Power Tiller Driven Irrigation System

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***Abstract*—Irrigation is a fundamental requirement for agricultural productivity. In many rural regions, unreliable electricity supply and high installation costs limit the use of electric irrigation systems. This study presents the design, fabrication, and performance evaluation of a power tiller driven irrigation system. A 12 HP diesel engine is used to drive a 7 HP centrifugal pump through a belt drive mechanism. The system is designed to be portable, economical, and efficient. Experimental analysis shows fuel consumption of 1–1.5 L/hr. with consistent discharge. The system provides an effective alternative for small and marginal farmers.**

***Index Terms*—Power tiller, Irrigation system, Belt drive, Centrifugal pump, Agricultural machinery, Diesel engine**

I. INTRODUCTION

Agriculture in developing regions relies heavily on irrigation for consistent crop growth, but unreliable electricity and frequent power outages in rural areas often disrupt irrigation practices, reducing productivity. Conventional electric pump sets require stable power and high installation costs, while diesel pumps involve additional investment and maintenance. Meanwhile, power tillers are widely used but remain underutilized during non-tillage periods.

To address these challenges, this study proposes integrating a centrifugal pump with a power tiller to develop a multipurpose system. The approach enhances machine utilization while reducing the need for additional equipment, resulting in a cost-effective, portable, and efficient irrigation solution suitable for rural conditions.

II. PROBLEM STATEMENT

Farmers face major challenges in irrigation, especially in rural areas, due to unreliable electricity supply, which affects the operation of pump sets and leads to inconsistent watering. High initial costs of irrigation systems make it difficult for small farmers to adopt them, and there is also a lack of portable and flexible solutions. Additionally, power tillers are often underutilized when not used for tillage. To address these issues, this study proposes a low-cost irrigation system driven by a power tiller, reducing electricity dependence, lowering investment costs, and improving the use of existing farm machinery.

III. OBJECTIVES

The objectives of this study are to design and develop a compact and efficient irrigation system powered by a power tiller, making use of readily available agricultural machinery. It also focuses on optimizing power transmission through a properly designed belt drive mechanism to ensure minimum power loss and smooth operation. In addition, the study aims to evaluate the overall performance of the system in terms of efficiency, discharge, and fuel consumption under different working conditions. Special emphasis is given to ensuring that the system is portable, easy to operate, and suitable for use by small and marginal farmers in rural areas.

IV. LITERATURE REVIEW

Previous studies indicate that belt drive systems are widely utilized in agricultural machinery due to their simplicity, flexibility, and cost-effectiveness. Al-Sayed (2018) reported that proper belt tension is essential for efficient power transmission, as it minimizes slippage and energy losses while enhancing system performance and lifespan. Similarly, Singh and Kumar (2019) emphasized the importance of appropriate pulley selection and alignment in achieving optimal efficiency and durability. Furthermore, FAO reports highlight the growing need for low-cost, energy-efficient irrigation solutions that utilize locally available resources.

These findings collectively support the feasibility of integrating irrigation systems with existing machinery such as power tillers, offering an economical and sustainable solution for small and marginal farmers.

V. SYSTEM DESIGN

5.1. Power Source

A 12 HP diesel engine power tiller is used as the primary power source, operating at approximately 2000 rpm to provide the required mechanical energy for pump operation. Its robust construction, reliability, and compatibility with various agricultural implements make it suitable for continuous farm use.

The fig. of power tiller(7hp) is above:

5.2. Pump Selection

A 7 HP centrifugal pump was selected based on the required discharge and head for effective irrigation, considering factors such as water source depth, delivery height, and flow rate. Centrifugal pumps are preferred for their simple construction, smooth operation, and low maintenance requirements. The selected pump capacity ensures adequate water delivery while maintaining compatibility with the 12 HP power tiller engine, resulting in efficient and balanced system performance.

The fig. of centrifugal pump is given below:

5.3. Belt Drive Design

A V-belt is used to transmit power from the engine to the pump due to its flexibility and ability to absorb shocks and vibrations. Proper belt tension is maintained to minimize slippage and ensure efficient power transmission. The pulley ratio is selected based on pump speed requirements to achieve the desired performance and discharge.

VI. MATERIALS AND COMPONENTS

The system comprises a 12 HP power tiller engine as the primary power source and a 7 HP centrifugal pump for water delivery. Power is transmitted through a V-belt and pulley arrangement, ensuring smooth and flexible operation. The components are mounted on a sturdy steel frame to provide stability and minimize vibrations. Bearings and shafts are incorporated to enable smooth rotation and reduce friction losses, thereby enhancing overall system efficiency.

VII. METHODOLOGY

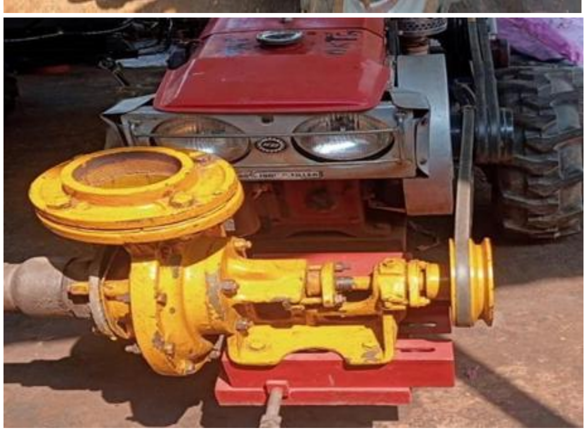
The system was fabricated by mounting a centrifugal pump on a rigid frame and connecting it to a power tiller using a belt drive mechanism. The frame ensures structural stability and minimizes vibrations, while proper pulley alignment enhances power transmission efficiency and reduces belt wear. Appropriate belt tension was maintained to prevent slippage and excessive stress. The pump, shafts, and bearings were securely installed and lubricated to reduce friction and improve performance, with safety guards provided for moving parts. The assembled system was tested under various conditions to evaluate discharge, fuel consumption, and overall efficiency, ensuring reliable field operation.

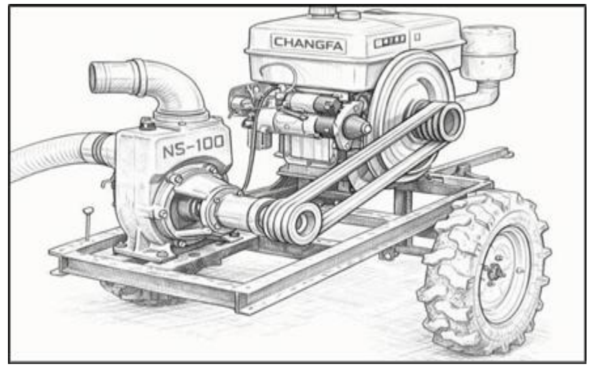
VIII. WORKING PRINCIPLE

The power tiller driven irrigation system operates by converting mechanical energy from a diesel engine into hydraulic energy through a centrifugal pump. The 12 HP engine runs at approximately 2000 rpm, and this rotational motion is transmitted to the pump via a V-belt and pulley arrangement, enabling smooth and flexible power transfer. The pump speed is controlled by selecting suitable pulley ratios to meet the required operating conditions.

As the pump shaft rotates, the impeller imparts centrifugal force to the water, increasing its velocity and pressure. The pressurized water is then discharged through the outlet for irrigation, while a low-pressure region at the impeller center continuously draws water from the source, ensuring uninterrupted flow.

The performance of the system depends on proper belt tension, accurate pulley alignment, and maintaining optimal engine speed. Overall, the system efficiently converts chemical energy in diesel into mechanical and then hydraulic energy, making it a reliable and practical solution for irrigation in areas with limited or no electricity supply.





The fig. of power tiller driven irrigation system is above.

IX. DESIGN CALCULATIONS

9.1. Power Requirement

$$P = \frac{2\pi \cdot n \cdot T}{60 \cdot \eta}$$

9.2. Belt Velocity

$$v = \frac{\pi \cdot D \cdot n}{60}$$

9.3. Power Transmission

$$= (1 - 2) \times \quad = (_1 - _2) \times \quad = (1 \quad - 2 \quad) \times$$

9.4. Efficiency

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

X. PERFORMANCE ANALYSIS

Parameter	Value
Engine Power	12 HP
Pump Power	7 HP
Speed	2000 rpm
Fuel Consumption	1–1.5 L/hr
Discharge	15–25 L/s (approx.)

XI. RESULTS AND DISCUSSION

The system demonstrated efficient performance under varying load conditions, delivering adequate water discharge for small and medium-scale farms. Stable operation with minimal vibration indicated proper alignment and a robust frame structure. The belt drive ensured effective power transmission, while the use of the power tiller for irrigation improved its overall utilization. The system also proved to be cost-effective, particularly in off-grid areas, by eliminating dependence on electricity and reducing operational expenses compared to conventional pumps.

XII. ECONOMIC ANALYSIS

The system eliminates electricity costs by operating independently of the power grid, making it suitable for areas with unreliable power supply. It utilizes existing machinery such as a power tiller, reducing the need for additional equipment and lowering initial investment. Although it operates on diesel, costs can be controlled based on usage, and maintenance requirements are relatively low. Overall, the system reduces capital and operational expenses while improving resource utilization, making it economically beneficial for small and marginal farmers.

XIII. ADVANTAGES

The system is designed to be portable, allowing it to be easily transported and utilized in different locations based on field requirements. This flexibility makes it highly suitable for farmers who need a movable irrigation solution. It also supports multi-purpose usage, as the power tiller can be effectively used for both agricultural operations such as tillage and for irrigation, thereby improving overall machine utilization and efficiency. The system operates independently of electricity, making it particularly advantageous in rural and off-grid areas where power supply is unreliable or unavailable. In addition, the design is simple and robust, requiring minimal maintenance and basic technical knowledge for operation. This makes the system user-friendly, reliable, and practical for regular use by farmers, ultimately saving time, labor, and operational costs.

XIV. LIMITATIONS

The system has certain limitations, as it requires continuous fuel consumption for operation, which adds to the running cost. It also results in the emission of pollutants due to the use of a diesel engine, contributing to environmental concerns. Furthermore, the overall efficiency of the system depends on the condition of the belt, as improper tension, wear, or misalignment can lead to power losses and reduced performance.

XV. APPLICATIONS

The system can be effectively used for irrigation of small and medium-sized farms, ensuring a reliable and timely water supply for crop cultivation. It is also well-suited for lifting water from various sources such as wells, canals, ponds, and storage tanks, making it highly versatile in different agricultural conditions. Furthermore, the system can support a wide range of rural agricultural operations where access to electricity is limited, providing a portable and independent solution for water pumping needs.

XVI. FUTURE SCOPE

The future scope of this system includes integration with solar hybrid systems to reduce dependency on diesel fuel and promote environmentally sustainable operation. Automation can be incorporated using sensors and control systems to regulate water flow, monitor soil moisture levels, and enable efficient irrigation with minimal manual intervention. The use of advanced transmission systems such as gear drives or chain drives can further improve power transmission efficiency and reduce energy losses. Additionally, improvements can be made in the design of the frame and components to enhance durability, reduce vibrations, and increase overall system life. The system can also be adapted for larger-scale applications and integrated with smart farming technologies, making it more versatile and suitable for modern agricultural practices.

XVII. CONCLUSION

The developed system effectively utilizes a power tiller for irrigation, thereby reducing overall costs and improving the efficient use of available agricultural machinery. By eliminating the need for a separate engine or electrical connection, it offers a practical and economical solution for farmers, particularly in rural and off-grid areas. The system is easy to operate, portable, and adaptable to different field conditions, making it suitable for small and medium-scale farming applications. Furthermore, with proper design improvements and technological enhancements, the system has significant potential for further development, including increased efficiency, automation, and integration with sustainable energy sources.

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