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Pelton Turbine – A Review

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Abstract: In the area of energy resources hydraulic energy is a traditional form and most commonly used for electricity generation. For the conversion of hydraulic energy into mechanical energy various hydraulic turbines are used. Further mechanical energy is converted to electrical energy.

Pelton turbine is a common turbine used in high head areas. The effectiveness of the turbine is depending on various parameters. A lot of research is going in the area of hydraulic turbines to increase its performance. We have collected some research journals and studied. The present paper involves a brief study on effect of various parameters on Pelton turbine performance.

Keywords: Pelton turbine, Review, Working parameters, Performance.

I. INTRODUCTION

Hydraulic energy is the potential energy stored in the water at the places of dams and reservoirs. For the utilization of this power hydraulic power plants are commonly used. The hydraulic power plants are the electrical energy generators by converting hydraulic energy in to mechanical energy by hydraulic turbines and the transformed in electrical energy by using electrical generators.

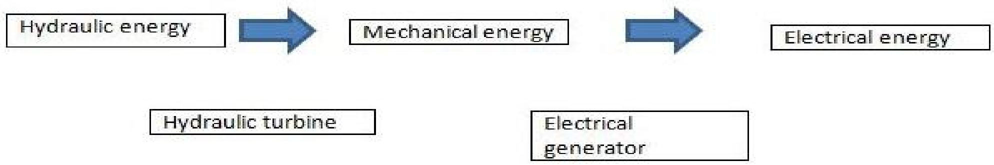

Fig. 1 Flow diagram of hydraulic power plant

A. Pelton Turbine

The Pelton turbine also called as Pelton wheel generally used in the area of high head. The Pelton turbine is an impulse and tangential flow turbine. Pelton turbines are requiring comparatively less quantity of water. Water is transported in penstocks from head race to the turbine in power generation house. Pelton turbine consists a circular disc commonly called as runner on which a number of buckets are evenly spaced around its periphery. Each bucket consists of two symmetrical halves. The buckets are in the shape of double hemispherical. These symmetrical parts are divided by a sharp edged ridge called splitter. Water, at high head, flows through the penstock and at the end of penstock; one or more nozzles are fitted to convert all the available energy of water into kinetic energy. The water comes out of the nozzle as jet and impinges on the buckets, causing it to revolve. The impact of water jet produces force on bucket causing wheel to rotate. The jet of water splits equally by splitter and flows round the inner bucket surface and leaves at the outer edge of buckets. The rear of the bucket is designed such that the water leaving the bucket should not interfere with the passage of water to the preceding bucket.

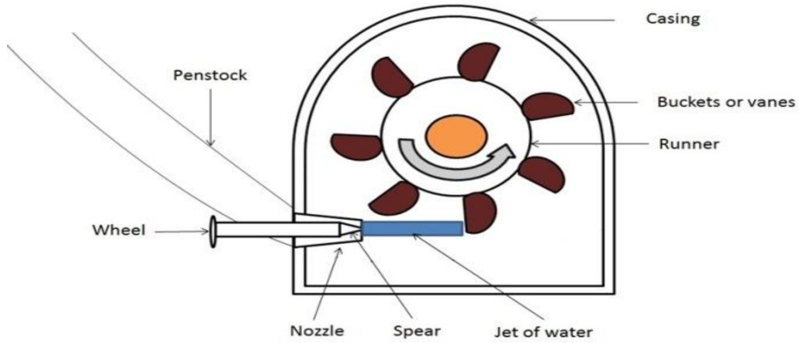

Fig. 2 Pelton turbine

B. Selection of Turbine Types:

Turbine was invented by French engineer Claude Burdin in 1822 and was used as water mill in ancient times. Nowadays, many types of turbines were fabricated for different purposes based on different operating conditions in performance such as steam turbine, gas turbine, hydraulic turbine, and wind turbine. Water turbine is distinguished into three types- reaction turbine, impulse turbine and gravity turbine. The reaction turbine is driven by the pressure variation and altitude to obtain mechanical energy, and it is operated by high velocity and impulse turbines are operated by the hydraulic head. The gravity turbine is operated by the water weight incoming from the upper head of the turbine and leaving the water to the tailrace. Francis reaction turbine, also known as a radial flow turbine, is commonly used for getting higher efficiency. Pelton impulse turbine is mainly used for the purpose of generating electricity and also utilized in producing mechanical power for the irrigation, machinery process in grain mills. The advantages for using Pelton turbine is that it works best at high head and low flow conditions and produce higher power from a small turbine, and it is not necessary to be considered for specific flow conditions like other turbines.

II. LITERATURE REVIEW

A. Vishal guptha, Dr. Vishnu prasad, Dr. Ruchi kare

The paper deals with the shape of jets from nozzle and its effect on force and torque of the buckets & runner. The jets used are square, triangular, elliptical and circular in shape. From the results it is found that circular jet is having high efficiency when compared to other shapes. The circular jet has uniform impact over the bucket. The sharp edges of square, triangle resulted in loss of efficiency. The efficiencies are found to be 88.03%, 77.80%, 84.72% and 76.56% for circular, triangular, square and elliptical nozzles respectively.

B. Salf Aldeen Saad Obayes And Mohammed:-

The paper deals with the effect of different nozzles, water head and discharge on performance of Pelton turbine. The increase in nozzle diameter led to increase in water discharge which in turn decreases water head. The decrease in water head led to decrease of the Pelton turbine performance like torque, power and efficiency. It is found that best performance was achieved when outer diameter of nozzle is 8.87mm. It resulted in increase of torque, brake power, power, efficiency and speed by 60.2%, 66.48%, 60% and 15.35% respectively. The optimum design for ratio of circumferential blade velocity and jet velocity is near 0.5.

Conclusion from this experiment is

1) Increasing the nozzle diameter lead to increasing in the water discharge and decreasing the water head, where subjected to pump operating which boost the water flow through the nozzle to Pelton turbine.
2) The water discharge decreasing as the water head decreased for every certain nozzle size, which lead to decreasing the Pelton turbine performance (torque, brake power, efficiency and the range of rotational speed)
3) The best performance of Pelton turbine system was obtained by the nozzle number three with outlet diameter of 8.87mm, where the percentage increased in torque, brake power, efficiency and the rotational speed of 60.2%, 66.48%, 60% and 15.35% respectively comparing with the second nozzle with outer diameter of 5.19mm at the maximum values.
4) The optimum design for the Pelton turbine when choosing the nozzle outer diameter, which gives the ratio of circumferential blade velocity over rotating wheel to the jet velocity of water approaches from the value of 0.5.

C. Kailash Singh, Chouhan Gr Kishorey

The paper deals with the speed of different materials of runner for different parameters such as discharge and its effect on efficiency of plant. The modal was developed on a ANSYS 12.0 software. The materials used are cast iron, wood, hollow cast iron and Bakelite. The experiment was done for different runner materials and parameters such as discharge, velocity, power input and efficiency. The velocities varied for different runner materials are 2.32m/sec for solid cast iron, its RPM was 117.8. The RPM was 122.5, 137.5 and 142.5 for hollow cast iron block, wood and Bakelite respectively. The experiment was done at low head and found that Bakelite was more optimum when compared with other materials. The efficiency of solid cast iron runner of turbine is 64% at 117.8 rpm and 56% at 122.5 rpm for hollow cast iron. The efficiency of wooden runner of turbine is 27% at 137.5 rpm. The efficiency of Bakelite runner of turbine is 15% at 142.5 rpm.

D. I.U Atthanayake

This paper deals with the effect of formation of boundary layer and thickness on the efficiency of a turbine plant. The boundary layer formation and thickness depends upon the surface roughness of the buckets. The surface roughness can be calculated using boundary layer analysis. When flow of water is considered in turbine; loss in power is due to friction in buckets and change of flow along the path.

E. Pushpendra Mahajan, Prof. Anurag Nema

This paper deals with the usage of Pelton wheel, where working fluid is a gaseous Toulene rather than water as working fluid. The dimensions and forces involved are calculated using developed design procedure. Finite analysis for bucket is done and found that maximum shear stress generated in bucket is 103.16Mpa and deflection is 0.033mm. The shear stress generated is less than the yield limit of 370Mpa.thus the design is safe for given load conditions.

F. Audriuszidonis, Georgea. Aggidis

This paper deals with the optimum number of buckets for an efficient turbine by using numerical study. Three parameters: number of buckets, bucket radial position and bucket angular position are found to be interrelated. The best condition for positioning of angular and radial position for each number of buckets was found. The efficiency is increased 0.8% for single jet and 0.4% for dual jet operation. The reduction of number of buckets from 18 to 15 reduces complexity and cost of runner manufacturing.

G. A.J Ujam, S.O Egbuna

This paper deals with the effect of bucket tip angle and bucket splitter and effect on efficiency of a turbine. Simulation program was developed on MATLAB and simulated the relationship among bucket tip angle, energy coefficient, bucket exit angle and hydraulic efficiency. It is found that 3^0 bucket tip angle was optimum. The power developed to bucket splitter was maximum and decreases as the tip angle increases. The power delivered to bucket splitter increased with increase in angle from 1^o and 3^o the power output was 2.3677×10^9 respectively and from 5^o and 11^o there is continuous decrease in power output.
Flow simulation of jet deviation by rotating Pelton buckets using finite volume particle.

H. Chrishan Versaz, Ebrahim, Jahanbakhsh:-

This paper was prepared on the basis of a numerical simulation on a high speed water jet impinging on rotating Pelton bucket using finite volume particle method (FVPM). The pressure field in the buckets inner wall is in good agreement with the experimental and numerical data during the impingement first stage. The tail of pressure profile is under estimated. The pressure fluctuations on buckets outer wall are important due to lack of particles at this location. The computing time to obtain a converged pressure profile remains important with today's computing power.

I. B. Zoppé, C. Pellone, T. Maitre, P. Leroy

This paper deals with the numerical analysis of a flow in a fixed bucket of a Pelton turbine. The parameters varied in this experiment are head, jet incidence and flow rate. This enabled to measure pressure, torque and flow visualization. The numerical analysis is performed with FLUENT code using two phase flow volume method. The varying incidence & diameter called a leakage flow through cut out is found. This increases rapidly with increase in jet diameter & bucket incidence. The losses due to edge slightly vary with incidence & decrease with jet diameter.

J. M. M. Alnakhlani, Mukhtar, D. A. Himawanto, A. Alkurtehi & D. Danardono

This paper deals with the highest efficiency possible among different types of Pelton wheels through the change of bucket volume, bucket angle attack, nozzle needle seat ring and nozzle needle tip. The maximum efficiency achieved was 21.65 at 90 degree needle seat ring and 45 degree needle tip, +15% bucket size and 92 degree angle of attack. The efficiency was likely due to lightness of the +15% bucket compared to standard bucket.

K. Varun Sharma, Sanjeev Kumar Dhama

This paper deals with the analysis of stress inside the Pelton bucket. It is concluded that stress on turbine blade is reducing as water moves out in its direction of flow along the periphery of the Pelton turbine blade. The maximum stress is found to be 113 MPa where the jet strikes the blade at 0 degree angle. The minimum stress value is 0.027 MPa at outermost periphery of the blade. The wear and rear of blade depends upon internal stress produced along periphery.

L. Liji-Qing, Maymyat Moe Saw

This paper focuses on fatigue analysis of Pelton turbine bucket by numerical approach that shows the results of life cycles, damage, Von Mises stress and mean biaxiality ratio to estimate the better design and operating performance of the Pelton turbine bucket to reduce the corrosion and failures. Stainless steels, aluminum alloys and cast iron are considered for bucket materials. In conclusion, the construction and design of advanced hoop Pelton turbine is better than simple Pelton bucket.

M. Abhishek Sharma, Prashant Sharma ,Anil Kothari

The paper deals with the performance of different shapes of spear at different mass flow rates and nozzle openings. The pressure increases at the inlet of nozzle with increase in mass flow rate. The pressure is maximum for second spear and nozzle geometry at 5928.18 kg/sec and is minimum for first spear and nozzle with 3952.12 kg/sec mass flow rate. The pressure at outlet is near atmospheric pressure. The coefficient of pressure is maximum for second spear(0.9608).The coefficient of velocity is maximum for first spear (0.7897) having 4930.15 kg/sec mass flow rate.

III. OVERVIEW

TABLE I OVERVIEW OF THE LITERATURE REVIEW

S.NO	Author	Working area	Input parameter	Output parameter	CONCLUSION
1.	1.Vishal guptha 2.Dr. Vishnu prasad 3.Dr. Ruchi kare	Shape of the jet from the nozzle	1.Square, 2.Triangular 3.Elliptical and 4. Circular in shape.	1.Effectiveness	Circular shape of the jet is the most efficient than the other shapes.
2.	1.Salf Aldeen saad obayes 2.Mohammed Abdul Khaliq Qasim	Different nozzles diameter	1.Nozzles outlet diameters	1.Torque 2.Brake power 3.Efficiency 4.Rotational speed	Increasing the nozzle diameter lead to increasing in the water discharge and decreasing the water head.
3.	1.KAILASH SINGH 2.CHOUHAN GR KISHOREY 3. MANISH SHAH	Bucket material, Jet velocity, Speed of runner	1.Cast iron 2.wood 3. hollow cast iron 4.Bakelite	1.Efficiency	Bakelite runner is very beneficial as compare to other three materials we used at low head
4.	1.I.U ATTHANAYAKE	Effect of formation of boundary layer and thickness on the efficiency	1. Boundary layer	1.Efficiency	The power loss can be occurred due to both the friction in the bucket and the change of pressure along the flow path
5.	1.PUSHPENDRA MAHAJAN 2.PROF. ANURAG NEMA	Change in working fluid	1. Gas as a working fluid	1.Maximum shear 2.Deflection 3.Shear stress	Hydraulic efficiency of turbine ignoring friction losses in the bucket was found to be 90.14 %.
6.	1.AUDRIUS ZIDONIS 2.GEORGE A.AGGIDIS	Optimization	1.Number of buckets 2.bucket radial position 3. bucket angular position	1.Efficiency	Optimized values for buckets and its position has been done.
7.	1.A.J UJAM, 2.S.O EGBUNA 3. N. E.NWOCHA	Bucket geometry	1. Bucket tip angle	1.Hydraulic efficiency	The power developed at the tip angle of 3^0 is high and further increase in tip angle leads to reduce the power
8.	1.CHRISHAN VERSAZ 2.EBRAHIM JAHANBAKHSH 3.FRANÇOIS AVELLAN	Numerical simulation	1. Velocity of water jet	1.Pressure fluctuation	Pressure field on the bucket inner surface for the various impinging angles has been shown and concluded
9.	1.B. Zoppé 2.C. Pellone 3.T. Maitre 4.P. Leroy	Flow analysis	1.Head 2.Jet diameter 3.Bucket incidence	1Pressure distribution 2.Forces	The losses due to edge slightly vary with the incidence and decrease with the jet diameter.
10	1.MM ALNKHANI 2.MUKHLAR DA 3.HIMAVANTA	Efficiency increasing possibility	1.Bucket volume 2.Bucket angle attack 3.Nozzle needle seat	1.Efficiency	The results shows that there is a relationship between the efficiency rate and the size of

			ring 4. nozzle needle tip		bucket and angle attack
11	1.VARUN SHARMA 2.SANJEEV KUMAR DHAMA	Analysis of stress	1. Different shapes of the bucket	1.Maximum stress 2.Minimum stress	stress on turbine blade is reducing as water moves out in its direction of flow
12	1.LI JI-QING 2.MAYMYAT MOE SAW	Fatigue analysis of bucket	1. Bucket material (Stainless steel, aluminum alloy and cast iron material)	1.Total deformation 2.maximum principal stress	Stain less steel design is safe when compared to other material.
13	1.ABHISHEK SHARMA 2.PRASHANT SHARMA 3.ANIL KOTHARI	Computational fluid dynamics (CFD)	1. shapes of spear 2.mass flow rates 3. nozzle openings	1.Pressure 2.Efficiency	Concluded for shape of sphere based on their geometry.
14	1.HEINZ-BERND MATTHIAS 2.JOSEF PROST 3.CHRISTIAN ROSSEGGER	Influence of the splash water distribution in the casing on the turbine efficiency	1.Shape of the casing.(Cylindrical, Rectangular)	1.Efficiency 2.Hydraulic loss	Efficiency and losses are presented at various shapes of the dome.

IV. CONCLUSIONS

From reviewed different research paper it has been concluded that

1) Most of the research people have taken flow rate, bucket geometry, jet velocity as input parameters.

2) For any hydraulic power plant the performance is the most important quality parameters. So, most of the research People have taken efficiency as the quality parameters.

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