

Research Article

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Energy Saving in a Variable-Inclination Archimedes Screw

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Abstract

An analysis was undertaken of a new development of Archimedes screw consisting of a variable-inclination screw suitable for applications in which the downstream level may vary (e.g. sea level). As a result the energy consumption when the downstream level is low is less than that of a conventional, fixed Archimedes screw. In addition, investment costs are lower as a result of less expensive civil work being required. Moreover, this screw can also act as a check gate because it has a float at its downstream end. The flow rate for different rotational speeds was measured and a good fit was obtained with a developed graphical model. This paper analyses the operation of an Archimedes screw prototype pump of variable inclination and models its behavior. Its energy consumption is then measured and compared with that of conventional fixed inclination screw pumps.

Keywords: Archimedes screw; Discharge flow rate; Elevation height; Conventional pump; Variable inclination pump

Introduction

The Archimedes screw is a device for lifting water to low heads which dates back to the third century BC and is still in use today. Its main advantage is its effectiveness when lifting low-head debris-laden water. Though technological advances have logically seen various modifications to the device since its first use to the present day, its operating principle remains the same. Its principle applications are in drainage water pumping stations and water treatment plants. It has also proved valuable in installations where damage to aquatic life needs to be minimized. Given the antiquity of the device and the consequent empirical knowledge that has been acquired, little is to be found in the literature on its technical aspects. A manual was however written by Nagel [1] for the design of installations with this type of pump in which he explains a graphical method for calculating the flow rate in a screw pump according to the screw's geometry and rotational speed. Wijdenks and Bos [2] proposed a simple empirical equation to obtain the discharge from an Archimedes pump,

$$Q = k \cdot \pi \cdot D^3 \left[\frac{\pi n}{60} \right] \quad (1)$$

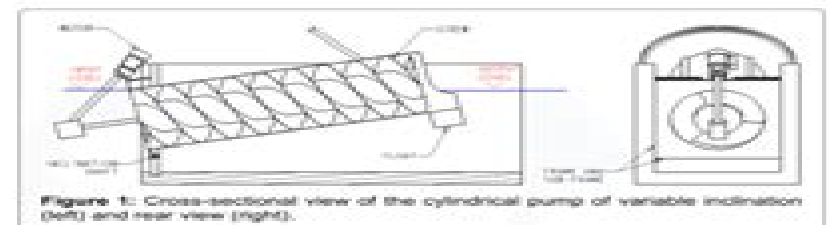
Where: k is an empirical coefficient which depends on the shape of the screw, characterized by: S/D , d/D , and the inclination β [2], n is the turning speed (rev/s) and D is the outer diameter (m).

Rorres [3] developed computer software to find the volume of water lifted in one turn of the screw depending on the inner radius and pitch. From this he was able to obtain the optimum geometry values that maximize water volume per turn. However, the programme does not take into account the losses which occur in the gap between the screw and the casing. The screws are driven by electric motors the sizing of which depends on two basic factors: The discharge flow rate and the elevation height. Discharge can be regulated through advances in the control of motor turning speed, either through the use of variable frequency drives [4] or a gear reduction system. This paper analyses a new development of the conventional Archimedes screw. The modification involves variation of the inclination of the screw depending on the downstream water level, thereby obtaining a considerable energy saving in those applications in which the downstream level is variable (i.e. sea level).

Description

The pump used in this study was designed and manufactured

by B&G BUERA Ltd. under patent No. ES 1 051 874 U. It has a variable inclination capability through the incorporation of a shaft perpendicular to the input section and a float in the output section which additionally allows the pump to act as a check gate. The pump screw is comprised of a tubular carbon steel shaft onto which is welded a three-bladed helix of cold-rolled carbon steel sheet. Seed terminations are screwed onto the ends of the shaft and the support flanges are fixed onto these. The exterior cylinder of the device is also made from carbon steel sheet and is TIG welded. There is also a support frame where the pivotal shaft of the pump is mounted which can be fully removed from a sub-frame embedded in the concrete sidewalls which acts as a runner. The presence of neoprene perimeter strips which act as hydraulic seals impede any manner of filtration or contraflow as a result of the arrangement of these intermediate elements between the flow inlet and outlet. The pump dimensions are as follows: outer diameter 1500 mm; shaft diameter 750 mm; total length 4500 mm; pitch length 1500 mm; blades 3 and blade gap 5 mm (Figure 1). The pump's asynchronous motor is located in the pump input section, transmitting motion via a transmission connected to a reduction gearbox located near the input below the level of the water. The transmission system has no



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Archimedes 55 Manual

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