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FABRICATION OF PORTABLE PICO HYDRO- POWER GENERATOR USING SPIRAL TURBINE

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ABSTRACT

Flowing water has a potential in electricity in generation and storage purposes in addition the routine activities. Rural electrification is required to improve the substance of individuals that are located where centralized power grids do not reach. It is a known fact that India is very rich in water resources from where we can hardness enough water for irrigation and huge amount of electricity. Here in Pico hydro power generation, the main aim is to produce power in remote areas where there is lack in the power sources by using stream water. Recent innovations in Pico hydro technology have made it an economic source of power even in some of the world's poorest places. It is also a versatile power source. In Pico hydro power generation, we can run the turbine even at low heads at not in case of small hydro power generation.

Keywords: Pico Hydro, Power Grids, Irrigation, Remote Areas.

I. INTRODUCTION

Due to awareness about the importance of a sustainable environment, the role of renewable energy has been recognized as great significance for the global environmental concerns. One example of renewable energy is hydro power in which its potential application to future power generation cannot be underestimated. Particularly in lower head hydro resource, the cost of the commercially available low head water turbine is considerably high per kilowatt output, more research need to be done on lowering the cost of these low head hydro power systems. Depending on fossil fuel energy should be decreased and substitute with renewable energy resources. Any kind of green energy source becomes research object such as solar, wind, water, geothermal and biomass nowadays. Any small contribution of renewable energy source will influence the percentage of energy mix that use around the world. Among the renewable energy resources, energy from water in mini/micro hydropower has gained the highest attraction due to its environmental friendly operation.

Water energy is of great importance for sustainable future because it is a clean, cheap and environmental friendly source of power generation. Particularly in lower head, it can be the best economical option for remote area electrification in developing countries. Around the world, there are many sources of hydro power in the form micro or Pico hydro power from low head river or irrigation has not been exploited yet. In developing country such as Indonesia, from 400 MW potential capacity of micro hydro power, only around 1.8% of potential micro hydro power which exploited for power generation, while many areas are still lack of electricity particularly in rural areas. Application screw turbine as micro or Pico hydro power generation will solve that problem and it can increase electricity ratio around this country.

This paper highlights the development of screw turbine and presents the experimental performance of screw turbine for ultra-low head hydro resource. This paper reports performance of screw turbine based on experimental data collected from some inclination angle position of screw turbine. Furthermore, discussion about the challenges and opportunities for promoting screw turbine as alternative renewable energy technologies is also included in this paper, followed by conclusion with recommendations for development of screw turbine.

Spiral Hydraulic Power Unit is promising hydro power generation equipment which has potential for dissemination in non-electrified areas, with its characteristics including low head generation and dust-resistance. "Pico hydro power generation" is a unit that enables around 10W generation by securing a flow of 10ℓ/sec and a head of 0.1m. This product can be manually assembled and utilized as security lighting, drawing power from a nearby waterway. If this product is implemented in developing countries where electrification is an issue, people's lifestyle can be modernized, resulting in providing enormous social and cultural impact.

1.1 PROBLEM IDENTIFICATION

1. Various kinds of turbines which extract hydroelectricity require a certain amount of head.
2. Also, they require large complicated arrangements and setup.
3. The depleting quantity of fossil fuels and its continued usage is a great threat to the environment.

1.2 OBJECTIVE OF STUDY

1. The work is to fabricate a working Transverse Horizontal Axis Water Turbine.
2. Testing it for the shaft power it gives in terms of watts, the generator power in terms of voltage. Voltage produced by the generator will indicate the electricity produced by the mechanical work of the turbine. If we see a greater picture, the paper aims at reducing the use of non-renewable sources and finding an efficient way too harness green energy and contribute to good health of the environment and the society at large.

II. METHODOLOGY

Spiral turbine works as follow; water flows into the top of the turbine, make it turn while water keep moving down as the length of the screw. The hydrostatic pressure from water on the blade surface causes it to turn. Rotation of shaft can generate electricity by connecting to a generator. In this experiment, the turbine consists of a cylindrical shaft onto which four helical blade is wrapped to the shaft with 1 revolution. It has been fastened using gas welding and covered by cylindrical casing. Blades of turbine were made of aluminum for easy machinability, and the shaft was made of galvanized iron sheet.

The size of diameter shaft, blade, and housing were selected according to available tools and materials. No attempt was made to balance the finished turbine. The turbine shaft supported directly by ball bearing at the top and bottom of turbine housing.

Generally, the total extractable power of a water turbine can be found from Pw=ρgQh

Where, ρ is the density of water, g is the acceleration due to gravity (9.81 m/s2),

h is the available head of water source (m) and Q is the volumetric water flow rate (m3 /s).

The mechanical power Ps available at the turbine shaft can be determined by measuring the torque T at a corresponding angular speed ω. The torque is found by measuring the tangential force F on a pony brake with moment arm radius of pulley r.

$T = Fr$ $ps = T\omega = 2\pi nT$ 60.The mechanical efficiency of the turbine shows how effectively the available kinetic energy of the water is transformed into turbine motion and it becomes $\eta = ps\ p\omega$

2.1 DESIGN METHODOLOGY

The screw is inclined with horizontal direction by making an angle of θ i.e. slope of the screw is tan θ. The geometry of the screw is governed by two types of parameters, these are1. External parameters 2. Internal parameters.

1. External parameters are:

a. Outer radius (RO)

b. Total length (L)

c. Slope of screw (K)

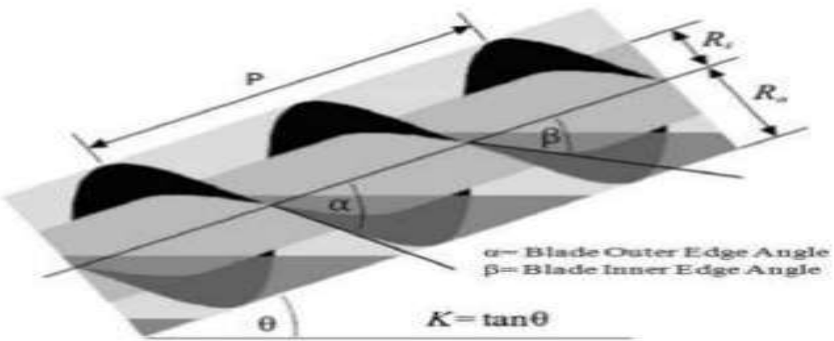

Figure 1: Profile view of a segment of a Two- Bladed Archimedes Screw

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Internal parameters are: a. Inner cylinder radius (Ri) b. Pitch of one blade (P) c. Number of blades (N): N= 1, 2, 3, 4… Here we take the external parameters as fixed. Now considering the assumption that the blade thickness is negligible, it can be seen that the total volume of water in one cycle of the screw is monotonically increases with the number of the blades. If the blades have non negligible thickness then they will occupy an increasing fraction of the volume of the screw as their number increase. In this case an optimal value of N is determined.

In modern screws the blade number is taken as 1, 2 or 3 due to the manufacturing, weight and cost constraints. We have taken the blade number of the screw as 2.In order to optimize the performance of the screw turbine, Maximum volume of water in one cycle of the screw,

VTmax= $\pi RO\ 2P$ Volume of one chute, Vc = $(RO\ 2 - RI\ 2)/\ N$ Volume of one bucket, Vb=VT/N

2.2 WORKING:

A Turbine is basically a component design to convert kinetic energy of water to rotational energy which in turn produces electricity. When water (fluid) strikes on the turbine blades, it pushes the blades and makes them rotate, harnessing kinetic energy (energy of flow) and converting it into mechanical energy. More and more kinetic energy is harnessed if there is more pressure of the flow of water. The total weight of this water power generator is only 18 kilograms. This is the firstever generator of its kind that can be easily carried by one person. Kinetic energy of a mass in motions is given by, E = 1/ 2 mv 2 ----------(1) The power in the water is given by the rate of change of energy, P= $dE/\ dt$ = 1 /2 $m/\ dt$ -----(2) As mass flow rate is given by: $dm/\ dt$ = ρA dx/dt ---------{ $dx/\ dt$ =v} we get, dm/dt = ρAv Hence, from equation (2), the power can be defined as: P= 1 /2 ρAv 3 The power captured by the rotor of the wind turbine and the total power available is not the same That is why the coefficient of performance comes into picture, Pavail= 1/ 2 ρAv 3Cp Where, Pavail =Power available ρ = Density of Water A= Swept Area= πdl v= Free stream velocity Cp= Coefficient of Performance Water carries a lot of energy even when it flows at low speed and is heavy thus, these turbines can also be relatively slow.

2.3 Hydroelectricity energy conversion

Hydroelectricity energy conversion can be well understood in three simple steps.

1. The potential energy of water is converted to kinetic energy when it flows through the river.
2. Kinetic energy of moving water is converted into rotational (mechanical) energy by a water turbine.
3. Rotating water turbine drives a generator that turns mechanical energy into electrical energy.
4. Single units can be used in local river bodies and rivers according to the geography of the river.

III. FABRICATION

3.1 CONSTRUCTION

The construction of this ultra-small water power generator is very simple. It consists of an iron casing inside which the turbine blade is mounted as in the figure. The generator is attached at one end of the casing. This facilitates it to directly produce electricity and makes work easier. The front part of the casing is 15 cm higher than the lower side, which generates sufficient current inside water to run the turbine blades.

“Life in remote areas of the world that still lacked power there are many places where individuals or whole areas have no access to electricity if we can provide them with the means to make their own power they’ll be able to change their lives that’s my hope an ultra-small generator that could provide environmentally friendly electricity for any place on earth where there’s even a slight flow of water,” The main component of the ultra-small water power generator is the Rotor which is made of up four blades of hydrofoil NACA 0018 mounted on the two endplates. There is a frame to support the rotor assembly. There is a chain-sprocket assembly to increase the rotor output. The rotor is connected to chain-sprocket assembly by a shaft.

The output velocity of the chain-sprocket assembly is then fed to the output shaft and thereby connected to the generator or any other output measuring device. The figure 1 shows the actual fabricated setup picture and table 1 shows the different components, materials used and its fabrication details.

Table 1: Materials used and its Fabrication details

S.NO	Part	Material	Quantity	Method of Fabrication
1	Frame	Galvanized Iron with protective paint coating	1	General Engineering Methods
2	NACA 0018 Hydrofoil Blade	Galvanized Iron with protective paint coating	4	General Engineering Methods
3	Shaft	Mild Steel Bright	2	General Purpose machines
4	Flange	Cast Iron	3	Enlarging the flange w.r.t the bearing size with lathe a machine
5	Ball Bearings	Chromium steel	2	Purchased

3.1.1 NACA 0018 HYDROFOIL BLADE

The most vital component for harnessing energy in this system is rotor. The material used for the spiral turbine is galvanized iron. Rotor is responsible for converting kinetic energy of water into rotational energy. The turbine used in this system is inclined axis kinetic turbine. The rotor axis is orthogonal to the water flow but parallel to the water surface. This turbine consists of 6 number of hydrofoil shape blades. Blades were made of Standard hydrofoil shape of NACA0018. Galvanized iron material is used for blades as it is cost effective and is light in weight. A non-corrosive enamel coating was given to the blades to prevent corrosion due to water.

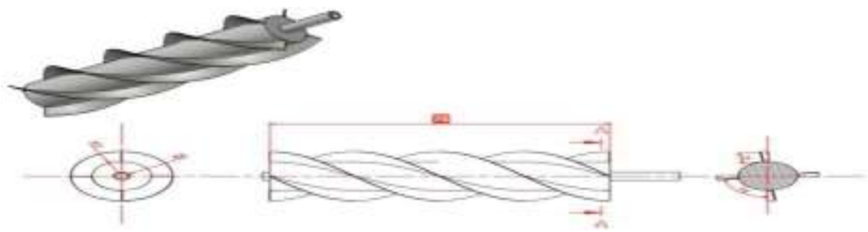

Figure 2: Dimensions of NACA0018 hydrofoil spiral blade

Figure 3: NACA 0018 Hydrofoil spiral Blade

3.1.2 SPECIFICATIONS

Table 2: Technical specifications for turbine rotor design

S.NO	Component	Parameter	Value
I	Fluid Properties	Density(kg/m^3)	1000
		Kinematic Viscosity (10^6 m^2 s^{-1}) at room temperature)	0.8745
II	Turbine	No. of blade	4
		Diameter of rotor(m)	0.12
		Length of rotor(m)	0.75
		Hydrofoil Blade profile	NACA0018
		Chord Length(m)	0.012

		Angle of attack(deg)	10

IV. RESULTS AND DISCUSSION

Spiral Hydraulic Power Unit is a promising hydro power generation equipment which has potential for dissemination in non-electrified areas, with its characteristics including low- head generation and dust-resistance."Pico hydro power generation" is a unit that enables around 10W generation by securing a flow of 10ℓ/sec and a head of 0.1m. This product can be manually assembled and utilized as security lighting, drawing power from a nearby waterway.

Outer radius (Ro) =0.12m Inner cylinder radius (Ri)=0.08m Total length (L) =0.75m Slope of screw (K)= tan11

Pitch of one blade (P)=0.75m Number of blades (N) = 4

Here, we take the external parameters as fixed. Now considering the assumption that the blade thickness is negligible, it can be seen that the total volume of water in one cycle of the screw is monotonically increases with the number of the blades. If the blades have non negligible thickness then they will occupy an increasing fraction of the volume of the screw as their number increase. In this case an optimal value of N is determined. We have taken the blade number of the screw as 4,R0=0.12 Q=AV

Efficiency=117.8/207.34

56.8% Hydraulic power developed, P= rho *g*Q*H

Where, rho = density of water = 1000 kg/ m3 g = acceleration due to gravity = 9.81 m/s^2 Q=flow rate

This product allows you to generate with lower head compared to other hydraulic power generation units. As the whole structure of this watermill is open type and simple, works such as assembly, installation, cleaning, and maintenance can be completed with ease. Besides, the spiral shape watermill prevents the unit to be clogged with floating substances or dusts.

Because this product doesn't require large waterways or pressure tubes for installation and there are not many component parts, this product is cost effective compared to another hydraulic generation units. When installed, the frame and the main body create a head by damming the waterway.

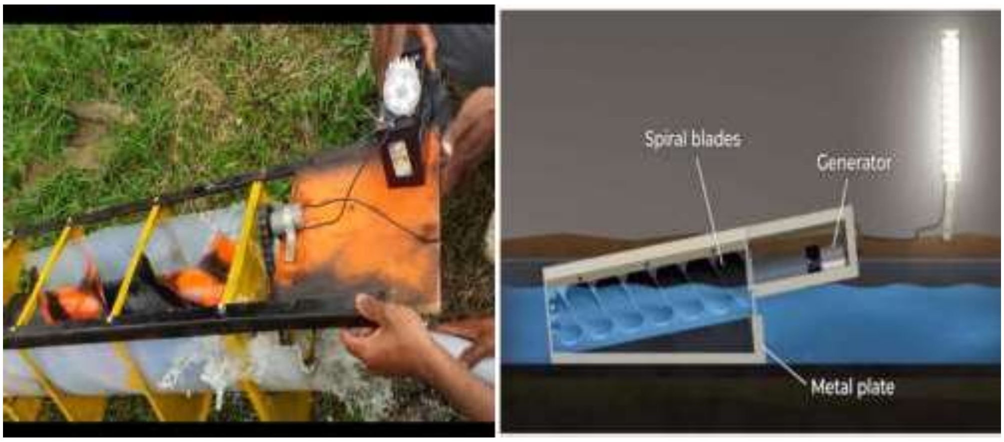

Figure 4: Overall view of Pico hydro power generation using spiral turbine

So this product can be installed and operated smoothly as long as the water way ensures required flow for generation. Regarding main consumables (such as bearing, generator, and watermill turbine) that require maintenance, no special skill will be needed to exchange them. Consequently troubles can be repaired promptly.

- Weight of the total system is 17.5 kg
- The system is constructed according to the head and flow

4.1 FUTURE SCOPE

Power from the natural flow of streams and small rivers can be harnessed to bring clean, available electricity to remote communities, providing light to study and work by helping small business grow. Pico hydro power is bringing electricity and prospects for a better future to remote communities across the world. As well as replacing polluting and dangerous kerosene for lighting, it can also power radios, TVs and machinery to run by batteries to storage the power from the generator. Providing new education and livelihood opportunities. Pico hydro power systems are widely used in Japan and the USA from the start of the 20th century, but most we are abandoned when national grids arrived. With the aid of fluid dynamics, parameters like, spiral flow housing, performance variation with head can be studied for further improvements of the system.

V. CONCLUSION

Valuable information about the performance characteristics of screw turbine was collected through the experiments. An ultra-small turbine for hydroelectric generation has been constructed by using inexpensive and available materials and components. Among three selected angle of inclination, lowest slope has highest efficiency. Future research plans include the impact of varying other parameters such as number of blade, pitch and more installed slope. Leakage and losses will also be investigated. Finally, the best result of propose model should be tested with a full size of turbine.

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