wind-driven piston pumps, a study was undertaken to identify, design and develop a suitable wind powered water pumping system with roto-dynamic regenerative pump.

Characteristics of wind regimes were modeled in terms of its energy density, the energy available in the wind spectra over a time period and the velocity carrying the maximum energy in the regime. Wind data from eight selected sites were collected and analysed using the proposed model. From the estimates of energy density and energy available over a time period, the wind-powered water pumping was found to be a viable option in all the study locations. A system with a design wind velocity of around 6 m/s, and cut-in and cut-out velocities of 3 m/s and 10 m/s respectively is found suitable for the region.

Performances of an innovative system with roto-dynamic pump and the most common wind pumping system with positive displacement piston pumps were analysed. Separate mathematical models were developed to estimate the instantaneous and the integrated performances of these systems at fluctuating wind regime conditions . Performances of these systems were simulated using a computer model. Considering the integrated performance, the roto-dynamic pumps offer higher output than that of a piston pump in all the wind regimes with an average wind velocity of 2 m/s and above.

Based on the results of wind regime analysis and modeling, a suitable roto-dynamic regenerative pump with 0.015 specific speed and 16.3 specific diameter was designed to match with a medium solidity 3 m rotor. The required gear ratio and diameter ratio were 3.28:1 and 9.14:1 respectively. A scaled down model of the design was fabricated and tested under various operating speeds and pumping heads. The regenerative pump model offered reasonably good performance even at low operating speeds. Maximum efficiency of the pump ranged from 35.7 per cent to 39.2 per cent. The shut-off head of the pump at its design speed of 1252 r/min was 8.58 m. The power requirement of the pump at the shut-off point and at the design speed was 32.62 W.

Based on the test results of the model pump, performance of the prototype wind powered regenerative pump was estimated. The proposed system is expected to deliver 153 litres of water per minute at a wind speed of 6 m/s against a design head of 5 m. Peak overall efficiency of the system was estimated to be 14 per cent. The system offered good performance even at off-design wind speeds. The proposed system with regenerative pump is found to offer better performance in wind powered water pumping, in comparison with reciprocating and centrifugal pumps.

Key Words: wind energy, energy potential, energy density, velocity distribution, wind turbine, wind pump, reciprocating pump, roto-dynamic pump, regenerative pump, load matching, horizontal axis rotor, dimensionless pump characteristics.