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Design and Fabrication of Waterwheel for Lifting of Water

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Abstract: Water is one of the basic necessities of life. In Pakistan, irrigated agriculture sector is the main user of surface as well as groundwater resources. Basically, a large amount of water is required for agricultural purpose and the transfer of water from the nearby water bodies requires a large amount of fuel in one form or the other. Securing water availability in regions of high altitude required the expenditure of energy. The energy demand and emissions of modern forms of water pumping have increased. While many traditional water wheels, which lift water at zero direct emissions, have been abandoned. This step is also the preservation and the wheels. The study area was conducted at the Department of Farm power and machinery workshop, Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam. For uplifting of water, a waterwheel was designed and fabricated with the diameter of 7ft, the radius from the connected shaft was 3.17ft and the center was 0.33ft. The total number of buckets was 8, with the capacity of 4.994 liters. The total material cost was 32,864 PKR without labor costs. For efficiency the waterwheel should be tested practically.

Keywords: Water, Design, Pakistan & Agriculture.

INTRODUCTION

Water is essential for sustaining life on the earth. Pakistan has abundant water resources, with rivers flowing down the Himalayas and Karakoram heights from the world's largest glaciers and free and unique bounty for this land. Pakistan is basically an agrarian economy. Out of its total geographical area of 79.61 million hectares, cultivated area is 22.05 million hectares. The total area under irrigation is 19.02 million hectares [1].Water is one of the basic human needs and imperative for sustaining quality of life on the earth. However, its unbalanced and unmanaged use makes it scarce. In Pakistan, about 96% of its available water is being used for agriculture and the remaining 4% for domestic, industrial, and other purposes. Basically, a large amount of water is required for agricultural purpose and the transfer of water from the nearby water bodies requires a large amount of fuel in one form or the other. Lifting water is crucial to irrigate agricultural terraces. But the energy demand and emissions of modern forms of water pumping have increased, while many traditional water wheels, which lift water at zero direct emissions, have been abandoned [2].In Spain, ongoing transformations in the irrigation systems can potentially reduce water consumption per hectare, but energy demand has increased by 657% between 1950 and 2008, following the wide-spread introduction of thermal-engine pumping systems [3]. Consequently, irrigation is responsible for 45% of GHG emissions from agriculture in Spain, conflicting with the EU's emission targets [4]. Persian waterwheels are usually driven by some form of right-angle drive. The first is the most common; the drive shaft from the secondary gear is buried and the animals walk over it; this has the advantage of keeping the Persian waterwheel as low as possible, in order to minimize the head through which water is lifted. The second example is a traditional wooden Persian waterwheel mechanism, which is based on the animal passing under the horizontal shaft. The sweep of a Persian wheel carries an almost constant load and therefore the animal can establish a steady comfortable pace and needs little supervision. The advantages of the Persian wheel were: It was based on a relatively inexpensive traditional technology. It could be locally constructed and maintained and lifted water up to 20 m (although it was most efficient at depths under 7.5 m and yielded of approximately 160–170 L/min of water for lifts of 9 m), it was easy to operate and it had medium efficiency (40%–70%) [5]. The delivery rate of early animal powered Persian waterwheels ranged between 20 m3 /h (for 1.5 m height lifting) and 10 m3 /h (for 9 m height lifting) [6].

Problem Statement

A large amount of water is required for agricultural purpose and the transfer of water from the nearby water bodies to regions of high altitude requires a large amount of energy in one form or the other. The energy demand and emissions of modern forms of water pumping have increased. As electrical energy and energy from fossil fuels are expansive, manually operated mechanical devices or devices are driven by natural forces, such as wind, had to be invented. Keeping in mind the scarcity of electricity and other conventional fuel to lift or transport the water from the nearby river bodies to the agricultural fields. Keeping in

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view the above arguments, the study was conducted to design and fabricate water wheel for solving this problem.

METHODOLOGY

Study Area

The study was carried out at the department of Farm power and machinery workshop, Sindh Agriculture University, Tandojam. The geographical location of the study area is at Latitude (LAT): 25.424461 N 25.42446°Longitude (LONG): 68.542200 E 68.54220°.

Figure 1: Geographical location of study area (Google earth)

Design and Layout of the Waterwheel

Side view of the waterwheel. The total diameter was 7 feet, the radius from the connected shaft was 3.17 feet and the center was 0.33 feet. The number of rods was 8 from each side.

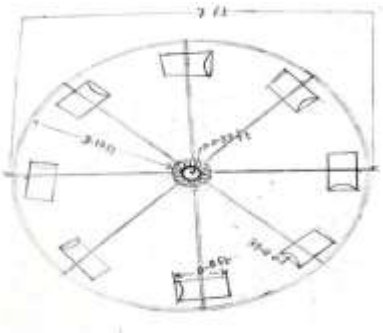

Figure 2: Side view of the waterwheel

Front view of the waterwheel the total length of corrugated iron was 21.98 feet, and the width was 9 inches.

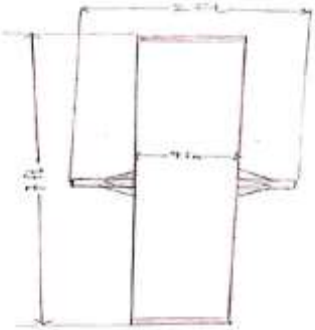

Figure 3: Layout of the front view of the waterwheel

Layout of the shaft. The total length of the shaft was 4 feet and the diameter was 2 inches. One side of the shaft was connected with a pulley and another side was connected with a bearing.

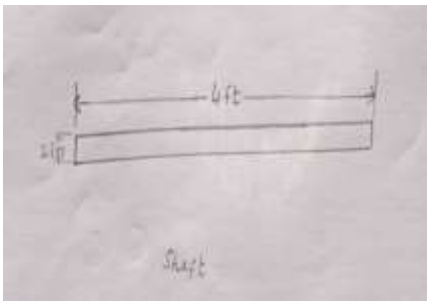

Figure 4: Layout of the shaft.

Design of Head

Total head or the head at which water drops to the trough is equal to the diameter of the arm at which water bucket is fitted denoted as d1.

The equation is given below:

(1.1) $D = d1+d2$

(1.2) $H = D-d_2$

OR

$H = d_1$

Material Required

The required material for the fabrication of waterwheel is given below;

- **Wheel:** Wheel is the circular corrugated iron (iron sheet). The required diameter was 7 feet (2.133m). The circumference of the wheel was calculated by the formula given below:
  (1.3) $C = \pi d$
- **Hub:** Hub is the center of the waterwheel at which the both solid and hallow shafts are connected. The required hallow shaft length was 1 foot and diameter was 0.34 feet.
- **Shaft:** Shaft is a rotating machine element used to transmit power from motor to wheel. The required total length of the shaft was 4ft (1.219m).
- **Buckets:** Buckets were required to carry water from the artificial open well to the required height. The total number of buckets were 8 fixed at the equal interval of the wheel. The capacity of each bucket was determined by given formula:
  (1.4) $V = \pi r^2 \times l$
- **Pulley:** Pulley is a simple machine that changes the direction of force or power. It was required to change the direction of power generated from motor through belt to shaft for rotating the waterwheel.
- **Bearing:** Bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The total four bearings were required two bearings

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were fixed to both walls and connected with shaft. Other two bearings were fixed with hub to reduce friction in shaft.

- **Motor Gear:** Motor gear is a combination of gear box component whose mechanism adjusts the speed of the motor, leading them to operate at a certain speed. Motor gear was required to operate the wheel at constant and normal speed so that the water should fall in water trough.

Construction of Waterwheel

Firstly, from iron sheet the circular wheel was made then the each element of waterwheel was aligned through electric welding to perfectly shape the waterwheel.

Figure 5: Constructed circular wheel

Figure 6: Welding of components

Figure 7: After welding of rods with wheel

Figure 8: After fixing of buckets

RESULTS AND DISCUSSIONS

Dimensions of Fabricated Water Wheel

The waterwheel was constructed with the diameter of 7ft, 8 metal rods was welded and buckets was fixed with nuts. In the hub the hallow shaft was welded with rods having the length of 2ft and diameter of 0.33ft.

Table 1. Dimensions of fabricated waterwheel

Sr.No	Item Name	Dimension s (ft.)
1	Wheel diameter	7
2	Shaft	4
3	Pulley diameter	0.42
4	Wheel circumference	21.98
5	Hallow shaft length	2
6	Hallow shaft diameter	0.33

Figure 9: Fabricated Water wheel

Table 2. Design Dimensions of the Waterwheel

Dimensions	Units
Diameter of large wheel	2.1336 m
Height of water lift	2.032 m
Number of buckets	8
Capacity of bucket	$0.004944m^3$
Total Capacity (Discharge) per revolution	$0.039552m^3$
Energy/power requirement	0.25hp

Height of the Wheel

The height at which the bucket is fitted is come out to be 6.667ft (2.032m). The designeddiameter of the waterwheel has successfully lifted the water at the required height.

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Capacity of Bucket

Average capacity of each bucket was came out to be 4.994 liters or $0.1746 ft^3$ or $0.004944 m^3$.Materials which were used for theconstruction of waterwheel:

The total cost of the material was 32,864 they arelisted below.

Table 3. List of Materials and Their Total Cost

Sr.No	Name ofMaterial	Cost (PKR)	Total cost of Material(PKR)
1	Metal pipes	7470	
2	Pulley	1100	
3	Bearings	3600	
4	Shaft	4062	
5	Corrugated Iron (9''width)	10212	32,864
6	Hallow shaft	3200	
7	Buckets	1600	
8	1 colorbucket	1300	
9	Nuts andBolts	320	

CONCLUSION AND FUTURE SCOPE

The designed waterwheel successfully uplifted the water from artificial well to required height Hence our required height for lifting water is achieved. All the components of wheel attached properly. It is one of old technique to uplift water but in modern day due to high fuel consumption and use of non- renewable energy resources the greenhouse gas emissions has increased. For that we have to move towards the renewable energy resources.

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