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Low Head Small Hydro Turbine

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Abstract: This paper presents the event of development of low head small hydro power in India. Hydro power is one in all the renewable resources which unfold across all regions within the country. Moreover, it's a supply of renewable energy that cheaper than others. The development of native small hydro power style and producing is vital to the price of generating electricity, and also the stability of domestic energy. The small hydro turbine designed as axial propeller device turbine appropriate for reservoir with water head varies 10 to 20 meters. The runner blade designed as marine propeller device with reversed mean chamber line that acquires a high-performance hydro turbine. The turbine has four fastened blades with a diameter of 0.4 meters, 0.35 hub to tip magnitude ratio and also the twelve pieces of adjustable guide vanes. The turbine shaft is directly coupling with a 160 k/W induction generator at a motion speed of 1,000 rpm. The performance tests results suited to water to head for all vary of 10 to 20 meters with a guide vane angle 40 to 45 degrees and derived with an overall efficiency of 70% to 80%. The total price of small hydro turbine is USD513k/W.

I. INTRODUCTION

Every country within the world is currently within the quest after new obtainable energy sources on the world to alleviate the potential of energy shortage within the future. Besides, world climate is currently modification that accomplished by warming caused by greenhouse gas emissions from the activities of personalities. Those problems culminated within the golden age of renewable energy in terms of investment for actual implementation and analysis sustenance as renewable energy is that the most trusted supply of energy that has the smallest amount impact on the setting. However, the renewable energy prices square measure generally more than that of alternative energy. Also, the renewable energy comes with uncertainty in electricity generation as it depends on natural conditions. Compared to alternative sorts of renewable energy like wind and star, it's found that small hydropower could be an alternative for contemporary era. Combined with the advancement in engineering, the small hydropower development may be applied for little water resource. Considering the obtainable potential energy sources in India, hydro power is a possible source of energy for each potentiality and producing value. Conversely, imports of hydropower machinery square measure still terribly expensive. Moreover, the import of machinery doesn't lead to the knowledge-based development in style and production of electricity power to India. Additionally, the current state of large-scale hydropower development is experiencing resistance from native communities and independent organizations. The development of little hydropower by dependence on local-based technology in design and manufacture looks to be acceptable alternative to the present state of affairs. The small hydropower comes have low impact levels and simple to implement, prevent, modify and accept native technology which might contribute to the development of data in electricity power generation domestically. It also promotes the development of India's hydropower industry in the machinery manufacturing industry. This article can gift the event of a little hydro turbine that is appropriate for water head vary of ten to twenty meter that may be applied to nearly any small water distribution system in India.

II. BACKGROUND

Hydro turbine could be a device that converts mechanical energy and potential energy of water into mechanical power to rotate the generator or alternative machines. The energy which will be generated from a hydro turbine is the magnitude relation between the water head and water flow volume as follows:

$$\mathbf{P = \eta \rho g h Q} \qquad (1)$$

Where P is that the energy (W), η is that the turbine efficiency (-), (ρ) is that the density of water (kg/m^3), g is the gravitational attraction (m/s^2), h is water head (m) and alphabetic character (Q) is water flow (m^3/s). Typically, hydro turbine delivers 80% to 90% efficiency, but the efficiency decreases because the turbine size decreases. For mini hydro turbines, typically less than one hundred kilowatts, the efficiency is concerning 60% to 80%. The hydro turbine will be classified by specific speed (N_s).

$$N_s = \frac{n\sqrt{Q}}{(h)^{\frac{3}{4}}} \qquad (2)$$

Where **n** is the rotation speed (rpm). For the low water head turbine with high flow, the particular speed is high. Small Hydro Power (SHP) has been developed by several countries with an accrued usage. SHP Technology Development Trends is that specialize in

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innovative technology for existing little water supplies or a natural water source with a low head. Run-of-River is the most effective way to use resources with the smallest amount impact on the atmosphere. The turbines that are developed for low head of up to twenty meters are mainly propeller turbines which are classified as the reaction turbine. The turbine driving force is originally engendered by the water flowing through the blade profile with curved cambered lines inflicting the pressure differential between front surface and back surface. All kind of reaction hydro turbine encompasses a draft tube attached to the turbine casing that is that the important part to extend the static water pressure at the top of the outlet. The development of hydro turbines can specialize in the installation that is appropriate for the site and water supply. As water sources are totally different, the turbine model and its installation characteristics are varied as well.

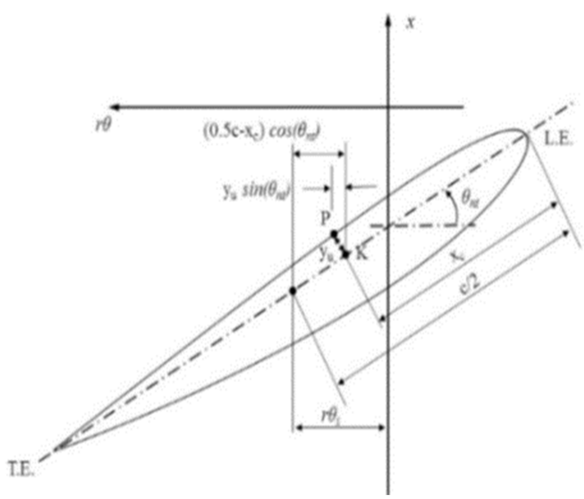
Runner blade of a propeller turbine is the most significant part because it must convert kinetic energy from water into mechanical power. Researchers have targeted on the way to design high performance runner blade shapes. According to Vipul Kakran, Free Vortex Theory has been adopted to create turbine blades because the velocity triangles can vary from hub to tip of blade. Since, the blade velocity is inconstant, and the twisted blades contemplate the assorted angle known as Vortex blading. Ritvik Singh Kahai has designed the propeller turbine based on velocity Triangle with distortion of the blades at varied radial positions. Subash Kamat has designed horizontal Kaplan turbine in which the shape of three turbine blades relies on a program developed by Mechanical solution Inc. using modified NACA airfoil. Vipul Kakran and Sushant Singh Sindhi conjointly designed propeller turbine by dividing the blades into 5 elements in cylindrical sections and using velocity triangles theory to calculate the blade inlet angles and blade outlet angle of every section and draw 3D blade model. Dr. Ravinder Tonk and Subash Kamat have designed a very low head turbine that dissimilar from a classically turbine design. Using Cascade theory to calculates the lifting force and drag forces on the foil and controls the pressure constant (Cp) within the given range to calculate stagger angle, camber angle and angle of attack.

III. HYDRO TURBINE DESIGN

A hydro turbine blade is that the element that is very crucial for the turbine performance. The hydro turbine design requires specialised information. For this article, the researchers present a new design of turbine design as marine propeller shape with reversed mean camber line. the form of the runner blade will be shaped by any p coordinate as equation (3)

$$X_p = -[r\theta_s \tan(\theta_{nt})] + (0.5c - x_c)\sin(\theta_{nt}) + y_u\cos(\theta_{nt})$$
$$y_p = r \cdot \sin\left(\frac{[(0.5c - x_c)\cos(\theta_{nt}) - y_u \sin(\theta_{nt})]}{r} - \theta_s\right) \qquad (3)$$
$$z_p = r \cdot \cos\left(\frac{[(0.5c - x_c)\cos(\theta_{nt}) - y_u \sin(\theta_{nt})]}{r} - \theta_s\right)$$

Where r is that the radial distance, c is that the chord length, θ_{nt} is that the pitch angle to the circumference, x_c is that the chord length, y_u is that the thickness and θ_s is that the skew. The definition of any point p on the surface of the runner blade is shown in Fig. 1(a). y_u can obtain from the coordinates of associate degree surface with the reversed direction of the mean camber line to get a runner blade of hydro turbine with distortion at radial pitch angle. Fig. 1(b) shows the turbine blade with reversed mean camber line compares to the initial mean camber line as seen in Fig.1(c)



(a)

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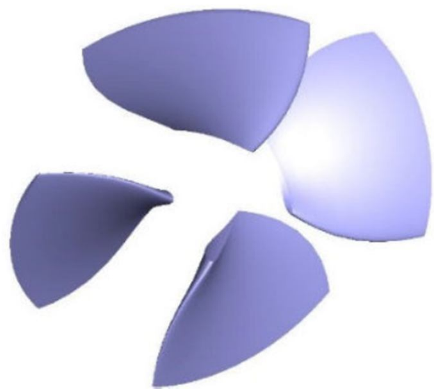
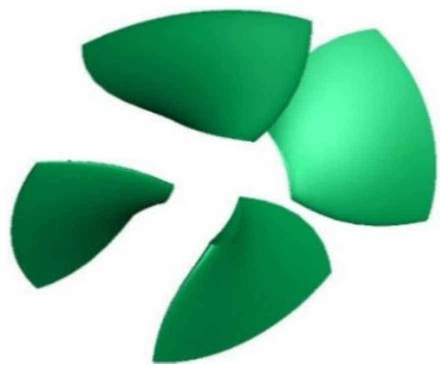


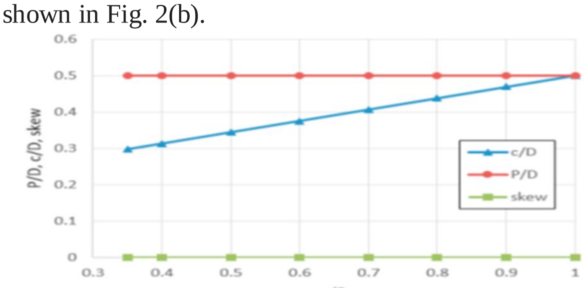
(b)



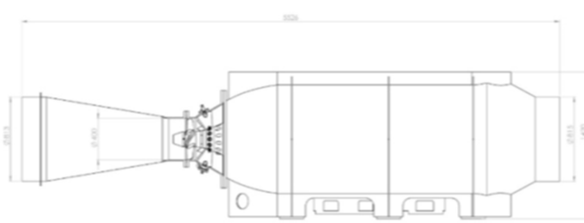
(c)

Fig. 1 (a) Definition of a point p on runner blade; (b) Reversed mean camber line; (c) Original mean camber line

For this study, the designed hydro turbine is appropriate for the water head vary of ten to twenty meter. the design of the runner blade relies on the pure geometric distribution as shown in Fig. 2(a) with the reversed mean camber line of air foil NACA4410 work the worth in equation three. Four turbine blades with diameter of 0.4 m are mounted to the hub at 40° the radial plane. The hub to tip magnitude relation is zero.35. There square measure twelve guide vanes which will be adjusted within the varying limit of 0°-90°. The small hydro turbine dimension is shown in Fig. 2(b).



(a)

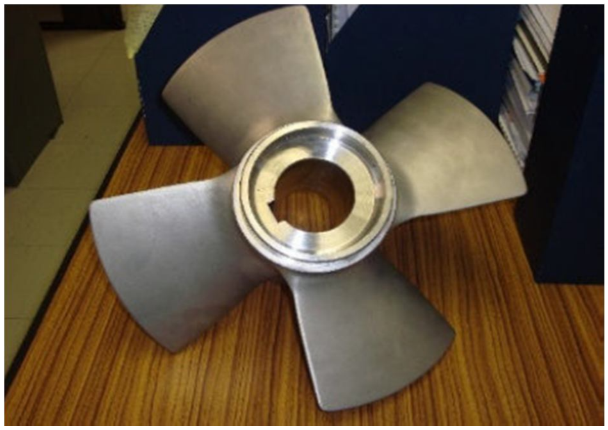


(b)

Fig. 2 (a) Geometry distribution of runner blade; (b) Small hydro turbine dimension

IV. TESTING

Turbine components were well-prepared by experienced manufacturer victimisation CNC machine to scale back the error within the production method. Fig. 3(a) shows the runner blade factory-made by CNC machine. Fig. 3(b) shows the installation of the guide vane made by CNC machine. Fig. 3(c) shows complete set of turbines that able to check. The generator set of this turbine using 160kw induction motor with 1,000 revolutions per minute installed to the bulb of the hydro turbine and directly coupling with turbine shaft.



(a)

(b)

(c)

Fig. 3 (a) Runner blade; (b) Guide vane; (c) Completed set

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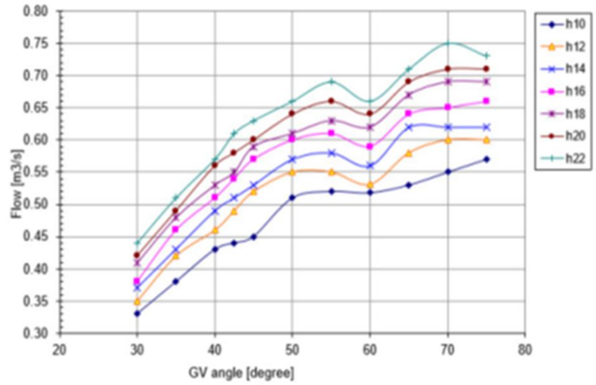
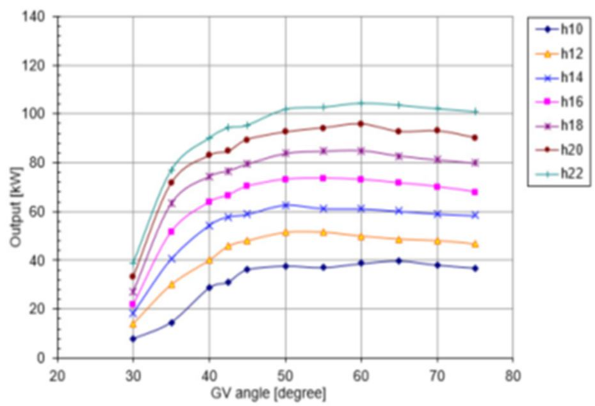
V. RESULT

According to tests the results by adjusting water head and adjusting guide vane at completely different angles. The result found that the rate of flow will increase because the guide vane angle will increase for each angle and each water head except from the guide vane at 60° which the rate of flow was but the guide vane angle of 55° and increases at the guide vane angle of 70° as shown in Fig. 4(a). Highest power output for any water head is within the varying limit of 50° to 60° of guide vane angle as shown in Fig. 4(b). The guide vane angle that provides highest overall efficiency of 78% to 80% is 40° to 45° whereas the guide vane angle that provides lowest overall efficiency is 30° as shown in Fig. 5(a). Finally, the rate of flow that comes highest overall efficiency is within the range of 0.5 to 0.55 m^3/s as shown in Fig. 5(b).

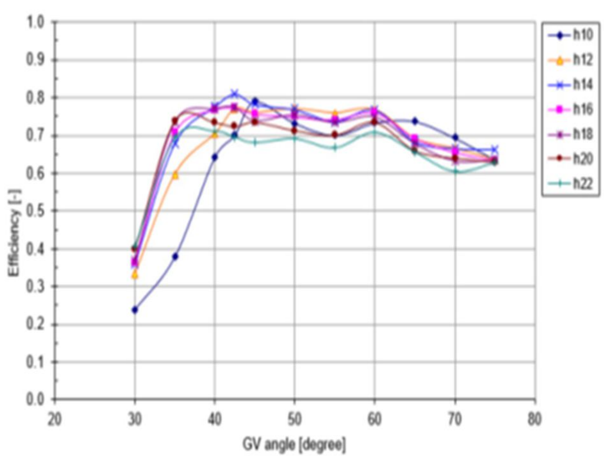


(a)

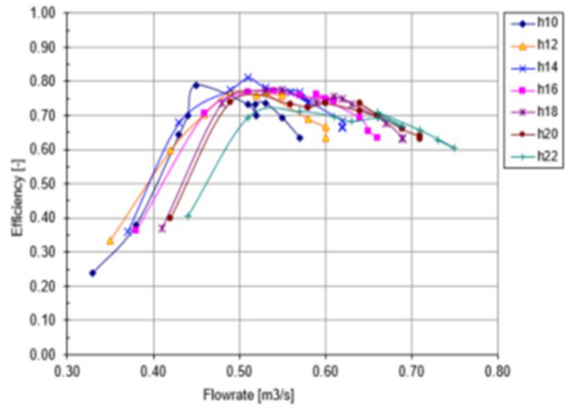


(b)

Fig. 4 (a) Flow rate vs guide vane angle; (b) Power output vs guide vane angle



(a)



(b)

Fig. 5 (a) Overall efficiency vs guide vane angle; (b) Overall efficiency vs Flow rate

VI. CONCLUSION

This study demonstrates the development of India's Low Head small Hydro Power by using basic information, theories and modern technologies to contribute in design and production. The key a part of the hydro turbine is that the runner blade that is based on the form of the marine propeller, along with the reversed mean camber line that is giving a high-performance hydro runner blade. Small hydro turbine testing has the high efficiency of 70% to 80% throughout the head varying from 10 to 20 m with hub blade angle at 40° and therefore the guide vane angle at about 40° to 45°.

According to the assembly of small hydro turbine, the analysis found that the price of production is near about USD513/kW compared with 1000kW power low head turbine (0 - 30 m) from Hydro Tasmania Company in Australia that prices somewhere near USD900/kW. Moreover, as per the Department for International Development, the UK and the world bank, estimated turbine worth that put in, Nepal, Peru, Zimbabwe and Mozambique is near about USD615-USD1,911/kW. Therefore, the low value of small hydro turbine generator is likely to be an incentive for small hydropower to learn and to develop systematically in India.

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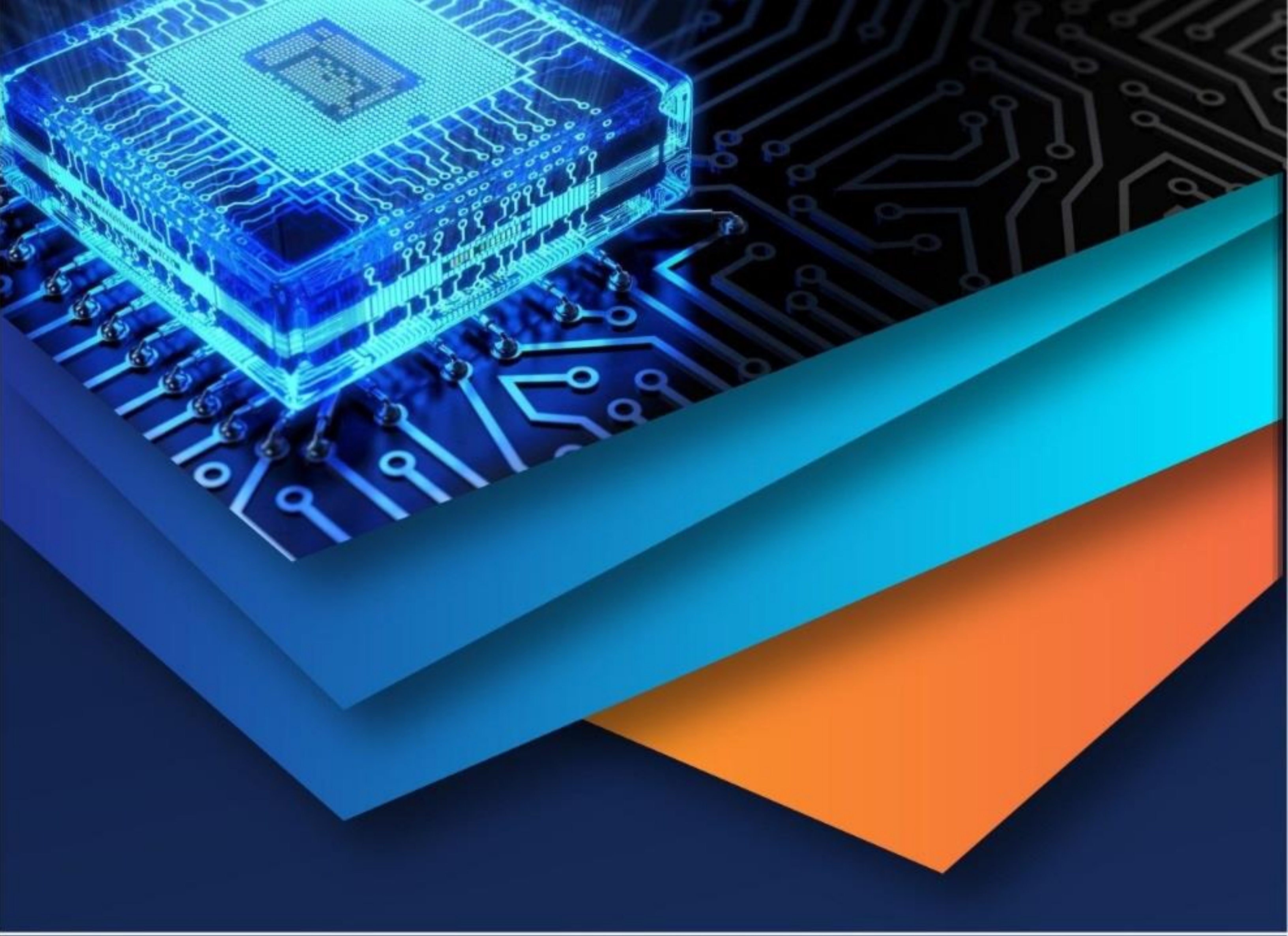

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