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Design and Fabrication of Mini Hydro Turbine

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***Abstract*: In the modern world 16% of the power depends on hydropower. That is power production of rotation of turbine wheel by water. Still 14% of world's population suffers for electrical power. This problem can be solved by hydropower generated by streams or rivers nearby areas where providing electrical power is difficult. We try to bring down this ratio by using a mini hydro turbine which can produce power with minimal head and velocity. While large hydropower provides electrical power for industry and domestic uses, small-scale hydro can make some contribution in providing basic need to rural and off-grid areas.**

***Keywords*: Hydropower, Minimal head and velocity, Domestic uses.**

1. Introduction

In modern world there are many industries and companies also increase in population more residual power consumption is also increased. World countries are looking for power generation to satisfy the needs.

There are many way to generate power but most of the middle-east countries uses petroleum products to generate power. Some other countries uses nuclear power, wind power likewise methods. Some of these methods are costly, low efficient, and causes pollution to atmosphere. But hydropower is more efficient and eco-friendly. Hydropower has some disadvantages like high cost, needs more maintenance. These disadvantages are due to construction of dams. But construction of dams are also necessary for increasing the head of the water to generate power. We came up with a product which over comes these disadvantages and satisfies the needs of the society.

2. Objectives

- In the modern world 16% of the power depends on hydropower. That is power production of rotation of turbine wheel by water. Still 14% of world's population suffers for electrical power.
- This problem can be solved by hydropower generated by streams or rivers nearby areas where providing electrical power is difficult. By using a mini hydro turbine which can produce power with minimal head and velocity.
- While large hydropower provides electrical power for industry and domestic uses, small-scale hydro can make some contribution in providing basic need to rural and off-grid areas.

3. Literature Review

[1] San San Yi et al., carried out a study about cross flow turbine to fulfil the requirements of electrical energy with the help of the small rivers. But the maximum power will be attained if the flow rate is high. To boost up the flow rate of the water they have used the nozzle and a runner. They had assumed that the expected power is 90kw. To get an expected output power they had assumed that the head is 13m and a flow rate is $1m^3/s$, to get a higher friction with water they have used 18 blades.

[2] Kamaruzzaman Sopian et al., carried out a study about hydro power from the small streams to fulfil the requirements of electrical energy with the help of small streams. In this survey they had tested two types of heads namely, High Head hydro turbine and Low Head hydro turbine. In the high head hydro turbine the maximum amount of energy produced is up to 5kW. But in the Low Head turbine the maximum amount of energy produced is 60kW. The hydro stream turbine consists of cross flow turbine, gear system and an alternator. By using this turbine the power output will be up to 360W.

[3] Bilal Abdullah Nasir et al., carried out a study about Design of Micro - Hydro - Electric Power Station to fulfil the requirements of electrical energy with the help of the hydro power. In this survey they had tested about a various types of turbines. Impulse turbine is suitable for high heads and low flow rate and the Reaction turbine is suitable for medium and low heads and high flow rate. This micro hydro turbine does not require a dam. It will be constructed in the run of water or in streams. In this survey they had assumed that the efficiency of the turbine is 80 to 90%. In this survey the back flow of water may be taken place which will affect the efficiency of the turbine.

[4] Oliver Paish et al., carried out a study of Small hydro power technology and current status to fulfil the requirements of electrical energy with the help of the running stream of water. In this survey they had tested two types of turbines namely Impulse turbine and the Reaction turbine. In the impulse turbine the pelton, the turgo and the cross flow turbines are used. But the impulse turbine needs very high head and low flow rate of water. But the reaction turbine needs a medium or low head and a high flow rate of water. In this survey the efficiency of the turbine is 80 to 90 %. (higher than most other prime movers).but by using this turbines the back flow of water will be taken place,

which will affect the efficiency of the turbine and the life of the turbine. To avoid the back flow of water the design of turbine blade should be accurately done.

[5] Pimnapat Iemsomboon, Trirath Pati and Krischonme Bhumkittipich et al., carried out a study of micro hydro turbine and PV for electrical generator. The design a PV-Hydro turbine Hybrid System for Bunnasopit school by calculate and to use program Homer for to exam Simulation study to work and optimized by the software program before install real system. Found that the system design can be able to supply energy to the load continually design size 1. PV = kWp, 2 Hydro Turbine = 3 kW, 3Convertor = 5kW Battery = 3,200 kWh. (200Ah of 16 set). The system can only generate electricity at 14 kWh/day. The total electrical generating is 23,360 kWh/year. The economics analysis result found that the hybrid system cost is 276.13 Bath/kWh. The investment and NPV are 3,493,630 baths (116,454.33 US. Dollar) and 1,235,273 Bath (41,175.76 US. Dollar), respectively. IRR and Benefit Cost Ratio 1.68 and 0.50 respectively. The benefit of this system is 73,000 Bath/year (2,433.33 US. Dollar). And all of project (20year or higher) can productivity of electrical energy 1,460,000 Bath (48,666.66 US. Dollar) Economical of fuel for generate electricity 36,0093.6 Bath (12,003.12 US. Dollar) per year.

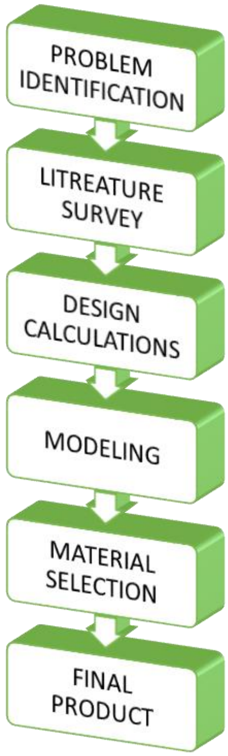
[6] Parea Rusan Rangan, Andrea Stevens Karnyoto, Yusri Anugerah Manapa Ambabunga et. al., carried out a study of Design of River Flow Floating Portable Micro-Hydro. This floating portable micro-hydro is still a design. This design is made based on observations of researchers. Next, we have to implement to create a prototype. Then, the prototype will be analyzed and be piloted in the actual environment to know the capacity and efficiency will be produced. Currently, researchers have not been able to determine the capacity of the generator output that to be used. All equipment and materials are readily available throughout Indonesia; only generators still have to be imported from outside Indonesia. The price of the generator will be low if the floating portable micro-hydro is mass produced. We are expected with this design, common Indonesian people who live in rural areas and living close to the river can enjoy cheap electricity and can maintain their power plants by their self.

[7] Kiran P. Huparikar[1], G. R. Naik et. al., carried out a study of Development of prototype turbine model for ultra-low head hydro power potential in Western Maharashtra. It is to focus on the potential of micro hydro power development and to understand the designing procedure of a ultra-hydro system. This paper deals with developed prototype model, at very low cost. The design of 0.2 kW developed using ultra-hydro plant prototype model can benefit to harness the unidentified hydro power potential which is available at K. T. weir (Kolhapur Type weir). The available hydro power potential can be used to supply and fulfil the demand of domestic water of nearby villages, for lightening the roads near K. T. weir.

[8] Bilal Abdu wijah et al. carried out a study of Design Consideration of Micro-Hydro-Electric power plant. Micro-hydro power continues to grow around the world, it is important to show the public how feasible micro hydro systems actually are in a suitable site. The only requirements for micro-hydro power are water sources, turbines, generators, proper design and installation, which not only helps each individual person but also helps the world and environment as a whole. The choice of turbine will depend mainly on the pressure head available and the water flow rate. There are two basic modes of operation for hydro power turbines: Impulse and reaction. Impulse turbines are driven by a jet of water and they are suitable for high heads and low flow rates. Reaction turbines run filled with water and use both angular and linear momentum of the flowing water to run the rotor and they are used for medium and low heads and high flow rate. Regulated turbines can move their inlet guide vanes or runner blades in order to increase or reduce the amount of flow they draw. Cross-flow turbines are considered best for micro-hydro projects with a head of (5) meters or less and water flow rate (1.0) m^3/s or less. Micro-hydro power installations are usually run-of-river systems, which do not require a dam, and are installed on the water flow available on a year round basis. An intake structure with trash rack channels water via a pipe (Penstock) or conduit down to a turbine before the water released down- stream. In a high head (greater than 50 m) and low water flow (less than 0.5 m^3/s), the turbine is typically Pelton type connected directly to a generator with control valve to regulate the flow of water and turbine speed.

[9] Suwat Phitaksuruchai, Rudklao Pan-Aram, Noppong Sritrakul, and Yodchai Tiaple et al., carried out a study of Performance Testing of Low Head Small Hydro Power Development in Thailand. This study demonstrates the development of Thailand's Low Head Small Hydro Power by using basic knowledge, theories and modern technologies to contribute in design and production. The key part of the hydro turbine is the runner blade, which is based on the shape of the marine propeller, along with the reversed mean camber line that giving a high performance hydro runner blade. Small hydro turbine testing has the high efficiency of 70% - 80% throughout the head range 10 to 20 m with hub blade angle at 40° and the guide vane angle at about 40° to 45°. According to the production of small hydro turbine, the research found that the cost of production is approximately USD513/kW [10] compared with 1000 kW low head turbine (0 - 30 m) from Hydro Tasmania Company in Australia [11] that costs approximately USD900/kW. Moreover, as per the Department for International Development, the UK and the World Bank [12], an estimated turbine price that installed in Sri Lanka, Nepal, Peru, Zimbabwe and Mozambique is approximately USD615-USD1,911/kW. Therefore, the low cost of small hydro turbine generator is likely to be an incentive for small hydropower to benefit and to develop consistently in Thailand.

4. Methodology



5. Components and Functions

A. *Hydro turbine*

Turbine consist of 3 blades and it overall diameter is 300mm also it length is 500mm its blade angle is 34.31^0. It is a rotating part which is holded at both sides by bearings. Shafts are welded to the turbine to maintain is rotation in its axis. The turbine material is SS304.

B. *Shaft*

Shaft diameter is 40mm is weld to turbine and also connected with pulley to transmit power from turbine.

C. *Ball bearing*

Bearing is used to decrease the friction in shaft and to increase the stability of turbine while rotation.

D. *Pulley*

Pulley is a mechanical derive used to transfer power. It consists of two v-pulley larger is connected with shaft and smaller is connected with generator and their dimensions are 100mm and 30mm.

E. *Generator*

A DC 0.5kw generator is used to generate power. Generator converts mechanical energy into electrical energy.

F. *Belt*

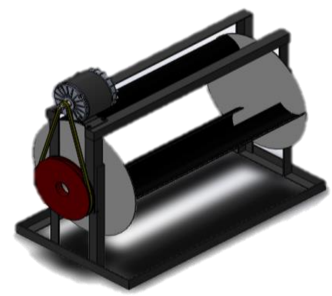
A leather belt is used to transfer power between two pulleys.

G. *Mild steel frame*

There are the frames one is base frame it is fixed and another one is upper frame it is adjustable. The total length of the frame is 580mm, breath is 330mm and maximum adjustable height is 500mm.

6. 3D Model of Product

3D Model and drafting for Mini Hydro Turbine is done by using SOLIDWORKS 2016.



7. Design Calculation

Assumptions made:
Power to produce = 5 kW
No. of blades = 3
Overall diameter (D_1) = 0.3m
Area of stream =0.1 m^2
Velocity of water =2m/hr
⇨ $0.5*10^{-3}$ m/s
Flow rate (Q) = $5*10^{-5}$ m^3/s
Overall efficiency (η) = 0.9
Temperature of water =20º C
Density of water at 20ºC = 1000kg/m^3

Shaft power output:
$P= (\eta * \rho * g * Q * H)$
where
g = acceleration due to gravity,
H = head.
$P= (0.9*1000*9.81*5*10^{-5}*1)$
= 0.44145 Kw

Specific speed:
$Ns=(172.556)/H^{0.425}$
=172. 556 ≈ 173 rpm

Turbine Speed:
$N=(Ns * H^{1.25})/P^{1/2}$
$= (172.556 * 1)/ (0.44145)^{1/2}$
= 260 rpm

Angle of attack:
For minimum efficiency
$\eta =1/2 * k_c^2(1+\psi) * \cos^2 * (\alpha)$
Angle θ= 13.36º

Shaft Diameter:
D_s = 0.04m

Blade angle:
β = 34.31º

Blade spacing:
t= (K*D)/ sin β
= (*0.06)/ sin 34.31
t = 0.314m

8. Working

Initially, when the turbine is placed in moving water it starts to rotate. This rotation is transmitted to generator mounted on the movable frame by pulley these pulleys are connected by using leather belt. The DC generator generates power the produced power can be stored or can be used for industrial or rural purposes.

9. Conclusion

Thus, we have come up with low-cost mini hydro turbine. We have been able to design and develop a mini hydro turbine for different purpose. In this paper the attempt made for designing and manufacturing of mini hydro turbine is successful.

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