

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,

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

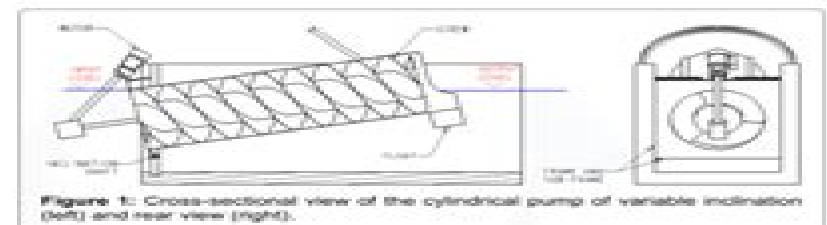
Where: k is an empirical coefficient which depends on the shape of the screw, characterized by: S/D , d/D , and the inclination β [2], n is the turning speed (rev/s) and D is the outer diameter (m).

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

Doug Knowling



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Table of Contents Archimedes 55 Manual

1. Understanding the eBook Archimedes 55 Manual
 - The Rise of Digital Reading Archimedes 55 Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Archimedes 55 Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Archimedes 55 Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Archimedes 55 Manual
 - Personalized Recommendations
 - Archimedes 55 Manual User Reviews and Ratings

- Archimedes 55 Manual and Bestseller Lists
- 5. Accessing Archimedes 55 Manual Free and Paid eBooks
 - Archimedes 55 Manual Public Domain eBooks
 - Archimedes 55 Manual eBook Subscription Services
 - Archimedes 55 Manual Budget-Friendly Options
- 6. Navigating Archimedes 55 Manual eBook Formats
 - ePub, PDF, MOBI, and More
 - Archimedes 55 Manual Compatibility with Devices
 - Archimedes 55 Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Archimedes 55 Manual
 - Highlighting and Note-Taking Archimedes 55 Manual
 - Interactive Elements Archimedes 55 Manual
- 8. Staying Engaged with Archimedes 55 Manual
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Archimedes 55 Manual
- 9. Balancing eBooks and Physical Books Archimedes 55 Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Archimedes 55 Manual
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Archimedes 55 Manual
 - Setting Reading Goals Archimedes 55 Manual
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Archimedes 55 Manual
 - Fact-Checking eBook Content of Archimedes 55 Manual
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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