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Fabrication and Installation of Mini Kaplan Turbine

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Abstract: As for balancing the power consumption demands, hydro power functions as a regulator reacting on the load fluctuation n throughout day and night. As the power grid load fluctuates smoothly and gently over a long period of time, conventional hydro turbines are sufficiently doing great job over decades. Since these hydraulic turbines are very important in present day power generation, as we are also mechanical engineering students it makes us to do the project in hydro turbines. This document gives the information about how we fabricated a mini Kaplan turbine parts and problems arised during installation of Kaplan turbine in Lendi College. The Kaplan turbine can collect grass, leaf and branches from the inflow, to avoid this major drawback; we made a storage tank by using optimum design calculations. Maintenance of turbine is major problem to avoid erosion since the moving parts involved in the design. Hence this study also discussed the proper material selection and some important parameters which affect the turbine erosion and its smooth running. This study also gives the information about draft tube theory such that how it makes the use of placing draft tube outlet immersed at the tailrace level by converting more pressure energy into mechanical energy.
Keywords: Kaplan Turbine, Draft tube, Runner, Galvanized iron, Head and Discharge.

I. INTRODUCTION

The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy [1]. Power is recovered from both the hydrostatic head and from the kinetic energy of the flowing water. The design combines features of radial and axial turbines. The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially through the wicket gate and spirals on to a propeller shaped runner, causing it to spin. The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy The turbine does not need to be at the lowest point of water flow as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to cavitation. Variable geometry of the wicket gate and turbine blades allows efficient operation for a range of flow conditions. Kaplan turbine efficiencies are typically over 90%, but may be lower in very low head application because the propeller blades are rotated on high-pressure hydraulic oil bearings, a critical element of Kaplan design is to maintain a positive seal to prevent emission of oil into the waterway. Discharge of oil into rivers is not desirable because of the waste of resources and resulting ecological damage. Kaplan turbines are widely used throughout the world for electrical power production. They cover the lowest head hydro sites and are especially suited for high flow conditions. Inexpensive micro turbines on the Kaplan turbine model are manufactured for individual power production designed for 3 m of head which can work with as little as 0.3 m of head at a highly reduced performance provided sufficient water flow. Large Kaplan turbines are individually designed for each site to operate at the highest possible efficiency, typically over 90%. They are very expensive to design, manufacture and install, but operate for decades. A Kaplan turbine is a type of reaction turbine. It is an axial flow turbine which is suitable for relative for low heads, and requires a large quantity of water to develop large amount of power. It is a reaction type turbine and hence it operate entirely in closed conduit from head race to tail race. The test rig consists of a 1KW Kaplan turbine supplied with water from a suitable 3HP pump through pipe lines, a valve and a flow measuring venture meter. The turbine consists of a galvanized iron sheet body with volute or scroll casing, an axial flow galvanized iron sheet runner, a links of adjustable guide vanes and a draft tube. The runner consists of three aerofoil section. The guide vanes can be rotated about their axis by means of handle lever. An electrical dc generator is mounted on the shaft to develop the power. Water under pressure from the pump enters through the scroll casing and the guided vanes into the runner. While passing through the spiral casing and guide vanes, a portion of the pressure energy (potential energy) is converted into velocity energy (kinetic energy). water thus enter the runner at high velocity and it passes through the runner vanes , the remaining potential energy is converted into mechanical energy i.e. the water head is converted into mechanical energy hence the runner rotates .the water from the runner is then discharge into draft tube. The flow through the pipe lines into the turbine is measured with the venture meter fitted in the pipe lines. Two pressure gauges are provided to measure the pressure difference across venture meter.

II. DESIGN OF MINI KAPLAN TURBINE PARTS

Runner blade: The design proportions of this runner blade are directly taken from the hydraulic turbines theory and design is developed from the auto cad as shown in the figure. The design calculations as we have obtained are like

$Discharge\,(Q) = 0.02755\,{m^2}/{s}$

$0.02755 = \frac{\pi}{4}(D_0^2 - D_b^2) * V_{f1}$

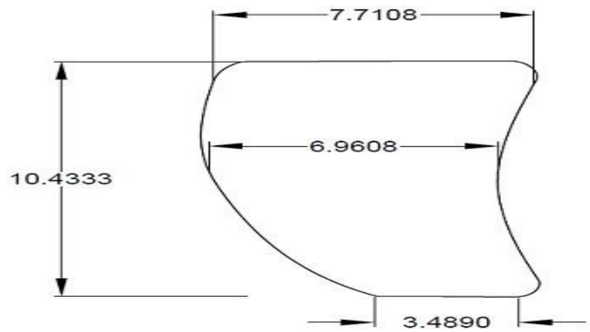
$0.02755 = \frac{\pi}{4}(D_0^2 - (0.35\,D_0^2)) * 3.25$

$0.02755 = 2.23\,D_0^2$

$D_0 = \sqrt{\frac{0.0755}{2.23}}$

=110mm

Where

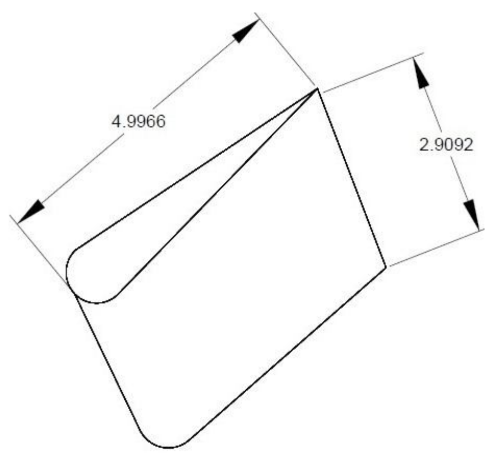


Outer diameter of runner $(D_0) = 180mm$

Diameter of hub $(D_b) = 0.35 * 0.11$

$D_b = 3.85cm$

$V_{f1} = Flow\ velocity\ at\ inlet$

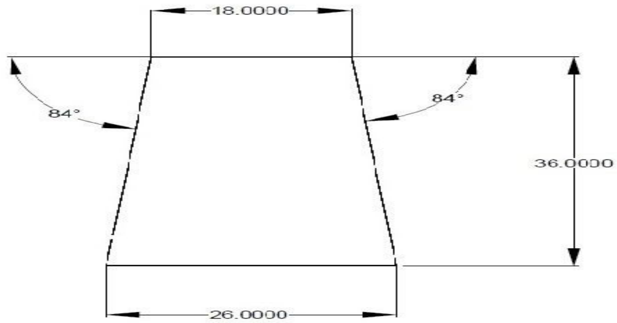


A. Guide vanes

The design proportions of these guide vanes are directly taken from the hydraulic turbines theory and design is developed from the auto cad as shown in the figure. The design calculations of this guide vanes are obtained are as follows

Height of the vane=3cm

Width of the vane=5cm



B. *Draft tube*

The design proportions of this draft tube are directly taken from the hydraulic turbines theory and design is developed from the auto cad as shown in the figure. The design proportions of this draft tube are as follows

$Assuming \quad v_1 = 2 \quad V_{f1} = 0.6 \quad head = 1.5M$

Speed ratio=$\frac{V_1}{\sqrt{2gH}}$ $\quad v_1 = 2 * \sqrt{2 * 9.81 * 1.5}$

Flow ratio =$\frac{V_{f1}}{\sqrt{2gh}}$ $\quad v_1 = 2 * \sqrt{2 * 9.81 * 1.5}$

$$\eta = \frac{shaft\,power}{mgh}$$

$$= \frac{0.5kw}{27 * 9.81 * 3.5}$$

$$\eta = 53.86\%$$

III. METHODOLOGY

A. *Fabrication of Spiral Casing*

It acts like casing to the guide vanes and runner setup. As the water passes through the spiral the velocity of the water increases so that more energy will be converted to rotate the shaft. The cross sectional area of this casing decreases uniformly along the circumference to keep the fluid velocity constant in magnitude along it path towards the guide vane. This is so because the rate of flow along the fluid path in the volute decreases due to continuous entry of the fluid to the runner through the openings of the guide vanes. As it is observed from the figure1 we have taken 3ft, 40mm diameter GI pipe is cut into different parts by certain angles. Later gradually bending the parts and by using oxy acetylene gas cutting we have made the casing. It is like that 40 mm diameter at the inlet and cross section gradually decreases to the end such that it makes the water to flow from the inlet with high velocity.

Fig. 1 Spiral casing

B. *Fabrication of guide vanes*

These are also known as stay vanes. As the name suggests these vanes are only adjusted to control the flow rate through the turbines but not for the rotation of the shaft. The basic purpose of the guide vanes is to convert a part of pressure energy of the fluid at it entrance to the kinetic energy and then to direct the fluid on to the runner blades at the angle appropriate to the design. In of the inlet turbine guide vanes are fixed. In this turbine 16guide vanes are used. As shown in the figure2 we have taken the GI sheet and cut into pieces as per the dimensions and by using gas welding, grinding, these vanes were fabricated. Height of the guide vane is 3cm and length of the guide vane is 5cm.

Fig. 2 Guide vane

C. Fabrication of runner blades

We have made runner blades model by using the cardboard. With the help of the cardboard model we made the actual runner blades by using GI sheet as shown in the figure 3. In this turbine 3 runner blades are made from the GI sheet with the help of portable grinding machine and straight snip cutter. These 3runner blades are welded to the hub. After passing into the casing fluid strikes the runner blades axially and the impact causes the shaft of the turbine to rotate, producing torque. The continuous flow of fluid makes the runner blade to rotate such that shaft mounted on it will also rotates and producing torque.

Fig. 3 Runner blades

D. Fabrication of draft tube

The draft tube is a conduit that connects the runner exit to the tail race. In this turbine a straight conical draft tube is used. The draft tube is such that outlet diameter is more than the inlet diameter. We have taken the GI sheet and made into piece of trapezoidal shape with Inlet diameter 18cm, out let diameter 22cm, Angle is 2.8° taper. By using oxy acetylene gas welding we have taken it into conical section as shown in the figure 4. The outlet of the draft tube is immersed in the tail water such that to reduce the velocity of discharged water to minimize the loss of kinetic energy at the outlet.

Fig. 4 Draft tube

IV. INSTALLATION OF THE KAPLAN TURBINE

During the installation of a Kaplan turbine we have taken 3hp 3phase centrifugal pump. Also we have used the sump tank fabricated by galvanised iron sheet. The pen stock arrangement is made by connecting PVC pipe from pump to the inlet of the spiral casing. The casing is also provided with blade control mechanism to control the flow rate by changing the angle of wicket gates arrangement. We have taken separate casings for the pump and turbine set up. The runner blades are mounted to the hub by oxy acetylene gas welding. This shaft arrangement is supported by ball bearings. As it is made up of metal it will easily corrodes when there is no proper maintenance. In order to avoid this we painted it with corrosive resistance paints. It is necessary to empty the tank and fill it with fresh water for at least once in a week. Since if the water contains solid impurities it will clogs at the pipe fittings. It is very important to place good supports in order to decrease the vibrations produce by pump and turbine shaft. It is very important to place good supports for reducing vibrations produced by pump and turbine shaft.

V. CONCLUSIONS

In this project we discussed the fabrication of mini Kaplan turbine parts and problems arise during the installation of turbine. Maintenance of turbine is major problem to avoid erosion since the moving parts involved in the design. Hence from the literature, this study also discussed the proper material selection and some important parameters which affect the turbine erosion and its smooth running. As it is made up of metal it will easily corrodes when there is no proper maintenance. In order to avoid this we painted it with corrosive resistance paints. It is necessary to empty the tank and fill it with fresh water for at least once in a week. Since if the water contains solid impurities it will clogs at the pipe fittings. It is very important to place good supports in order to decrease the vibrations produce by pump and turbine shaft.

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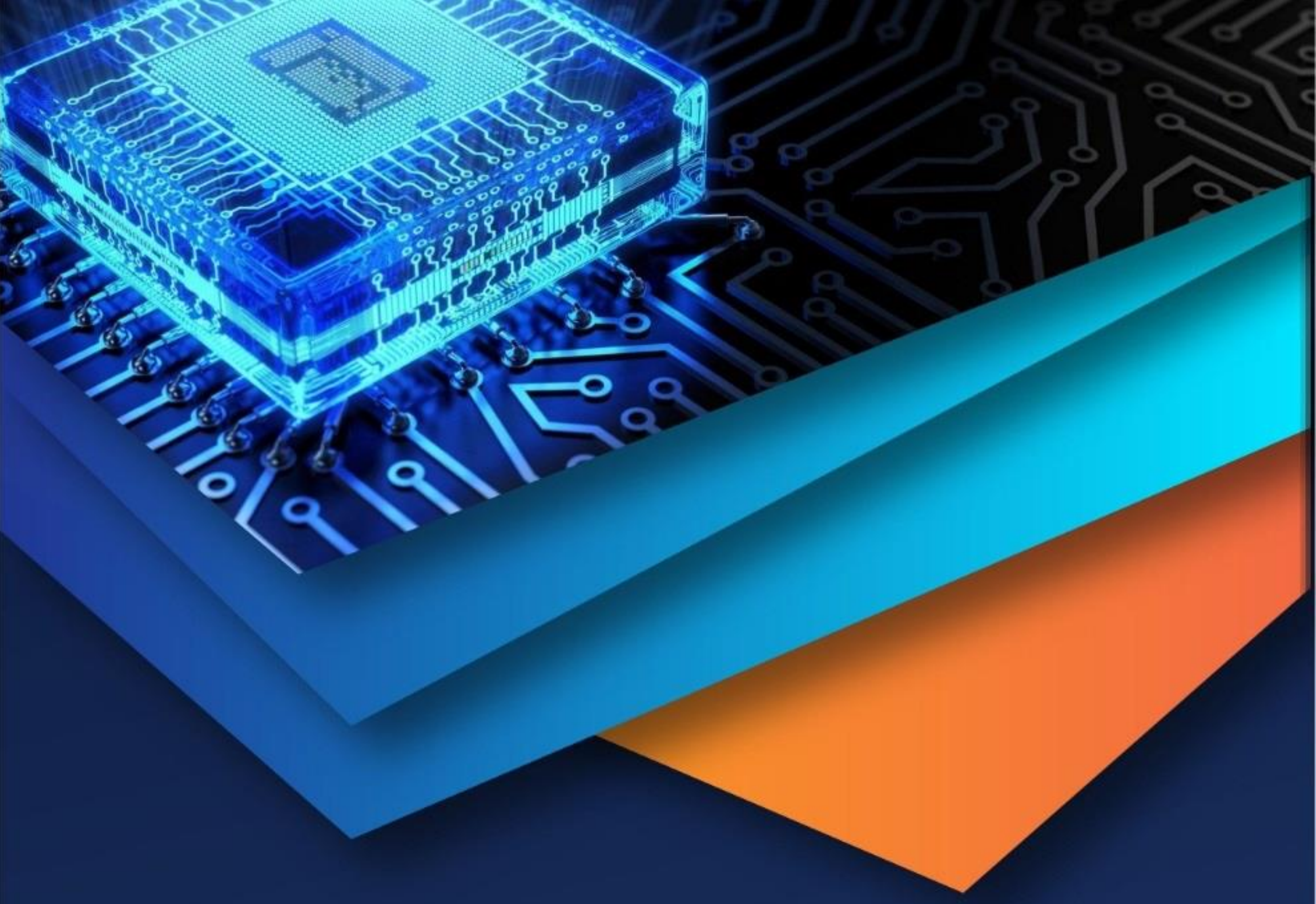

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