MICRO HYDRO WHEEL
TURBO-PUMP FOR CANAL BASED IRRIGATION
&
GENERATION OF ELECTRICITY
IN
INDO-GANGETIC PLAINS

SUBMITTED BY

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ABSTRACT

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Water provides the renewable energy options with a possibility of a continuous supply of energy without the need for storage. There are various factors that have to be considered in choosing an appropriate site, and if done suitably well, the extraction of energy from rivulets or drains can be made economically viable, especially to the rural communities.

Historically, the tendency has been to dam rivers to large scale electricity production .Recent trends suggest that small hydro systems will be able to provide an adequate amount of sustainable energy at greatly reduced costs.

In places where river flow throughout the year and are sustainable to harness the energy producing potential of these, which is an objective. In North Indo-Gangetic Plains, the small hydro potential is approximately 0.4 MW (as per Indian hydrological survey), which favors comparably with other countries.

This paper introduces, “the negligent “waterwheel” with high efficiencies and micro in sizes comparable to those of reaction turbines and less manufacturing and installation costs”, the new small micro hydro as a alternative source of energy, by taking into account the various social, economical and engineering features that comprise a small hydro system.

The research work on this was done at, Department of Mechanical Engineering IIT, Delhi, under the auspices of CIMMYT, India.

INTRODUCTION

Water is a liquid that seeks its own level. It has weight and, if two bodies of water at different elevations are connected, the higher flows toward the lower. This difference in elevation is called *head*. One way to create head, if a natural fall is not available, is to build a dam. When a dam is constructed on a stream or river, the water level behind the dam increases until the water flows over its top.

Another concept that is important to waterpower is *flow*. Flow is a measure of the volume of water that actually moves from a higher to a lower position. If you build a dam ten feet high on a small stream, you can use the impounded water to drive a waterwheel. If you build a dam ten feet high on a river, you will have more flow and your waterwheel can do more work than the one built on the stream.

The final concept that we need to know about is *efficiency*. Efficiency is a measure of the actual work produced by a waterwheel in relation to the potential energy of the system. As an example, if we had a dam ten feet high and a flow of 100 cubic feet of water (a measure of volume) per second (a measure of time) over the dam, the potential or theoretical energy that could be developed at the site would be 113 horsepower. But, there is not a waterwheel in the world that could extract the total energy available from the water flowing over the dam. In every case, some water is lost that cannot do useful work. It might squirt out through a leak in the system, be lost through some sort of turbulence with the waterwheel, or be used up just to overcome the friction in the bearings of the waterwheel itself. Let's say we measured the power generated by our waterwheel and we determined, through experiment, that it delivered 57 horsepower. We know the head to be ten feet and the flow to be 100 cubic feet per second, for we have also measured those quantities. Now we can determine the efficiency by dividing the power produced (57 horsepower) by the potential energy of the site (113 horsepower). The efficiency is 50 percent, which means that somehow we have been able to capture half the energy that could be produced at this site.

The undershot waterwheels described in old books are little more than a wheel with paddles projecting down into a rapidly moving stream of water. The water strikes the paddles and turns the wheel. This type of wheel was very inefficient because when the water pushed against the paddle it swirled around and wasted its energy. In addition, a lot of the water leaked past the paddles without doing any work. The efficiency of an undershot wheel might be as low as 20 percent. For this reason, they were seldom used. This type of wheel would have been employed in situations where there was plenty of flow but not too much head.

ACTIVITY AT RWC/CIMMYT & IIT, DELHI

The efficiency of the undershot wheel as low as 20 % is a past thing. Now the development is such that it has even crossed the barrier of 70% and has become a new challenge for the reaction turbines working at these efficiencies. It has also become a better option to be worked on because of its easy manufacturing, basically the metal work. The present waterwheels are comparatively smaller to the older waterwheels.

Here a comparison can be made with the infamous undershot waterwheel which is having a diameter of 3- 4 m and its near modern prototype is just one by fourth of the diameter of the antiquated waterwheels in size.

The work here was multifaceted introducing the new concept of turbines and quality of water used to run them. The drainage water has been put to use which contained large floating materials.

A Modern antiquated variety of the old waterwheel is the **Mangal waterwheel** which was a work done by a farmer[1]. The design of "Mangal waterwheel" has the following features

Type	**Under shot-wheel**
Wheel Outer Diameter:	4 m
Wheel Width:	1.2 m
Maximum speed:	13 rpm
No. of Blades:	24 Out of these 24, 18 small and 6 bigger blades are there.
Available Head:	1.5 m
Flow rate required for the wheel:	1800 liters/ second
Power	4kw
Cost	$4600

Material used for manufacture cast iron angle, support structure rings Blading material cast iron sheets

Fig 1. Mangal waterwheel

[1] Mangal Singh, Agriculturist cum inventor, Mangal Research and Dehati Development Society, Village & PO: Bhailonilodh, (Block - Bar), Lalitpur – 284123, UP, India. Ph: +91-05175-289635

The work at CIMMYT/IIT was introduction to making of a small micro version of the above Mangal waterwheel and development of this version such that it can be most viable, efficient and could be made in a rural area with no much need of big machinery to mould it into its structure.

Preliminary Work

The design of a new wheel for a site[2] with water head of 1.5m, such that a waterwheel of 8 KW is designed. The civil work at the site was done in prior and maximum amount of the total amount of expenses are consumed by the civil construction .The design features are:

Design Power	8 kw
Design speed of waterwheel	70 rpm
Gear box ratio	1:20
Water pump	12 hp, 1500 rpm, Head Range 10-12 m
No of vanes	14
Flow rate required for the wheel:	500litres/second
Theoretical Efficiency	68%
Cost (installation & manufacture)	$765
Material used for manufacture	Mild iron angle, support structure rings
Blading material	cast iron sheets

Fig 2. The first improved version of waterwheel installed by IIT-New Delhi and CIMMYT at Bhailonilodh, M.P., India.

The above waterwheel was tested for its efficiency and an efficiency which came out to be 59 %.

[2] Bhailonilodh, (Block - Bar), Lalitpur – 284123, UP, India.

The test revealed a major need in improving its efficiency after studying its performance results, its fallacies, its shortcoming and an intensive study of 6 months in field as well as theoretically was carried out and a much better version without the earlier fallacies taken out as the next in the series of development.

Up gradation of this small variant

An intensive study rolled out a variety of changes

- Aspect in which the design procedure was charted out
- Analysis of transfer of momentum of fluid power in the vanes.
- The effect on the water which comes out through the waterwheel
- The effect of drainage floats on the working of different pumps.
- The procedure the rural people followed in making the blade manufacture
- Manufacturing changes that might effect the transfer of momentum in the waterwheel system
- The requirement of civil worked were thoroughly analyzed and better furnished civil construction needed for the waterwheel bladings was designed, such that not least of the fluid power goes unused.

The site[3] for this experimentation was a dam built up for the system such that a required head 1m of water was regularly available from the drainage of the present wheel.

The design features of this site are as follows:

Design Power	5 kw
Design Head	1m
Design speed of waterwheel	50rpm
Gear box ratio	1:30
Water pump	3.7kw, 1450 rpm, Head Range 0-34 m
	13 liter/sec
No of vanes	15
Flow rate required for the wheel	400 litres/second
Theoretical efficiency	82%
Cost (installation & manufacture)	$765
Material used for manufacture	mild iron angle, support structure rings
Blading material	mild iron sheets

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[3] **Sonipat City ,Haryana,India**

Experimental results

Head of water available	0.85m
Speed output of waterwheel	35rpm
Pump discharge	11.6 litre/sec
Head of the pump at discharge	10m
Practical Efficiency	73%

Fig 3. Newly upgraded waterwheel at Sonipat, Haryana, India.

Advantages

1 The nonrenewable sources of petrol and diesel are not used, thus preventing environmental pollution and ozone depletion from greenhouse gas emissions.

2 The whole system is noiseless and does not disturb the surroundings with sound pollution. It uses a gear box for the power transmission of the fluid power, with helical gears which are much efficient in transfer of power and also have less wear and noise.

3 The effect of rotation of the turbine does have its own specific effect on the water which flows through it. The water flowing through the reaction turbine results in a meager oxygenation of the water and might help in improving the water quality and subsequent suitability for irrigation.

4 Because of the improved design, a very less amount of water is required comparatively from the earlier waterwheel due to which storage of water in the dam stagnates there for long helping in increasing the water table, thus increasing the ground water levels.

5 The size of the turbine varies basically around the diameter of 1m. It has an average weight of 400 kg. The efficiency is the major player in power transmission and the waterwheel is set to take on the costlier reaction turbines in its efficiency if it is properly worked on.

6 The cost factor is considered a major player, as people in Indian subcontinent are of middle income groups and this irrigation system can be afforded easily by a group of 4-5 farmers, as the whole irrigation system costs around $700.

Maximizing the benefits of waterwheel

Adoption of water saving technologies such as bed planting, alternate furrow irrigation and intercropping can save irrigation water to a great extent. All these technologies are interdependent on growing crops on raised beds, called bed planting. Bed planting was found to save water to the tune of 20-30% in various crops and hence growing four hectares of bed planted crop means additional water to one more hectare of crop. A simple proportionate extrapolation of this lead to 15-20% expansion in irrigated area after allowing for various other factors. Not only this, bed planting allows faster irrigation coverage of the field and hence less time of irrigation when compared to the conventional flat field irrigation systems.

Raised bed planting system: Saves water and shortens the irrigation time. Inset: multi-crop zero-till cum bed planter.