Mechanical Concept on Design and Development of Irrigation System to Help Rural Farmers for Their Agriculture Purpose During Unavailability of External Power

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Abstract: Odisha is one of the states in India, where almost 70% families depend on agriculture. Odisha is a common destination for tropical cyclones that generally initiate in the Bay of Bengal. These cyclones destroy the total agriculture system and electricity infrastructure of Odisha every year. Agriculture is the backbone of the economy of any state. Economy can be boosted by the adoption of modern technology and advanced irrigation methods. Continuous irrigation is only possible by using pumps which is operated by diesel, petrol, kerosene or electric power connected with tube well. For such type of arrangement farmers generally depend on electricity, petrol or diesel. But due to continuous electric failure for number of days as a result of frequent cyclones, farmers suffer a lot. With continuous increase in the prices of petrol, diesel, kerosene or electricity, poor farmers find it difficult to bear the cost. The aim and purpose of this work is to develop an irrigation system to help farmers for irrigation purpose to obtain better yields in agriculture with minimum expenses. In the present work mechanical concepts such as Mechanical Advantage (MA), Velocity Ratio (VR), Efficiency, energy storage concepts are used. The system consists of gears, flywheel, handle, bearings and other assembly unit. This arrangement is placed on a frame which is made up of mild steel angles having dimension 40 x 40 x 5 mm. A shaft having 25 mm diameter is used with a flywheel and four numbers of bearings. Driver and driven gears having 200 and 40 number of teethes in simple gear train arrangement are taken in this work. The concept is very simple and its manufacturing process is also very easy. There will be no issue for such type of product as it is environmental friendly and the main purpose of this system is to save the environment and reduce pollution. The idea can be easily implemented because here the input materials are easily available. So by using this system there is no need of any electric supply for irrigation purpose. The work presented here is innovative in nature and has not been developed by any other researchers in the past. By using this system even weak and physically disabled persons can lift water for the purpose of agriculture without any difficulty.

Keywords: Continuous irrigation; farmers; environmentally friendly; design and development
1. Introduction

Agricultural yields depend on availability of continuous irrigation method. Now a day the governments of several countries are providing various facilities to their farmers for enhancing agricultural yields and thus boosting the economy of the country. In some of countries, the government is also working for utilizing water from big rivers for irrigation purpose by constructing canals. The government is also spending lot of money for irrigation purpose like drilling of bore wells and repairing the old ones. The revenue generation of a country depends largely on the agricultural yields. In India almost 70% families depend on small and large scale agriculture. Due to job crisis the educated youths are also choosing agriculture as a prime profession. Even though the government has implemented various provisions for irrigation, the farmers still face problems every year and lose nearly 30% to 40% of their net profit due to unavailability of suitable methods of irrigation for the purpose of agriculture. Odisha is one such state in India where 70% families depend on agriculture. Almost all farmers use bore well at their farms where lifting of water from their bore well is done by using pumps operated by electricity, petrol or diesel. Odisha, being a state prone to natural calamities in the forms of cyclone and high flood, suffers from prolonged electricity failures which linger for 15 to 20 days after each disaster. During these periods the electricity supply is disrupted due to damage of transmission lines. So, during these critical periods, the farmers suffer the most. During COVID 19 pandemic period from March to July -2020, the farmers faced huge problems due to restriction in mobility imposed by the government. This system has been developed to solve the problem of irrigation faced by the farmers due to non-availability of electricity or petroleum products to run their pumps at the time when they need them the most.

The designed product has been used in one of the farm with an area of five acres where the farmers were producing vegetables. Earlier, the farmers were spending nearly ten thousand rupees every month for providing irrigation to the land. Moreover, they also faced problems in operating the pumps due to failure in electricity and poor means of transporting the petroleum products. The application of this system with their bore well has almost sorted out their problem. The farmers are now using this system without spending a single penny. Even more than five physically disabled farmers are using this system successfully for irrigating their farms. The arrangement of the system that consists of number of gears, bearings, shafts, fly wheels is shown in Figure 1. All the arrangements are placed on a frame and the dimension provided in the design may be changed for future works.

A numbers of works have been done by researchers on irrigation methods for various environmental conditions. Deepa et al. [1] studied on intelligent agriculture by provision of IOT breakthrough and found that the automated agriculture system is anticipated to benefit the farmers in managing an irrigation system. Sirimorok et al. [2] studied on knowledgeable watering systems established on framework of low bandwidth divided applications (LBDA) in cloud computing breakthrough in knowledgeable systems and computing and found that the irrigation scheduling model can effectively enhance the prognostic accuracy for the watering system. Gorguner et al. [3] studied on modelling effects of future climate alteration on reservoir repository and irrigation water requirement in a Mediterranean basin and found under all eight etched climate alteration projections growing trends for the annual water requirements are anticipated throughout 21st Century. Sandhu and Irmak [4] studied on performance evaluation of Hybrid-Maize stereotype for rain fed, finite and all-encompassing irrigation conditions and found that the highest dissimilitude in the middle of simulated and calculated data were detected for rain fed ministration, indicating incongruity of the archetype in dry/rainfed suburb and the necessity for archetype enhancements in water stress conditions. Mao et al. [5] studied on modelling the salt aggregation and leaching procedures in arid agrarian areas with a latest mass balance model and found that the developed archetype can decipher homogeneous and heterogeneous soil water fluctuation and solute transmission effectively.

Scheiber et al. [6] studied on hydrochemical adjustment of irrigation groundwater origin in an alluvial artesian basin and found that this adjustment of groundwater origin will allow managers, irrigators and modellers to evaluate the long term feasibility of groundwater utilisation in alluvial watersheds. Shull-Trauring et al. [7] studied lessening salinity of cured waste water with broad scale desalination and found that superior TWW with a consequential portion of desalted base water can allow groundwater salinity
remediation. Filgueiras et al. [8] studied L.P. Soil water fulfilment and real evapotranspiration prognostication using remote sensing data along with regression algorithms and found that between the regression archetypes tested cubist regression, gradient boosting machine and random forest fit the SWC and ET data. Zhou [9] studied an amalgamated irrigation strategy for water preservation and quality enhancement of cash crops and found that such strategy would inspire the metamorphosis of irrigation strategies from the traditional field irrigation postulation to a new chapter of irrigation superintendence. Huang [10] studied on agricultural water augmentation with a divided eco hydrological archetype in a mountain plain concavity and found that such augmentation in a exemplary year would result in 0.4% enhancement of crop creation for the whole concavity.

Liu et al. [11] studied on endowment of clay aquitard to sinkhole iron agglomeration and water quality and found that intrusion, sediment chemistry and hydraulic gradients affect the iron distribution in aquitard pore water. Massa et al. [12] studied on lessening nutrient and water losses from soilless harvesting in southern Europe and found that employing advanced recirculation blueprints have made it possible for repurposing the solution under saline conditions with optimal utilisation and minimal expulsion of nutrients. Dillis et al. [13] studied cannabis water-use practices and its impact on water resources and the environment and found that extraction of water from groundwater wells mostly occur during the summer dry season and showed their impact on connected surface water. Surya et al. [14] studied in-situ soil moisture sensors (SMS) for quantification and detection of soil moisture using advanced materials and found that Molybdenum disulfide (MoS2) offers the highest sensitivity than rest materials. Computing water use and groundwater rejuvenate under flood irrigation in the Heihe River Basin of north western China was done by Li. [15] He found that 50%irrigation quota improved water productivity for spring wheat and spring maize, improved utilization of crop water and protected ground water resources. Limon [16] studied index-based hydrological drought coverage for irrigated agriculture in southern Spain and found that by applying high ordinary deductibles the cost of marketable premiums could be reasonably priced for irrigators. Jimenez et al. [17] studied on intelligent agents and multi-agents for irrigation scheduling and found that by including artificial intelligence growth in crop yield and water savings could be achieved. Challenges regarding execution of transition from conventional irrigation to fertigation in countries having moderate climate using regained waste water was discussed by Chojnacka et al. [18].

The incorporation of soil moisture sensor measurements, root zone simulation forecasts and remotely sensed NDVI time-series was studied by Fontanet et al. [19] to improve crop performance and irrigation scheduling. Liu et al. [20] studied the accumulation of toxic metal lead (Pb) in irrigated water, wheat plant and soil samples and found that high levels of Pb could affect local animal and human population along with soil and wheat plant contamination. Pressure drop caused by two-phase flow of oil/water emulsions through sudden expansions and contractions was studied by Roul and Dash [21]. Edwards et al. [22] studied American Indian reservation farmer’s problems for investing in irrigation and found that trust ownership, a lack of access to capital using land as a collateral for on-farm investment in eastern Utah created the income gap between adjacent communities and Indian farmers. Zhao et al. [23] discovered a novel double-layer ditch system (DDS) with a fibrous stuffing to increase the removal of pollutant in agricultural drainage ditches and its effective in both in terms of performance and annual average removal efficiencies than single-layer ditch system. Irrigation performance evaluation was done by Benavides et al. [24] by using relative irrigation supply (RIS) as indicator. By using ANCOVA model they found that on-demand distribution systems and current forced on-farm irrigation systems improved RIS significantly. The main objective of this work is to help farmers for continuous irrigation purpose. It can be easily handled and operated. A physically disabled person can also use it. Multiple activities are possible by using this system. A woman farmer can easily access it. Dimensions provided in this work can also be varied as per requirement. It can enhance agricultural yielding and thus boost economy.
2. Experimental Set Up

The fig. 1 shows the experimental setup of the irrigation system which consists of spur gears, bearings, shaft, handle and fly wheel. The system is connected with the plunger rod of tube well in eccentric way. Gears are provided in simple gear train arrangements.

![Figure 1. Design layout of the continuous irrigation system](image)

The number of teeth on driver and driven gears are 200 and 40 respectively. Two shafts having length 640 mm and 600 mm are considered in this system. Driver and driven gears are mounted on these two shafts. Handle is connected at the end of one shaft and flywheel is connected at the end of other shaft. The shaft that carries flywheel at one end contains a pulley on its other end. That pulley is connected with plunger rod of the tube well. The shaft to which handle is connected carries driver gear having 200 numbers of teeth and other shaft to which flywheel and pulley are connected, carries driven gear having 40 numbers of teeth. Both gears are meshed with each other. Bearings are provided for smooth rotation of shafts. The experimental setup is constructed in the workshop with the help of welding machine, cutting machine, and gear hobbing machine. Spur gears are manufactured by using gear hobbing machine. After the manufacture of gears, black oxide finish method was used for preventing rust. The dimensions taken for this purpose may be varied as per requirement.
Figure 2. Isometric view and Front view of the continuous irrigation system

The figure 2 shows the isometric view and front view of the set up used for continuous irrigation system. Flywheel of mass 30 kg is provided for energy storage and smooth out put power deliberation purpose. When handle is rotated, the driver shaft and driver gear also rotate. As the driven gear is meshed with the driver gear, so the driven gear also rotates which causes driven shaft to rotate. One end of driven shaft is attached with flywheel and the other end is attached with the pulley. Due to rotation of pulley, the plunger rod, which is connected with the pulley, moves up and down. As a result, water is lifted in the upward direction with the motion of the plunger rod. All such arrangements are provided on a frame made up of mild steel angle of cross section 40 x 40 x 5 mm. The figure 3 and figure 4 show the pump body with motion of plunger rod.

Figure 3. Up and down motion of plunger rod
After water is discharged from the tube well exit, discharge of water is measured by provision of V-notch. Discharge through V-notch is given by the formula [25].

\[ Q = \frac{H^{2.48}}{21900} \]  \hspace{1cm} (1)

\( Q = \) Discharge  
\( H = \) Head

Discharge from the pipe (Bore well) is calculated by using the relation.

\[ Q = \frac{0.0174D^2x}{\sqrt{y}} \]  \hspace{1cm} (2)

Where  
\( x = \) coordinate in cm  
\( y = \) coordinate in cm  
\( D = \) Pipe diameter in cm  
\( Q = \) Discharge in litre per second.

3. **Results and Discussion:**

A survey was conducted in one of the district named cuttack in the state of odisha, where almost 80% families depend on agriculture. The data provided here corresponds to an agricultural farm having 3 acre area. Earlier that farmer was using the diesel pump, petrol pump and sometimes electric operated pump for irrigation purpose. The total expenditure on such cases is given in table1. The initial cost of the pump, running and maintenance cost are also shown in this table.
| Sl. No | Variables                  | Diesel Pump (2 HP) | Petrol Pump (2 HP) | Electric Pump (2 HP) | Present arrangement |
|--------|----------------------------|-------------------|-------------------|---------------------|---------------------|
| 1      | Purchase Cost (Rs)         | 17000/-           | 12000/-           | 10,000/-            | 6,000/-             |
| 2      | Expenditure per day        | 450/-             | 500/-             | 200/-               | 0                   |
| 3      | Maintenance per week       | 300/-             | 200/-             | 100/-               | 0                   |

From Table 1, it is observed that farmers are spending more for irrigation purpose and also there is the chance of unavailability of petrol, diesel and electric supply. To solve this, our system was used on the same farm and it was observed that without incurring any running and maintenance cost, same output was obtained. Its initial cost is also very less as compared to the cost of pumps. This is a new concept and innovative in nature. This arrangement can be used for solving irrigation problem and it can supply continuous flow of water with less effort and with reduced cost. This system is very easy to operate and can be easily installed with the existing tube well. This system is suitable for agriculture as well as for household purposes. It can also be used for supplying water for constructional work.

Time line to develop the product is given as follows. For product development it takes about 1 month. For scaling up to commercialization of the setup it takes about 2 months. Break - even point is about 2 months. There is a large market for this system for continuous supply of water from the bore well for the purpose of agriculture. There is no issue for the development of such type of product as it can save the environment and reduce air pollution.

The increase in Mechanical Advantage results in increase in efficiency. This concept is applied here in order to improve the efficiency of the system. When efficiency increases the effort applied to lift the given amount of water from the well for the purpose of irrigation decreases. The concept of energy storage by flywheel has been concerned here, due to which by less effort the lever of tube well operates smoothly.

For the operation of this system there is no need of electric supply and it does not require any petrol or diesel for its operation. The cost of this product is also very less and hence it can be easily installed by farmers. The weight of this product is also very less as a result it will be handy for the farmers to install it in their field. Soil property for agriculture purpose will not be affected by using this product. Continuous irrigation can be provided with the help of this system. Installation and maintenance are not major factors for such system. Zero emission is the main advantage of such system. Any types of farmers can use this method comfortably with less effort. This system can be used to solve the problem of irrigation faced by the farmers due to non-availability of electricity or petroleum products to run their pumps at the time they need these the most.

4. Conclusions:

The following conclusions can be drawn from this study.

i) The increase in Mechanical Advantage results in increase in efficiency as a result of which the effort applied to lift a specified amount of water from the well for irrigation purpose reduces.

ii) The concept of energy storage by flywheel has been applied here for smooth operation of the system and continuous supply of water for irrigation purpose with minimum effort.

iii) The cost of this product is very less as compared to other alternative available methods.

iv) The weight of this product is also less and therefore it can be easily taken by farmers to their field.

v) Soil property will in no way be affected by using this method as irrigation on the farm at any time is possible by using this method.

vi) Installation and maintenance are easy for such system.
vii) Zero emission is a major advantage of such system as this system works without any external energy sources.

viii) Any types of farmers like women and disabled persons can use this system.

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