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Study on Assistive Tilting Mechanisms For Vertical Axial Flow Water Pumps In Kuttanad

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Abstract:

This paper presents the design and fabrication of a tilting mechanism for vertical axial flow water pumps specially designed for water level maintenance in paddy fields of Kuttanad in India, which is the only place where paddy is cultivated below sea level. The mechanism is designed to enable the vertical axial flow pumps to be tilted from its vertical position to a horizontal position, allowing for easier maintenance and repair works of the pump. In this study we have researched on a hand lever operated mechanism, hydraulic based mechanism,chain block assisted mechanism and a motor powered mechanism. the hand lever operated mechanism is found to be the best for this specific application. The results of this study demonstrate the feasibility of using a tilting mechanism to improve the maintenance and repair of vertical axial flow water pumps.

Keywords:- *Vertical Flow Pumps(VFP's), worm gear, impeller*

1. Introduction

Kuttanad is the only place in India where paddy is cultivated below sea level [1]. The main problem faced by farmers of Kuttanad is agricultural losses ,especially in paddy and aquaculture due to massive floods. Traditionally a water pumping mechanism called the Pettiyum Parayum system was used. Now the latest Vertical Flow Pumps [VFPs] are used for water level maintenance. Time consumption & high cost for repair works are the major problems faced while servicing VFPs. By implementing the proposed tilting mechanism, we will be able to solve the above mentioned problem.

Water pumps are indispensable machines in various applications, including agriculture, irrigation, and domestic water supply. The axial flow water pump [2] is one of the most commonly used type of pump for water level maintenance. These pumps are designed to pump large volumes of water at low heads [3], since they are efficient, reliable, and require low maintenance.

However, the installation and servicing of these pumps can sometimes be a challenging task. In many situations, the pump needs to be installed vertically and in order to utilize the existing basement of traditional pumps. This vertical installation of the pump can make maintenance and repair work difficult and time-consuming. This is where the tilting mechanism can play a crucial role in improving the easiness of maintenance and servicing works.

The tilting mechanism enables the pump [4] to be tilted from its vertical position to a horizontal position, so that the pump can be accessed more easily. Additionally, it provides more flexibility in installation, allowing the pump to be installed with the minimal number of workers.

Several studies have been conducted to develop and improve the tilting mechanism for vertical axial flow water pumps. In this paper, we present our study on the various tilting mechanisms which

can be used for a vertical axial flow water pump. We also present the experimental results and our observations about the performance of the pump with the tilting mechanism.

Fig 1. Traditional Pettiyum Parayum System

2. Methodology

Various tilting mechanisms for vertical flow pumps are taken under consideration,

1) Chain block assisted tilting mechanism for vertical axial flow pumps

2) Hydraulic piston actuated tilting mechanism for vertical flow pumps

3) Gear operated tilting mechanism for vertical flow pumps
   a) Motor driven
   b) Hand lever driven

2.1. Chain block operated assistive tilting mechanism for VFP's.

2.1.1. Components:

A Chain block, also known as Chain hoist is a manual device used to lift and lower heavy loads. It consists of a heavy-duty chain, a set of gears, and a hand-held chain wheel or lever. The chain block is designed to be operated by hand. It is often used in areas where electricity is not available or where the use of an electric hoist is not practical. Chain blocks come in a range of weight capacities, from as small as 0.5 tons to as large as 50 tons or more. In this method, a Chain block is employed fortilting the VFP.

A frame is used to provide the support for the entire structure which involves the pump and the tilting mechanism.

2.1.2. Layout:

The pump is mounted on a base plate which is then placed on top of a fixed frame with rolling contact [5] between them. The base of the pump is mechanically connected to the fixed frame using two hinges. The pump can be moved towards & away from the delivery pipe for connecting & disconnecting the pump & delivery pipe, respectively.

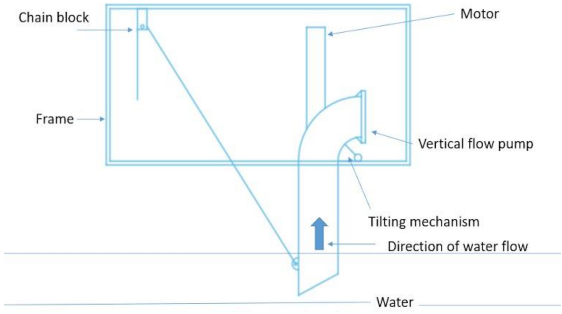

Fig 2 Chain block assisted tilting mechanism

2.1.3. Working Mechanism:

Initially, flanges of the pump & delivery pipe are disconnected. The pump can be slid away from the delivery pipe with the help of a chain block & rollers. After sliding a required distance, the sliding motion is arrested using a locking mechanism. The pump hinged to the frame can be easily tilted to a horizontal position with the help of a chain block. The pump is out of the water and can be easily serviced.

2.2. Hydraulic piston actuated assistive tilting mechanism for VFP's

2.2.1. Components:

The hydraulic cylinder is the main component of the mechanism. It is responsible for providing the necessary force to tilt the pump to a horizontal position.

The tilting plate is connected to the hydraulic cylinder and is responsible for tilting the pump to a horizontal position. It is connected to the pump through a hinge mechanism.

The control unit consists of a hydraulic pump, valves, and hoses. It is responsible for controlling the flow of hydraulic fluid to the hydraulic cylinder.

The hinge mechanism is used to connect the tilting plate to the pump. It allows the tilting plate to tilt to a horizontal position.

2.2.2. Working Principle:

The hydraulic tilting mechanism [6] is designed to tilt the vertically placed pump to a horizontal position. The mechanism consists of a hydraulic cylinder, a tilting plate, and a control unit. The hydraulic cylinder is mounted on the base of the pump and is connected to the tilting plate. The control unit consists of a hydraulic pump, valves, and hoses.

When the pump needs to be tilted, the control unit is activated. The hydraulic pump pressurizes the hydraulic fluid, which is then directed to the hydraulic cylinder through the valves and hoses. The pressurized fluid pushes the piston inside the hydraulic cylinder, which in turn pushes the tilting plate. The tilting plate is connected to the pump through a hinge mechanism [7], which allows it to tilt to a horizontal position.

Once the pump is tilted to a horizontal position, the servicing or maintenance work can be carried out easily. After the work is completed, the hydraulic cylinder is deactivated, and the pump is tilted back to its original vertical position.

2.3. Gear operated tilting mechanism for VFP's

A worm gear is a type of gear that consists of a worm (a screw-like cylindrical rod) and a worm wheel (a toothed wheel). The worm gear is a type of gear that provides high gear reduction ratios in a small space, making it useful in a wide range of mechanical applications. The operation of a worm gear is based on the principle of a screw and nut. When the worm rotates, it meshes with the teeth of the worm wheel, which causes the wheel to rotate. However, the direction of the rotation of the worm wheel is perpendicular to the axis of the worm, which means that the worm gear can only transmit power in one direction.

A tilting arm is a type of mechanical arm that can move in multiple directions and pivot around a fixed point. It consists of a series of connected links or arms, which are typically connected by hinges or pivots. The arm is designed to move in a particular range of motion, which allows it to perform various tasks such as lifting, rotating, or manipulating objects. Tilting arms are often used in industrial applications where precision and accuracy are required. For example, in welding, a tilting arm can hold the welding gun at a precise angle and move it along a straight line to ensure a high-quality weld. In assembly operations, tilting arms can be used to position and align components for efficient assembly.

2.3.2. Layout:

A worm gear [8] assisted tilting mechanism for vertical flow pumps is a device designed to assist in tilting a vertically placed pump to a horizontal position using a motor. This mechanism is typically used in situations where a pump needs to be serviced, maintained or replaced, and the weight of the pump makes manual tilting difficult or impossible.

The mechanism consists of several key components, including a worm gear, a motor, and a tilting arm. The worm gear is a type of gear that consists of a screw-like shaft with teeth that mesh with a gear wheel. When the worm gear rotates, it causes the gear wheel to rotate in a perpendicular direction. The motor is typically an electric motor that is connected to the worm gear via a belt or chain drive.

The tilting arm [9] is a structural component that connects the worm gear to the pump. It is typically made of a sturdy material such as steel and is designed to withstand the weight and the dynamic loads of the pump. The tilting arm is attached to the pump at one end and to the worm gear at the other end and ultimately the ends of the tilting arms are supported by plummer blocks..

2.3.3. Working Mechanism:

The working principle of the worm gear assisted tilting mechanism is relatively simple. When the motor is activated, it causes the worm gear to rotate. As the worm gear rotates, it turns the gear wheel, which in turn causes the tilting arm to move. The tilting arm is designed to pivot around a fixed point, allowing it to tilt the pump from its vertical position to a horizontal position.

The motor is typically controlled using a switch or control panel, [10] which allows the operator to start and stop the tilting process as needed. The speed of the motor can also be adjusted, allowing for precise control over the tilting speed.

Overall, the worm gear assisted tilting mechanism is a reliable and efficient way to tilt vertically placed pumps to a horizontal position. Its use can

save time and effort in situations where manual tilting is difficult or impossible.

2.4.Gear operated tilting mechanism for VFP's (Hand lever driven)

2.4.1. Components and Working

The worm gear is a screw-like mechanism that rotates a worm wheel. The worm gear and worm wheel are typically made of metal, and are designed to mesh together at a 90-degree angle. As the worm gear rotates, it turns the worm wheel, which then turns the shaft.

The shaft is connected to the pump, and is designed to rotate the pump as it is tilted from a vertical to a horizontal position. The shaft is typically made of metal [11] and is designed to be strong and durable, in order to support the weight of the pump and its contents.

The lever arm is the component that is used to rotate the worm gear. The lever arm is typically made of metal, and is designed to be long enough to provide sufficient leverage for the user. When the user rotates the lever arm, it turns the worm gear, which then turns the worm wheel and the shaft, causing the pump to tilt.

The worm gear assisted tilting mechanism is designed to make it easier for users to tilt a vertical flow pump, which can be difficult and heavy to move manually. By using the worm gear mechanism, the user is able to apply more force with less effort, making it easier to tilt the pump to a horizontal position.

A ratchet mechanism [12] is provided to the shaft which enables easy locking of the pump while tilting.

Overall, the worm gear assisted tilting mechanism is an effective and efficient way to tilt a vertical flow pump using a hand lever. It consists of several key components that work together to provide the necessary force and leverage, making it easier to move and position the pump as needed.

3. Discussions

Discussion based on various pros and cons of various tilting mechanisms and based on our analysis

3.1 Chain block operated assistive tilting mechanism for VFP's.

Advantages of using chain block assisted tilting mechanism

Easy to use: The chain block assisted tilting mechanism is easy to use and requires minimal training or expertise. This makes it a popular choice for applications where the user may not have extensive knowledge or experience with lifting or moving heavy equipment.
Precise control: The chain block allows for precise control over the lifting force, making it easier to position the pump accurately and safely.

Disadvantages of using chain block assisted tilting mechanism

Requires space: The chain block mechanism requires a certain amount of space to operate effectively. This can be a challenge in tight or confined spaces, or in areas where there is limited clearance or overhead space.
Limited mobility: The chain block mechanism is typically fixed in place, which can limit its mobility and make it less suitable for applications where the pump needs to be moved frequently or over long distances.
Relatively slow: The chain block mechanism can be relatively slow, especially when compared to other tilting mechanisms like hydraulic or pneumatic systems. This can make it less suitable for applications where speed is a critical factor.
Requires manual effort: The chain block mechanism requires manual effort to operate, which can be tiring and time-consuming. This can make it less suitable for applications where frequent or repeated tilting is required.

As chain block assisted tilting mechanism has a major problem of consuming more space and materials, we are considering other tilting methods.

3.2 Hydraulic piston actuated assistive tilting mechanism for VFP's

Advantages of using hydraulic piston assisted tilting mechanism

Improved Maintenance: The hydraulic tilting mechanism makes it easier to access the pump's internal components for maintenance and repairs. This is because it eliminates the need to dismantle the entire pump and allows for easier access to the pump's impeller and other components. This results in less downtime for the pump and reduces the maintenance costs.

Increased Efficiency: Tilting the pump to a horizontal position improves its efficiency by reducing the friction between the impeller and the casing. This reduces the amount of power required to run the pump, resulting in lower energy costs.
Enhanced Safety: Tilting the pump to a horizontal position reduces the risk of injury to personnel working on the pump. This is because it eliminates the need for personnel to work in awkward positions, reducing the risk of musculoskeletal injuries.

Disadvantages of using hydraulic piston assisted tilting mechanism

High Initial Cost: The hydraulic tilting mechanism requires additional equipment such as hydraulic cylinders, hoses, and valves, which increases the initial cost of the pump.
Complex Design: The hydraulic tilting mechanism requires a complex design, which increases the risk of mechanical failure. This increases the maintenance costs and downtime of the pump.
Increased Maintenance Requirements: The hydraulic tilting mechanism requires regular maintenance to ensure that it operates correctly. This includes checking the hydraulic system for leaks, inspecting the hydraulic cylinders and hoses, and ensuring that the system is adequately lubricated.
Usage of hydraulic piston actuation requires regular maintenance and it is working under wet atmosphere which causes problems to hydraulic actuation systems. we are considering other tilting methods. In case of any flooding, the whole hydraulic system will fail and it may cause workers to repair the hydraulic system and only after that further maintenance to the pump is possible, this may cause double work for the workers.

3.3 Gear operated tilting for VFP's (motor driven)

Advantages of using motor driven gear assisted tilting mechanism

Easy Servicing: The primary advantage of amotor-operated tilting mechanism is that it makes servicing a heavy vertical axial flow pump much easier. By tilting the pump to a horizontal position, maintenance personnel can access the pump's components without the need for scaffolding or special lifting equipment.
Time-saving: Another significant advantage of a tilting mechanism is the time saved during maintenance. By tilting the pump, it becomes easier to remove and replace worn or damaged components. This means less time spent on servicing, reducing downtime and increasing productivity.
Improved Safety: The tilting mechanism also improves safety during maintenance. Without the need for scaffolding or special lifting equipment, there is a lower risk of accidents and injuries.
Flexibility: The tilting mechanism also offers flexibility in terms of where the pump can be placed. A vertical pump takes up much less floor space than a horizontal pump. But with the tilting mechanism, it is possible to have the benefits of a vertical pump while still being able to perform maintenance more easily.

Disadvantages of using motor driven gear assisted tilting mechanism

Cost: The biggest disadvantage of a motor-operated tilting mechanism is its cost. This mechanism is more expensive than a fixed vertical or horizontal pump. Depending on the size of the pump and the tilting mechanism, the cost could be significantly higher.
Maintenance: The tilting mechanism itself requires maintenance, adding to the maintenance workload. It must be regularly inspected and maintained to ensure it remains in good working order.
Complexity: The tilting mechanism adds complexity to the pump system. This means there are more components that could potentially fail, increasing the risk of downtime.
Space: The tilting mechanism takes up additional space, which could be an issue in certain applications

As the maintenance for vertical flow pumps is not always required, which will cause the motor not to be worked for a long duration, so another tilting mechanism will be considered.

3.4 Gear operated tilting for VFP's (hand lever driven)

Advantages of using hand lever operated gear assisted tilting mechanism

Easy to use: The hand lever mechanism is easy to use and requires minimal training or expertise. This makes it a popular choice for applications where the user may not have extensive knowledge or experience with lifting or moving heavy equipment.

Precise control: The worm gear mechanism allows for precise control over the tilting motion, making it easier to position the pump accurately and safely.
Low maintenance: The worm gear mechanism is relatively low maintenance, requiring minimal lubrication and upkeep compared to other tilting mechanisms like hydraulic or pneumatic systems.
Durable: Worm gear mechanisms are generally very durable and can withstand heavy use over time, making them a reliable choice for long-term use.

Disadvantages of using hand lever operated gear assisted tilting mechanism

Limited speed: The hand lever mechanism can be relatively slow, especially when compared to other tilting mechanisms like hydraulic or pneumatic systems. This can make it less suitable for applications where speed is a critical factor.
Limited lifting capacity: The hand lever mechanism may have limited lifting capacity compared to other mechanisms, which can limit its usefulness in certain applications.
Requires manual effort: The hand lever mechanism requires manual effort to operate, which can be tiring and time-consuming. This can make it less suitable for applications where frequent or repeated tilting is required.

This method of tilting enables easy serviceability and compactness in its design, so as per the constraints in the paddy fields.

4. Result

The hand lever driven gear operated tilting mechanism for VFP is successful and is working properly. This method of tilting enables easy serviceability and compactness in its design.

5. Conclusion

In conclusion, the worm gear assisted tilting mechanism for vertical flow pumps that is powered by a hand lever is a reliable and effective way to tilt a pump from a vertical to a horizontal position. It provides precise control over the tilting motion, is low maintenance, and is generally very durable... Overall, the suitability of this mechanism will depend on the specific requirements and constraints of the application in which it is being used.

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