© 2020 | International Journal of Scientific Research in Science and Technology
IJSRST | Volume 7 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
DOI : https://doi.org/10.32628/IJSRST

Optimization and Manufacturering of a Micro Zero Head Turbine For Power Generation

[1]C. Pramod Kumar, [2]K. Pavan Kumar Reddy M.Tech (Ph.D)
[1]M.Tech Scholar, Mechanical Engineering, SVIT Engineering College, Anantapur, , Andhra Pradesh, India
[2]Assistant Professor, Head of The Department, Mechanical Engineering, SVIT Engineering College, Anantapur, Andhra Pradesh, India

ABSTRACT

A zero head water turbine has been used as a source of power generation where construction of a dam for the head is not required. It works on natural flow of water to generate a specific power output. The power is however limited by flow of water which is sufficient to keep generate a suitable number of revolutions per minutes for the blades. Present research was aimed to design and manufacture a micro zero head turbine which could produce sufficient power to light a couple of energy saver bulbs upto a wattage of 50 to 60 that can suffice the lighting requirements of far flung villagers and dwellers having access to natural streams of water but no electricity supply. It resulted in design and fabrication of one such turbine which was able to generate a power of approximately 50 watts at a free stream velocity of 1.2 meter/second. Findings of this research were quite in harmony with theoretical results which may be used for increasing the size of micro turbine along with a proportionate rise in generated power.

Keywords : Power Generation, Design, Turbine and Results

I. INTRODUCTION

Micro-hydel power (MHP) technology has matured over a period of time. Centuries back, man learnt how to make use of water for power generation and even presently, in some countries primitive hydraulic devices could be found. Now a day's MHP are being developed using modern design tools and technologies. These are being used for power generation at far flung places where naturally flowing streams of water exist in abundance. Such power generation initiatives are being duly supported by the local governments.

Additional advantages of a Micro zero head turbine are high efficiency in low speed currents, little resistance to the onward force of a tide and it also allows marine life to harmlessly escape from the rotor blade. Investigations regarding the influence of design parameters in low head axial flow turbines like blade profiles, blade height and blade number for micro-hydro application continue to be inadequate, even though there is a need and potential for the application of such turbines. Investigations have been made to analyze the cost of various components of low head run-of-river small hydropower projects based on the actual quantity and the prevailing market price of each item.

Micro hydro is a type of hydroelectric power that typically produces from 5 kW to 100 kW of electricity using the natural flow of water. Installations below 5 kW are called pico hydro. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks, particularly where net metering is offered. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without the purchase of fuel. Micro hydro systems complement solar PV power systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro is frequently accomplished with a peloton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing.

The natural power of a running river or a stream has been of interest for electricity production for many years. The technology of small-scale hydro power is diverse, and different concepts have been developed and tried out. This report will focus on water current turbines with a unit power output of about 0.5-5 kW. These turbines are supposed to be used for domestic electricity applications such as lighting, battery charging, or for the use of a small fridge. The units are small, cheap and often owned, installed, and used by a single family.

Water current turbines, also called hydro kinetic or in-stream turbines, have received a growing interest in many parts of the world. Two main areas where hydrokinetic devices can be used for power generation purposes are tidal currents and river streams.

This report will focus on water current turbines for river applications. These turbines generate power from the kinetic energy of a flowing stream of water without the use of a dam or a barrage. Water current turbines can be installed in any flow with a velocity greater than 0.5 m/s. Because of low investment costs and maintenance fees, this technology is cost effective in comparison to other technologies. The continuous supply of electrical energy is also an advantage in comparison to solar power or other small scale renewable technologies. This kind of small-scale hydropower is considered environmentally friendly, meaning that the water passing through the generator is directed back into the stream with relatively small impact on the surrounding ecology. Small-scale water current turbines can be a solution for power supply in remote areas. Because of the low cost and durability of this kind of hydro power, developing countries can manufacture and implement the technology to supply the needed electricity to small communities and villages.

There are different kinds of small-scale hydropower. The term “pico hydropower” is said to be water power up to 5kW and is a smaller version of the more established term; micro hydropower. Pico hydropower is usually used when we think of hydropower on a regular basis, where the power is made by falling water and an artificial water-head. The report will not consider this type of hydropower. The report will mainly focus on kinetic “in-stream” hydro turbines. These turbines produce electricity from the free-flowing water in a river or stream and do not rely upon a water-head to produce electricity.

For the scope of this report the focus was on applications in free-flowing rivers, although several of the devices may have applications in tidal waters, ocean currents and man-made channels. Short reviews of some of the existing turbine technologies are outlined. The paper will also look at the commercial market in this field and consider some experiences already made in rural areas in different parts of the world. In order to find the existing technologies and companies with viable concepts, a web based search is accomplished. Earlier written reports are also reviewed.

Discussions on performance analysis and modeling issues are beyond the scope of this work. This report have been made with financial support from Norad - Norwegian Agency for Development Cooperation.

COMPARISON TO CONVENTIONAL HYDRO

Most current hydroelectric projects use a large hydraulic head to power turbines to generate electricity. The hydraulic head either occurs naturally, such as a waterfall, or is created by constructing a dam in a river valley, creating a reservoir. Using a controlled release of water from the reservoir drives the turbines. The costs and environmental impacts of constructing a dam can make traditional hydroelectric projects unpopular in some countries.

Damless hydro captures the kinetic energy of rivers, channels, spillways, irrigation systems, tides and oceans without the use of dams.

Construction of a dam and reservoir may have harmful environmental effects. For example, the damming of a river may "block the movement both of fish upstream to spawn and of silt downstream to fertilize fields". Where sites aren't cleared "the vegetation overwhelmed by the rising water decays to form methane – a far worse greenhouse gas than carbon dioxide", particularly in the tropics.

Since no dam is required, low-head hydro may dramatically reduce the following:

- The safety risks (of having a dam), avoiding the risk of a flash flood caused by a breached dam
- Environmental and ecological complications
- Need for fish ladders
- Regulatory issues
- The initial cost of dam engineering and construction
- Maintenance
- Removing Silt accumulation.

However, low-head units are necessarily much smaller in capacity than conventional large hydro turbines, requiring many more to be built for a given annual energy production, with some of the costs of small turbine/generator units being offset by lower civil construction costs. Just as for large hydro, not every site can be economically and ecologically developed; sites may be too far from customers to be worth installation of a transmission line, or may lie in areas particularly sensitive for wildlife.

Another potentially promising type of low head hydro power is dynamic tidal power, a novel and unapplied method to extract power from tidal movements. Although a dam-like structure is required, no area is enclosed, and therefore most of the benefits of 'damless hydro' are retained, while providing for vast amounts of power generation.

COMPONENTS USED

- Fly Wheel
- Batteries
- Shaft
- Blades
- Bearings
- Generators

II. LITERATURE REVIEW

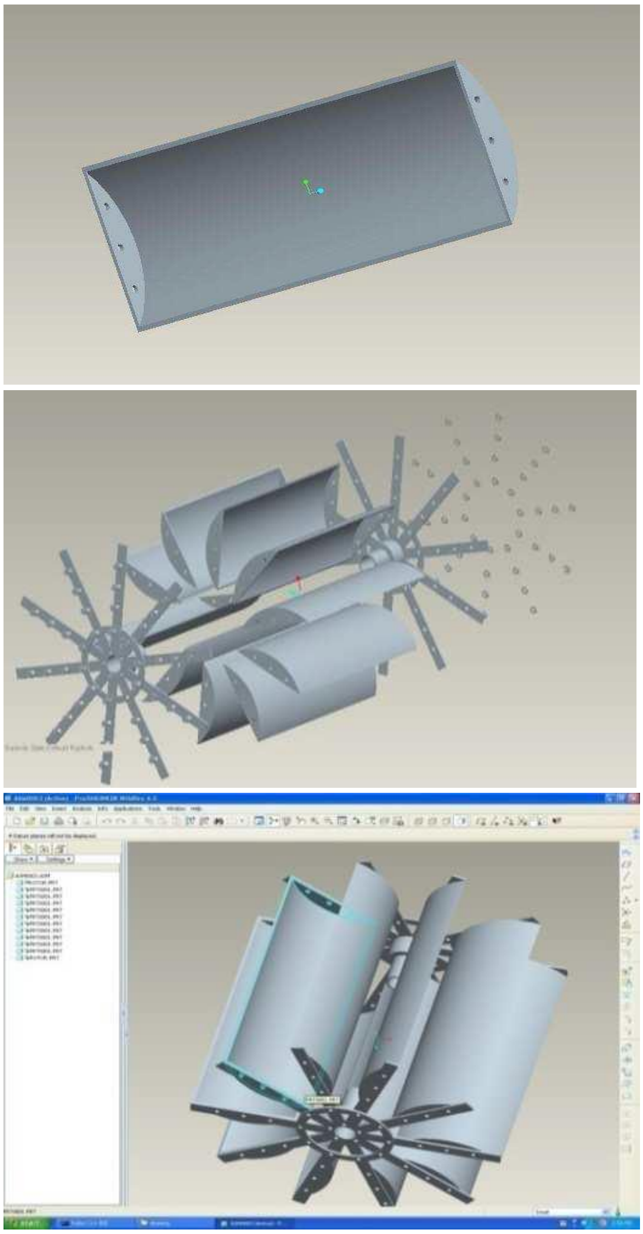
An overview of important of turbine blade angle and blade effects are describely presented. It is mainly focused on studying the different parameters of turbine rotor to improve the efficiency of the cross flow turbine for micro hydro power plant. From the literature review, it is noted that cross flow turbine should have blades between 18 to 37. At various blade angle and no of blades the efficiency is changed for micro hydro power plant. At various height and blade angle the efficiency will be changed. Some of the researcher had done their analysis on turbine rotor. They had changed blade angle, blade material and no of blades at various condition at various site. For cross flow turbine the efficiency found for micro hydro power plant is very low comparatively with other turbines. So by changing the numbers of blades, blade angle & blade spacing of rotor to increase the overall efficiency of micro hydro power plant.

III. DESIGN OF PROTOTYPE

Primary consideration for Micro Zero head turbine design was that it should fit a limited space ranging from 1 to 4 feet width of the free stream of water flow in far flung areas and must have minimum of the following geometric specifications :-

a. Perpendicular distance from shaft centre to force exerting on blade = 130mm
b. Pulley radius = 110mm
c. Blade dimension = 100 x 100 mm²
d. Blade shape = semi circular
e. Number of blades = 08
f. Flow velocity = 0.5 m/s, 1m/s, 1.2m/s, 1.5m/s

These dimensions were a result of required power generation and subsequently it was to be tested experimentally. Other design parameters included variable flow rates to provide different power values, out flow of one blade not to obstruct the other and availability of continuous value of torque at a certain rpm for same value of power generation. The calculated geometric dimensions were used to arrive at prototype design as shown in fig-1 which shows the design of individual blade, an exploded view of the rotor and blade assembly and final assembly of the complete turbine blade and rotor.



Blade and rotor assembly

A. DESIGN OF BLADE

Shape of blade was made as a semi-circular bucket so that maximum flow rate may enter from the free stream and its thickness was based on strength to thickness ratio. Use of semicircular blade was expected to provide the following properties:- a. The velocity profile of water stream is normally high at the top surface and decreases downwards as shown in fig 2. b. A semi-circular shape was expected to allow more flow of water to enter bucket as compared to one that could be striking a flat plate. This property was also established by past research.

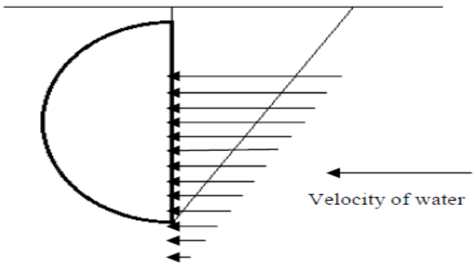


Fig. 2. Velocity profile on blade [4]

B. GEOMETRIC MODEL OF BLADE

For exact calculations of the geometry of a blade one has to consider the velocity V of water and angle α which Force applied by water profile makes with the centre line of blade. Therefore the component of velocity acting on bucket perpendicular could be represented as is VCosα. So when bucket is at centre line where α = 0, the relationship of applied force of water could be given as:

$$Fi = \rho VA(V-u)$$

Where u is bucket speed, ρ is density of water, V free stream velocity, u being bucket tangential velocity and A was the bucket area expected to be designed. The next important parameter was the angle between two buckets for finding the exact number of blades for providing optimum value of torque for a stabilized power output. This angle was calculated by assuming that the bucket directly facing water is not rotating and is perpendicular to free stream of water initially. At this point all the water would be entering the bucket and bucket velocity is assumed to be zero. Whereas any consecutive at that instant could be at an angle to the water stream. Initial force of water striking the bucket could be termed as Fi that could be calculated through the following relationship:

$$Fi = \rho VA(V-0) \ \ (u = 0 \text{ when bucket is stationary}) = \rho AV^2$$

However the fore being applied to the second bucket which is at an angle at α could be found by the following relationship. Please note that value of u would be zero for this case also because both the buckets are stationery:

$$Fr = \rho VA(VCos\alpha-0) = FiCos\alpha$$

These relationships would result in finding the angle between two consecutive buckets and torque values could be evaluated for a required power output. The schematics of two consecutive buckets are shown in Figure 3.0 and the values of Torque for various rpm of the micro turbine are shown in Figure 4.0. It may however be noticed that for a micro turbine and power output of 50watts approximately with head velocity of 1.2 meter/second the highest value of torque obtained was at 25 degree between two consecutive buckets as shown in fig.

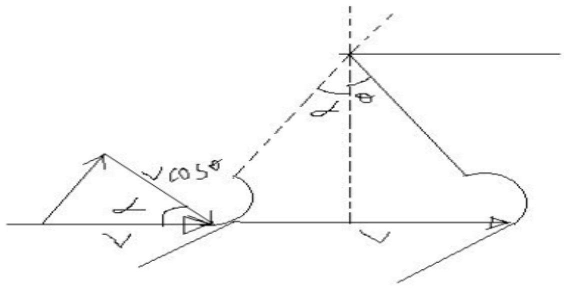


Fig. 3. Calculation of torque by number of blades

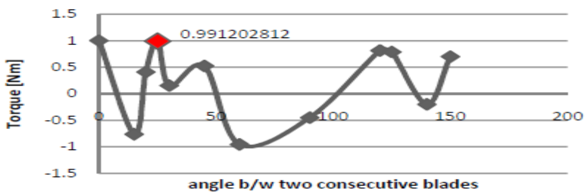


Fig. 4. Torque-Power relation

Based on the above calculations, the total length of blade from shaft centre to tip of blade was estimated to 200mm. Its distance from shaft centre to pitch diameter was observed to be 150mm for one blade. However for estimating the total number of blades the circumference of the complete circle of the micro turbine came out to be 816.4mm. Based on this data the approximately 8 blades were estimated for the required torque and power generation. Typical geometric specifications of a blade are shown in Fig. 5.

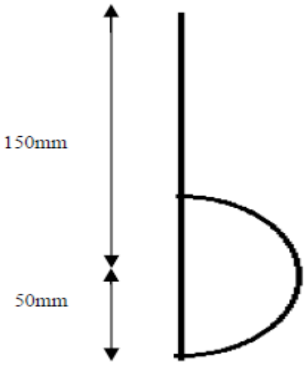


Fig. 5. Blade dimensions

IV. INTRODUCTION TO SOFTWARES USED COMPUTER AIDED DESIGN (CAD)

Computer Aided Design (CAD) is the use of wide range of computer based tools that assist engineering, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product life cycle management process and involves both software and sometimes special purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modelles.

INTRODUCTION TO PRO/E

PRO/E is the industry's de facto standard 3D mechanical design suit. It is the world's leading **CAD/CAM /CAE** software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model. Because that ***PRO/E*** is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains.***PRO/E*** is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. ***PRO/E*** provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly solid and surface modeling can be done easily.

MODAL IS DRAWN

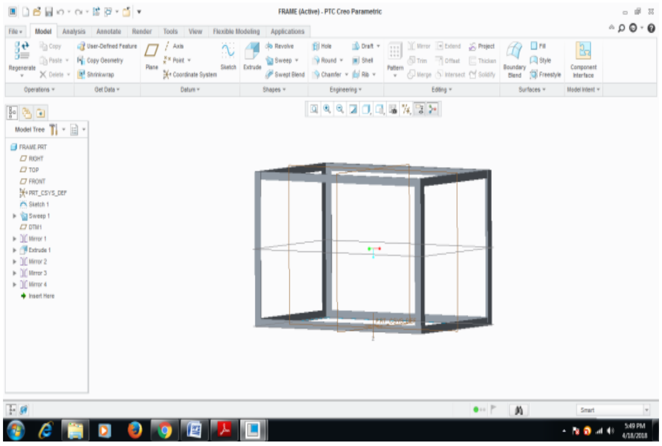


Fig: Frame

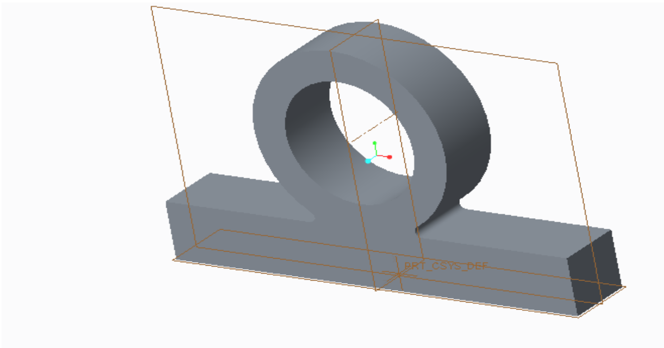


Fig: bearing

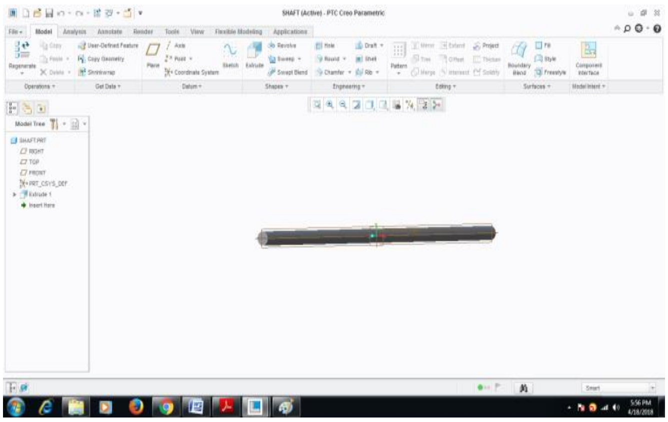


Fig: shaft

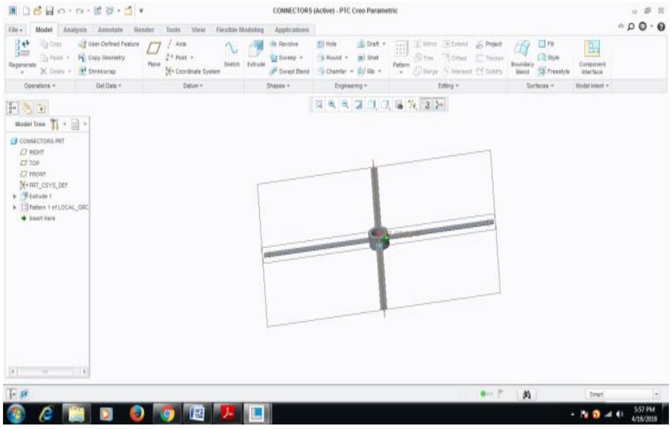


Fig: Connectors

V. WORKING PRINCIPLE

According to Newton's law a force is directly proportional to the change in momentum. So if there is any change in momentum of fluid a force is generated. In the hydraulic turbine blades or bucket (in case of Pelton wheel) are provided against the flow of water which change the momentum of it. As the momentum is change a resulting pressure force generated which rotate the rotor or turbine. The most important phenomenon is the amount of change in momentum of water which is directly proportional to force. As the change in momentum high the force generated is high which increase the energy conversion. So the blade or buckets are designed so it can change maximum momentum of water. This is the basic principle of turbine. These turbines are used as hydro electric power plant.

In hydropower plants with Pelton turbines, the available hydraulic energy exists as potential energy, which is measured in the form of the geodetic height difference between the upper level of water in the reservoir and the turbines in the machine house of a lower altitude. This height difference is denoted as hydraulic head in the terminology of hydropower. The conversion of the potential energy into the usable mechanical energy is completed by first converting the potential energy into kinetic energy in the form of high-speed jets at the altitude of the turbine wheel. For the energy conversion, one or many injectors can be used. By neglecting the friction losses in the injector, the jet speed is calculated according to the Bernoulli equation by with H as the net pressure head at the inlet of the injector. This equation is generally called the Torricelli formula. As second step, the conversion of the kinetic energy of the jet into the mechanical energy is accomplished by the interaction between the jet and the rotating buckets of the Pelton turbine. As a working principle for simplicity, a straight translating bucket of constant speed U is first considered (Fig. 2.1). This assumption of straight movement means that during the interaction between the jet and the bucket, only the impulsive force is effective. The interaction between the water jet and the bucket is considered directly in the relative moving system.

$$C_0 = \sqrt{2gH},$$

FINDINGS

As a result of extensive in house experimental design of a micro zero turbine and the design and manufacture of final assembly as shown in the above research we arrived at the following findings:.

a) Turbine blade design and number of blades are the vital parameter for extracting optimum power from a micro zero head turbine.

b) The velocity of water flow decreases from top(being the highest) to bottom, therefore the depth of stream may not have significant influence on the power generated.

c) The free stream velocity itself will be the major source of creating torque which could ultimately provide sufficient rpm for power generation in a typical setup..

d) These turbines could be installed where the flow velocities were as low as 1 meter/second. However higher flow speeds would give higher rpm of the turbine leading to higher values of power.

e) The design of such a power turbine is very simple and could be manufactured and constructed at a local workshop for use in far flung areas. Its cost is negligible because of absence of requirements of dams

f) Present research was focused on generating a low power value, However, present design could be scaled up for higher values of flow velocities and bigger size of turbine blades to generate sufficient power that could serve an entire house hold.

VI. CONCLUSION

Present research may be concluded by stating that such turbines could be used at regions where there is abundance of free water streams; small and large. The sizes of the turbines could be various as per the power requirements of users. This type of turbine could be an economical source of power generation where electric power could not be provided due to absence of power transmission lines and requirements of huge investments on infrastructure. Such initiatives if supported by local governments could provide the fruits of electric power to dwellers of distant land.

VII.REFERENCES

[1]. Faulkner, S. A. (1991). A simplified low head propeller turbine for micro hydroelectric power, Masters Degree Thesis, University of Canterbury.

[2]. Ho-Yan, B. P. (2012). Design of a Low Head Pico Hydro Turbine for Rural Electrification in Cameroon, Masters Degree Thesis, The University of Guelph Guelph, Ontario, Canada

[3]. PEEDA. (2009). Low Head Pico-Hydro Promotion Project, Nepal, People, Energy and Environment Development Association

[4]. Simpson, R. & Williams, A. (2011). Design of propeller turbines for pico hydro, Retrieved June 15, 2012, from www.picohydro.org.uk

[5]. Singh, P. & Nestmann, F. (2009). Experimental optimisation of free vortex propeller runner, Retrieved May 12, 2012, from www.sciencedirect.com

[6]. Susanto, J. & Stamp, S. (2012). Local installation methods for low head pico-hydropower in the Lao PDR, Renewable Energy, 11, (2012) 139-117

[7]. Turton, R. K. (1995). Principles of Turbomachinery, Chapmann & Hall (pp. 29-38)

[8]. R.H. van Els and A.C.P.B. Junior. The Brazilian experience with hydrokinetic turbines.

[9]. H.J. Vermaak, K. Kusakana, and S.P. Koko. Status of micro-hydrokinetic river technology in rural applications: a review of literature. Renewable and Sustainable Energy Reviews. 2014;29:625-633.

[10]. M.J. Khan, G. Bhuyan, M.T. Iqbal, and J.E. Quaicoe. Hydrokinetic energy conversion systems and assessment of horizontal and vertical axis turbines for river and tidal applications: a technology status. Applied Energy. 2009;86(10):1823-1835.

[11]. M. Anyi and B. Kirke. Hydrokinetic turbine blades: design and local construction techniques for remote communities. Energy for Sustainable Development. 2011;15(3):223-230.

[12]. J.F. Manwell, J.G. McGowan, and A.L. Rogers. Wind Energy Explained: Theory, Design and Application. Wiley, Chichester. 2009.

[13]. A.H. Munoz, L.E. Chiang, and E.A. De la Jara. A design tool and fabrication guidelines for small low cost horizontal axis hydrokinetic turbines. Energy for Sustainable Development. Wind Power Special Issue. 2014;22:21-33.

[14]. J.G. Slootweg, H. Polinder, and W.L. Kling. Dynamic modelling of a wind turbinewith doubly fed induction generator. In Power Engineering Society Summer Meeting, Vancouver, Canada. 2001;1:644-649.

[15]. E. Chica, F. Pérez, A. Rubio-Clemente, and S. Agudelo. Design of a Hydrokinetic Turbine. WIT

Transactions on Ecology and the Environment. Wessex Institute of Technology, UK. 2015;195:137-148.

[16]. E. Chica, F. Pérez, and A. Rubio-Clemente. Rotor structural design of a hydrokinetic turbine. International Journal of Applied Engineering Research. 2016;11(4):2890-2897.

[17]. J.N. Goundar and M.R. Ahmed. Numerical and experimental studies on hydrofoils for marine current turbines. Renewable Energy 2012;42:173-179.

[18]. Matweb. Material Property Data. http://www.matweb.com. 2015.

[19]. D.M. Grogan, S.B. Leen, C.R. Kennedy, and C.M. Brdaigh. Design of composite tidal turbine blades. Renewable Energy 2013;57:151-162.

[20]. S.H. Pierson. Composite Rotor Design for a Hydrokinetic Turbine. University of Tennessee Honors Thesis Projects, University of Tennessee Knoxville, Tennessee, 2009.

Cite this article as :

C. Pramod Kumar, K. Pavan Kumar Reddy, "Optimization and Manufacturering of a Micro Zero Head Turbine For Power Generation", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 7 Issue 3, pp. 78-86, May-June 2020.

Journal URL : http://ijsrst.com/IJSRST207314