

Design and Fabrication of a Working Prototype of a Hydro Turbine

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ABSTRACT: The world's hydroelectric potential needs to be considered in the new energy mix, with planned projects taking into consideration social and environmental impacts, so that necessary mitigation and compensation measures can be taken. Hydro development should go hand in hand with further research and development in the other renewable options such as solar and wind power. In this paper, we are going to show the various opportunities in remote and isolated areas of North east India wherever the areas are not connected to national grid. The design of a prototype of a hydro turbine has been discussed in this work. The hydro turbine will be boon to such kind of areas where there are natural resources of falling water from some height particularly in the hilly areas and also the areas which are not connected to the national grid.

KEYWORDS: Hydro, turbine, hydroelectric, prototype

I. INTRODUCTION

ELECTRICITY AS THE MAJOR SOURCE OF POWER

We all know that electricity is one of the most important discoveries in human race and it has become the most widely used source of energy to be used in almost every aspect in generating power. Power is a basic part of nature and it is one of our most widely used forms of energy. We get power, which is a secondary energy source, from the conversions other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources.

Different Types of Electricity Generating Power Plants

- Steam power plants
- Geothermal power plants
- Gas power plants
- Nuclear power plants
- Wind power plants
- Hydro power plants

Energy sources are valuable for their abilities to generate electricity, heating and other necessities of Industrial & Commercial life and modern home requirements. While conventional forms of energy, which includes fossil fuels and nuclear energy, have supplied most of the world's electric power for the past century, a recent focus on climate change and energy independence has raised interest in unconventional forms of energy, many of which emits less carbon and is renewable.

Our project topic is based on the use of hydro power energy to convert it as electric energy so as to use it for various commercial, industrial and home requirements. Besides electricity can be produced by various ways like using Coal Power (Thermal electric power), Nuclear Power, Wind Power, Solar Power etc.

ADVANTAGES OF USING HYDRO ELECTRICITY

Hydroelectric energy offers a number of advantages for people who use it, the environment, and electricity suppliers.

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1. Using this type of energy to generate electricity is not dependent upon the price of uranium, oil, or other types of fuel. This makes electricity costs lower and more stable, one of its most significant advantages.
2. The pollution created by hydroelectric energy generation is quite minimal. There is some pollution involved in initially constructing the power stations, but this is true of all power plants. It also does not produce radioactive waste or involve the environmental impact of fuel being transported to it.
3. It doesn't require many employees to run a hydroelectric station. According to wikipedia.org, most plants of this type are largely automated. This is another one of the advantages which help keep the cost of hydroelectricity low.
4. Hydroelectric power stations can be set up in almost any size, depending upon the river or stream used to operate them; big enough power a single home, factory, small town or large city.
5. Another of its advantages is that hydroelectric is a renewable form of energy, like wind and solar; it doesn't rely upon finite resources like natural gas or coal to generate power.
6. Hydroelectric stations can operate for many years after they are built. Wikipedia.org states that a number of operational hydro stations were constructed fifty to one one-hundred years ago; in contrast to this, IAEA.org indicates that the "design life" of nuclear power plants is generally thirty to forty years.
7. Small hydro electricity generation systems sometimes offer more economic advantages for home owners than solar power, and tend to last longer than solar panels do.

The above mentioned factors make hydroelectric a form of energy generation which offers advantages with regard to cost, pollution, flexibility of installation, and conservation of resources.

II. RELATED WORK

OUR PROJECT AND ITS BACKGROUND KNOWLEDGE

CAUSES FOR SELECTING THE PROJECT:

* India's incremental demand for the next decade is projected to be the highest in the world.

This increasing energy demand also translates into higher demand for electricity.

*North-east India has lots of hydro power resources like streams in most of the hilly areas which have the potential for using for utilization of hydro power.

*The components of Micro hydro power can be locally manufactured and the Micro hydro power systems can be locally built.

*The possible target sites for Micro hydro systems are the isolated areas, which are not connected to the national grid of electricity.

PRINCIPLES OF OPERATION

1. When the magnetic flux linking a conductor or coil changes an emf is induced in it whose magnitude is given by $e = -Nd/dt$ which is known as Faraday's law.

2. The basic principle of hydropower is that if water can be piped down from a certain level, then the resulting water pressure is converted to work. If the water pressure is allowed to move a mechanical component then that movement involves the conversion of the potential energy of the water into mechanical energy. Hydro turbines convert water pressure into mechanical shaft power, which can be used to drive an electricity generator, a grinding mill or some other useful device.

KNOWLEDGE OF SOME OF THE IMPORTANT PARTS FOR THE PROJECT:

Pelton wheel:

The Pelton wheel is an impulse turbine which is among the most efficient types of water turbines. It was invented by Lester Allan Pelton in the 1870s. The Pelton wheel extracts energy from the impulses (momentum) of moving water. In a Pelton Tribune or Pelton Wheel water jets impact on the blades of the tribune making the wheel rotate, producing

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torque and power. Different types of Hydraulic Turbines were developed with the increasing need for power. Three major types are Pelton Wheel, Francis and Kaplan Turbine.

Design of Pelton Wheel Turbine

The Pelton Turbine has a circular disk mounted on the rotating shaft or rotor. This circular disk has cup shaped blades, called as buckets, placed at equal spacing around its circumference. Nozzles are arranged around the wheel such that the water jet emerging from a nozzle is tangential to the circumference of the wheel of Pelton Turbine. According to the available water head (pressure of water) and the operating requirements the shape and number of nozzles placed around the Pelton Wheel can vary.

Working Principle of Pelton Turbine

The high speed water jets emerging from the nozzles strike the buckets at splitters, placed at the middle of a bucket, from where jets are divided into two equal streams. These streams flow along the inner curve of the bucket and leave it in the direction opposite to that of incoming jet.

The high speed water jets running the Pelton Wheel Turbine are obtained by expanding the high pressure water through nozzles to the atmospheric pressure. The high pressure water can be obtained from any water body situated at some height or streams of water flowing down the hills.

The change in momentum (direction as well as speed) of water stream produces an impulse on the blades of the wheel of Pelton Turbine. This impulse generates the torque and rotate the shaft of Pelton Turbine the impulse received by the blades should be maximum possible. That is obtained when the water stream is deflected in the direction opposite to which it strikes the buckets and with the same speed relative to the buckets.

III. PRICIPAL COMPONENTS REQUIRED AND THEIR USES

MECHANICAL SECTION: The various mechanical components required for the project include-

- a) PELTON WHEEL: For converting water potential energy to Mechanical (Rotational) energy.
- b) SHAFT: To link the rotational energy of the Pelton wheel to the alternator for generating power.
- c) BEARINGS: For easy movement of the shaft in the frame and rotor.
- d) STABLE FRAME: To hold whole of the project firmly and rigidly so that there is no breakdown or vibrations or less movements.
- e) SCREWS,NUTS, BOLTS, HAMMER ETC: To be used for tightening various parts of the machine which include linking the shaft with the Pelton Wheel.
- f) PUMP: To provide the water flow and to create artificial Head.
- g) NOZZLE: To provide the water jet coming out of the pump for high velocity jet.
- h) Other various mechanical parts as per the requirements basis.

ELECTRICAL SECTION: The various electrical components required for our project includes-

- a) ALTERNATOR: To be used for current generating purpose
- b) CABLES: to connect and test the generated electricity.
- c) 12V BATTERY: To charge the electro magnet inside the stator of the alternator.
- d) Other devices and materials as per the requirements.

MEASURING INSTRUMENTS: the various measuring instruments include

- a) MULTIMETER: To measure current, voltage generated.
- b) TACHOMETER: To measure the RPM of the shaft.
- c) MARKED BUCKET: To measure the rate of flow of the water from the pump.
- d) VERNIER CALLIPER, SCREWGaugES ETC: For measuring various dimensions.

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IV. CONSTRUCTION METHODOLOGY OF THE PROJECT

CALCULATION FOR DESIGNING THE PELTON TURBINE

Data obtained from project work-

Diameter of the wheel, $D= 42\text{cm}$

Diameter of the jet(coming from the nozzle), $d= 3.5\text{ cm}$

Artificial head from pump= 15m

$$\begin{aligned}\text{Step1: velocity of jet at inlet, } V_1 &= C_v(2gH)^{1/2} \\ &= 0.98(2*9.81*15)^{1/2} \\ &= 16.81\end{aligned}$$

$$\begin{aligned}\text{Step2: velocity of wheel, } U &= (2gH)^{1/2} \\ &= 0.43(2*9.81*15)^{1/2} \\ &= 7.38\text{ m/sec}\end{aligned}$$

$$\begin{aligned}\text{Step3: RPM of the shaft, } N &= 60u/\pi D \\ &= 60*7.38/3.1416*0.42 \\ &= 335.6\text{ rpm}\end{aligned}$$

$$\begin{aligned}\text{Step4: Jet ratio, } m &= D/d \\ &= 42/3.5 \\ &= 12\end{aligned}$$

$$\begin{aligned}\text{Step5: Number of buckets, } Z &= 15+0.5 m \\ &= 21\text{ in nos.}\end{aligned}$$

DESIGN OF THE PELTON WHEEL

As we know that the shape of the bucket or runner is quite complex in construction and there are material and machine limitations to manufacture an exact form of Pelton bucket. So, in order to make an efficient bucket of the Pelton wheel which will do the same work as the scientifically proved diagram of the bucket, we had used some household ladle whose shape resembles to that of a bucket.

STEPS

- 1) Taking a mild steel flat rod of 30mm width and 0.5 mm thickness, we had made a circle by hammering on an anvil so that all the 21 nos. of equidistant buckets could be placed. For this purpose, we measure the periphery of the circle and marked in 21 parts as we get from calculation.
- 2) We then joined the circles taking 8 pieces of straight bars of 30mm width and 0.5mm thickness and joined it to the manufactured circled bar using arc welding process.
- 3) Then we take the spoons or the ladle which are stainless steel and cut it at the middle leaving 5 cm from the main bucket by using a hacksaw. We also cut the upper portion of the bucket by using the grinding wheel so that water get passes outside as shown in the diagram.
- 4) We then join the splitter made of thin sheet of mild steel by using special electrode made for arc welding operation required for joining stainless steel and mild steel named as Durochrome heterogeneous welding rods
- 5) We take 2cm square rod of 5cm length and cut into 21 equal dimensioned pieces using power hacksaw and join it in the circular manufactured bar by using arc welding process as shown in the figure.
- 6) We then take a hollow circular mild steel bar of inner dia 25 mm having a small amount of tolerance and fitted to the main centre of the circular framed turbine so that it can be fitted to the shaft.

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Fig.1. Bucket of the Pelton wheel

Fig.2. Pelton wheel without bucket



Fig..3. Pelton wheel with bucket

DESIGN OF THE FRAME:

Design of the frame is of great importance as it has to be manufactured in order accordingly with the design and scale of the project. The frame should have the capacity to hold the whole project firmly so that it could not fall or break down during the running of water or running of the Pelton wheel during its live operation,

STEPS:

1. We start the fabrication part of the project from the construction of frame. As shown in the below given diagram we cut the L-shaped mild steel bars and square hollow rods into required dimension (in cm) by using a power hacksaw machine
2. First we have joined the L-shaped bars into the specified dimension so that a robust base can be fabricated. For that process, we have joined and welded all the pre-cut steel bars of various dimensions by using arc welding process using E6013 type electrode. After the construction of the main base, we then cut hollow square steel bars to be fitted vertically into the base. For this purpose also we have cut the bars and welded to the main base again by using arc welding method using E6013 type welding electrode.

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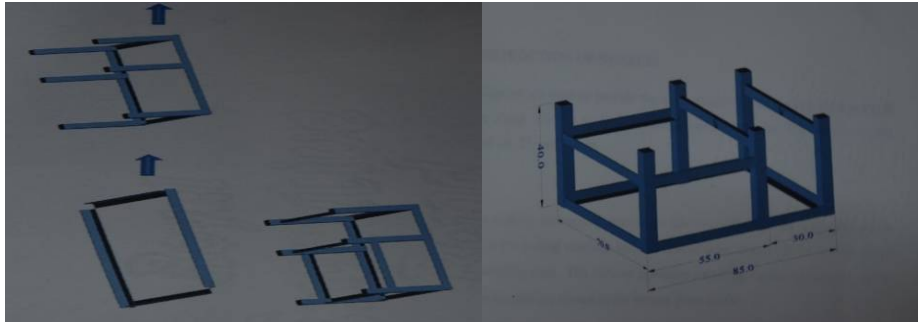


Fig..4. Steps for completion of the main frame

CONSTRUCTION OF NOZZLE:

Nozzles are used to provide the high velocity jet coming out of the pump to the Pelton wheel. We had made these different sizes of nozzles. The diameters of the nozzles are 20, 25, and 30mm.

STEPS

For making converging nozzles we take two different sizes of cylindrical rods and cut it in machine into the desired sizes. Then both the rods are joined by using welding rods. The various operation regarding the construction of various sizes of the nozzles are shown in the picture given below: We have used different types of nozzles so that we can vary the jet velocity of the water jet so as to obtain different values of rpm of the rotating Pelton wheel.



Fig.5. Steps for constructing the nozzle

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DESIGN OF SHAFT:

STEPS

- 1) We now move onto the shaft part, for which we take a 35 mm diameter cylinder rod of 580 mm length. We use lathe machine to make the shaft as per required size and for this we use operation like turning, facing and finally we get the shaft as per required size 30mm for the pelton wheel part (shown in the figure)
- 2) To fit the shaft in the base frame and connect it to the alternator we had use bearing housing of internal diameter 20 mm hole on the base. This bearing housing is used for the purpose of holding the main shaft to the frame rigidly. The bearing housing is held tightly with the main frame by using nuts and bolts of 10 mm dia and length 1.5 inch.
- 3) To connect the alternator and the shaft, coupling is used. For coupling, one part of the shaft is threaded to join the alternator. We make a key slot on the shaft and the coupling part, which is done in the lathe and the shaper machine so that the rotatory motion of the shaft is being transferred to the rotor shaft of the alternator. For threading part we use 14 mm screw pitch and gear arrangement is (30, 70, 50, 100) in the lathe machine. This threading is done for the purpose of joining the other part of the coupling with the rotor shaft of the alternator.



Fig.6. Design of shaft with key slot

V. RESULTS

After completion of all the required parts, an alternator is fitted to the main shaft of the rotating turbine and a proper cover is made by using sheet metal so that water could not get entered inside the turbine which may cause some problems to the alternator used. As all the required parts are manufactured and fabricated painting is done on the all required parts so that there should not be any rusting problem. Painting also gives an attractive look to the model.

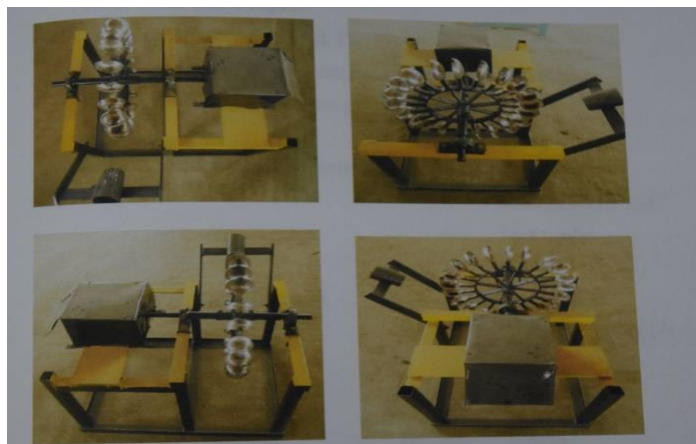


Fig.7. Final completed view of our project

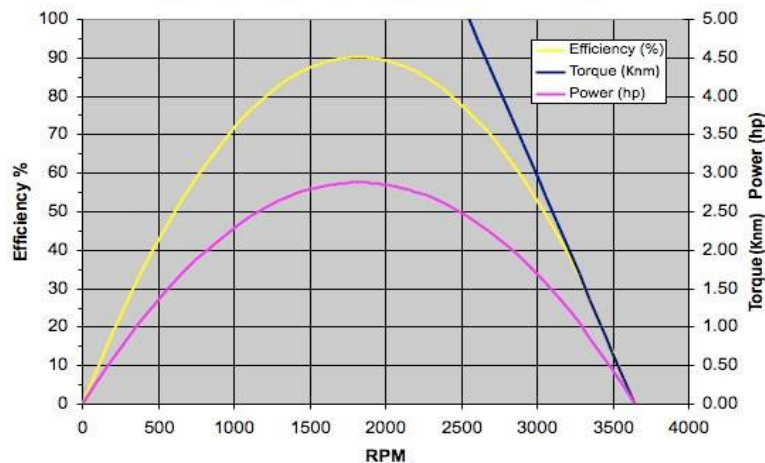


Fig.8. Characteristics curve for the turbine

VI. DISCUSSIONS ON THE PROJECT MODEL

- 1) The design and fabricated model have given around 500 rpm when rotated with the help of a pump under the artificial head of 15m. This rpm can be further enhanced by using a higher head resulting in more discharge of water and more jet velocity.
- 2) The Pelton wheel may not rotate after a while or stop rotating if enough RPM is not generated as per the limitations of the Alternator due to partial excitation of the rotor. Partial excitation of the rotor inside the alternator generates opposition force to the rotating shaft. If we can overcome this force, then only current will be generated produced/generated in the alternator.
- 3) If there is manufacturing defect in the alignment of the Pelton wheel, then there will be vibrations to the Pelton wheel which may result in fewer rotations or zero rotations.
- 4) Special care should be given to the manufacture of the frame so that it could not fall down during operation.
- 5) The Pelton wheel, shaft and Alternator should be held tightly in the frame so that there must be lesser vibrations as much as possible.
- 6) The design of the nozzle should be such that it could discharge the required amount of water without any failure with a high velocity. This velocity of jet would generate the force on the Pelton wheel will lastly rote the conductor of the Alternator.
- 7) Care should be taken during the manufacturing process so that there should be no loss of materials which would result in more amount of investment.

VII. CONCLUSION

As robust global economic expansion continues the question of where a growing world population will continue to get the electricity to drive the economic engine remains. While most of the new generation supply will come from thermal resources, conventional thinking on the development of new resources and supplies should provide greater emphasis on using sustainable, renewable resources. Hydroelectric power has an important role to play in the future, and provides considerable benefits to an integrated electric system. The world's remaining hydroelectric potential needs to be considered in the new energy mix, with planned projects taking into consideration social and environmental impacts, so that necessary mitigation and compensation measures can be taken. Clearly, the population affected by a project should enjoy a better quality of life as a result of the project. Hydro development should go hand in hand with further research and development in the field of other renewable options such as solar and wind power. Energy conservation measures should also be optimized and encouraged.

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Any development involves change and some degree of compromise, and it is a question of assessing benefits and impacts at an early enough stage, and in adequate detail, with the full involvement of those people affected, so that the right balance can be achieved. Two billion people in developing countries have no reliable electricity supply, and especially in these countries for the foreseeable future, hydropower offers a renewable energy source on a realistic scale. Our project aims at designing and fabricating a similar type of project but the scale of the project may be lesser compared to the micro hydro power turbine due to limitations of the machines and availability of the materials.

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