Value Analysis of Pelton Wheel Turbine in Hydroelectric Power Plant

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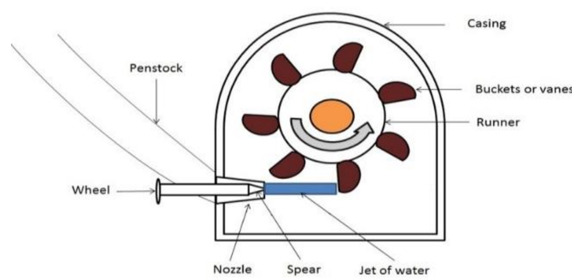
***Abstract*- A pelton turbine bucket is the individual component which makes up the turbine section of a pelton turbine. The blades are responsible for extracting energy from the high pressure water produced by the nozzle jet. The pelton bucket are very often the limiting component of pelton turbines. To survive in this difficult environment, blades often use exotic materials We know that the efficiency is directly related to material performance making the material selection of primary importance. In this project, materials considered for turbine blade are steel, cast iron and fiber glass reinforced plastic. Optimization is done by different materials by performing coupled field analysis on the turbine blade for both the designs. The objective of this project is to perform coupled field analysis of pelton wheel bucket for various material on the pelton wheel for finding out the efficiency, high stress handling factors and suggest a efficient material to replace the currently used material..**

I. INTRODUCTION

Pelton turbines belong to the family of free jet turbines. A nozzle is placed at the end of the pressure line which converting the potential energy of the water into kinetic energy by forming a water jet. The jet is directed to the runner buckets, the hydraulically active parts of the turbine. At the entrance into the symmetrically shaped buckets the water jet is split into two parts, each developing a sheet of water on the buckets curved surface. At the end of the working cycle, the water leaves the bucket in the opposite direction of the free jet. The rotational mechanical energy is then transferred through the shaft to the generator which is produced by momentum and pressure of water jet striking the buckets.

Pelton turbine basins, single or two pails together are for the most part made by mold throwing. The throwing of basins for Pelton turbines should be possible by replicating from other existing bucket.



It is fitting to cast the single cans and, subsequent to machining, to settle them to the rotor plate. In this way convoluted throwing molds can be kept away from. It is not prescribed to make the pails of split channel areas or other welding developments of sheet metal segments, as a result of lacking quality and poor effectiveness. The basins can be made of diverse materials. This is likewise the case if the rotor is cast in one piece. On present day Pelton turbines the basins are basically of cast steel with 13% chrome. However, different materials and routines are additionally utilized, including cast iron, or composites, for example, bronze or aluminum, or infusion forming with fiber glass fortified plastic. Every material has its own particular properties, one of these being the permissible anxiety. The breaking points for application must be ascertained deliberately for every material. At the point when ascertaining the permissible head for a certain turbine arrangement the static strengths must be ascertained, as well as the exhaustion stress and the divergent powers are additionally to be considered Fast changing of the heap on the containers has an unfavorable impact on the allowable strengths, particularly when the anxiety is higher than ordinary. This could be brought about by unequal dispersion of the material, breaks at basic spots, because of consumption or because of welding.

II.LITERATURE REVIEW

K.Chandra Sekhar, P.Venu Babu[1] Pelton turbines are hydraulic turbines which are widely used for large scale power generation. In this thesis we performed the investigation on structural analysis of pelton wheel bucket is carried out by varying meshes and keeping remaining parameters constant Nikhil Jacob George, SebinSabu, Kevin Raju Joseph,[2] In this projexct the Static Analysis On Pelton Wheel Bucket is done, where the pelton wheel is analysed by ansys with keeping the parameters constant and changing the loading conditions AlexandrePerrig, Francois Avellan, Jean-Louis[3] In this project Flow in a Pelton Turbine Bucket is investigated both by numerical and experimenta . where the flow is incestigated by measuring the velocity and area of the runner and the nozzle. Rajesh Bisane, Dhananjaykatpatal[4]In this project the Experimental investigation & cfd analysis of an single cylinder four stroke c.i. engine exhaust system is done , with this the analysis and cfd is done to the exhaust gas of the engine.

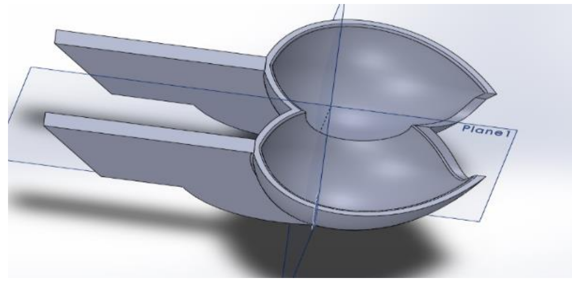
Junyi Li and Qijuan Chen [5] have proposed a nonlinear mathematical model for hydro turbine governing system (HTGS). All the components of HTGS which is conduit system, hydraulic servo system, turbine, generator, and are considered in the model. There are three main contributions of this paper compared with prior works. First, a new fully coupled nonlinear mathematical model of HTGS was presented and the parameters were from a practical power station, which made the work more consistent.

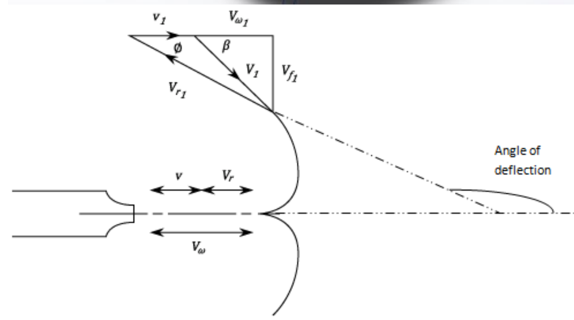
III. PROBLEM DEFINITION

Static characteristics of the Pelton wheel turbine are to be investigated therotically in the present work. The von misses stress and total deformation caused by the water jet of Pelton wheel is to be investigated. Finally the experimental results are to be compared with that obtained from suitable analysis software using solid works simulation.

IV. WORKING PRINCIPLE

LetVj = velocity of the jet andVb= velocity of bucket





Hence the speed at which jet enters the bucket is given by

Vj-Vb

The inside of the bucket should be as smooth so as the water does not loose speed at expense of outflow of water. If the jet speed is twice the speed of bucket, then water relative to bucket leaves at speed;

Vj-Vb = 2Vb-Vb = Vb

(i) The velocity of the jet at inlet is given by

$$V_1 = C_v \sqrt{2gH}$$

Where = Cv co-efficient of velocity =0.98 or 0.99.

H= Net head on turbine

(ii) The velocity of wheel (u) is given by

$$u = \phi \sqrt{2gH}$$

Where = ϕ speed ratio. The value of speed ratio varies from 0.43 to 0.48

iii) The angle of deflection of the jet through the buckets is taken at 165o if no angle of deflection is given.

iv) The mean diameter or the pitch diameter D of the pelton turbine is given by

$$u = \frac{\pi DN}{60} .or.D = \frac{60u}{\pi N}$$

v) Jet Ratio: it is defined as the ratio of the pitch diameter (D) of the pelton turbine to the diameter of the jet (d). It is denoted by m and is given as m = D/d (=12 for most cases)

(vi) Number of bucket on a runner is given by

$$Z = 15 + \frac{D}{2d} = 15 + 0.5m$$

V. METHODOLOGIES

Solidworks is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Assault Systems. Written in the C++ programming language, Solidworks is the cornerstone of the Assault Systems product lifecycle management software suite.

Fig 5.1 : Pelton wheel bucket

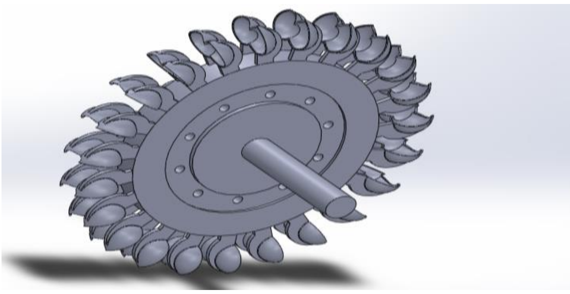


Fig 5.2 : Pelton wheel

VI. MATERIALS SELECTION

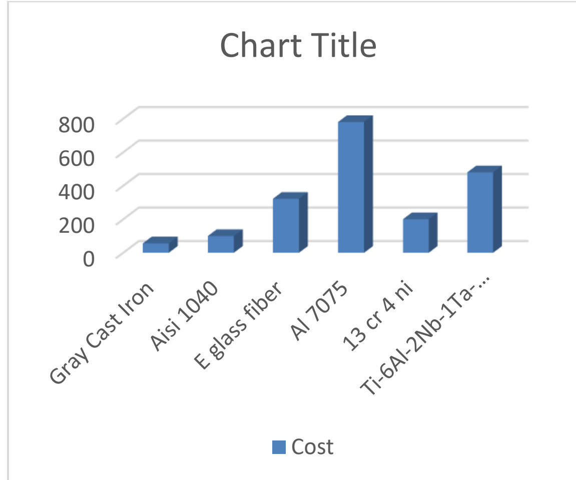
We have selected five materials randomly and then test our crankshaft model for the required loading Conditions. After the thorough analysis we have selected one material from the following five materials

- Grey cast iron
- AISI 1040
- E glass fiber
- Aluminum alloy Al 7075
- 13cr4ni
- Titanium AlloyTi-6Al-2Nb-1Ta-0.8Mo

Material Properties

Materials	Density,(Kg/m³)	Young's Modulus,(GPa)	Poisson Ratio	Tensile Yeild Strength,(Mpa)	Cost, (Rs/Kg)
Gray Cast Iron	7200	110	0.28	276	56
AISI 1040	7845	200	0.29	515	100
E glass fiber	2570	72	0.21	1700	322
Al 7075	2810	72	0.33	503	780
13 cr 4 ni	7700	206	0.331	720	200
Ti-6Al-2Nb-1Ta-0.8Mo	4480	117	0.31	760	480

Cost of Materials



VII. RESULTS AND DISCUSSIONS

Here in this investigation structural analysis of pelton wheel's bucket is carried out by varying meshes and keeping remaining parameters same. In this research pelton wheel's bucket undergo Coarse and Fine mesh in order to get results. For every mesh 6 different types of materials were considered and their material properties were clearly shown in before chapter Even though the materials used for analysis are same due to variation in meshing the results varied and clearly shown in the results and in figures. Materials used to perform analysis were Grey cast iron, AISI 1040, E glass fiber, Aluminum alloy Al 7075, 13cr4ni, Titanium AlloyTi-6Al-2Nb-1Ta-0.8Mo

i)Grey cast iron

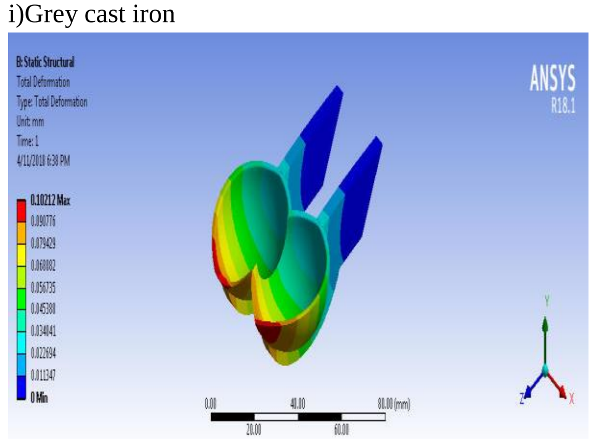


Fig 7.1: Total deformation in gray cast iron (fine)

The figure 7.1 shows that the pelton bucket undergoes total deformation of 0.10212 mm and minimum of 0 mm.

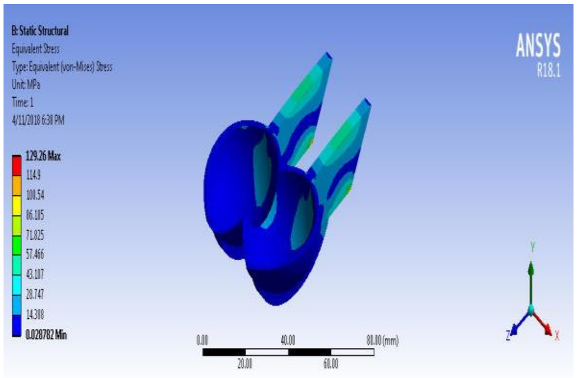


Fig 7.2: von misses stress in gray cast iron (fine)

The figure 7.2 shows that the pelton bucket undergoes maximum stress of 128.2.26 Mpa and minimum of 0.028782 Mpa.

ii)Aisi 1040

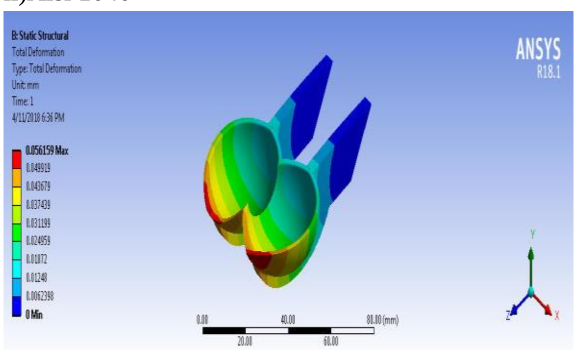


Fig 7.3: Total deformation in AISI 1040 (fine)

The figure 7.3 shows that the pelton bucket undergoes total deformation of 0.056159 mm and minimum of 0 mm.

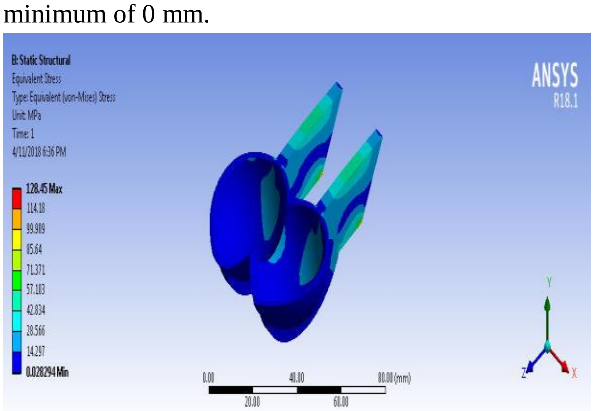


Fig 7.4: von misses stress in AISI 1040 (fine)

The figure 7.4 shows that the pelton bucket undergoes maximum stress of 128.45 Mpa and minimum of 0.028294 Mpa.

iii) E glass fiber

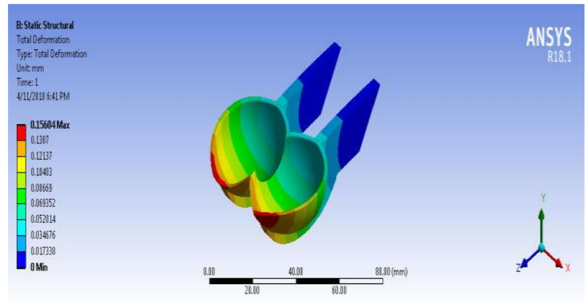


Fig 7.5: Total deformation in E glass fiber (fine)

The figure 7.5 shows that the pelton bucket undergoes total deformation of 0.15604 mm and minimum of 0 mm.

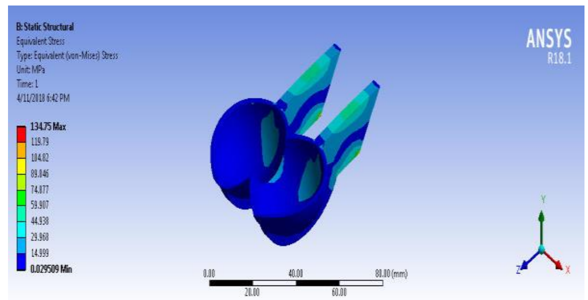


Fig 7.6: von misses stress in E glass fiber (fine)

The figure 7.6 shows that the pelton bucket undergoes maximum stress of 134.75 Mpa and minimum of 0.029509 Mpa.

iv)Aluminum alloy Al 7075

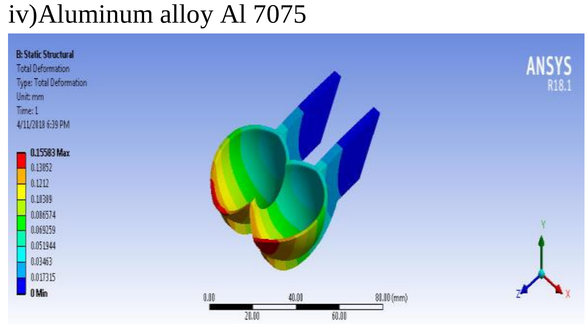


Fig 7.7: Total deformation in Al 7075 (fine)

The figure 7.7 shows that the pelton bucket undergoes total deformation of 0.15583 mm and minimum of 0 mm.

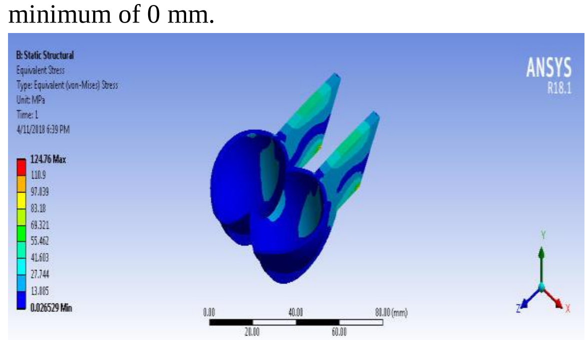


Fig 7.8: von misses stress in Al 7075 (fine)

The figure 7.8 shows that the pelton bucket undergoes maximum stress of 124.76 Mpa and minimum of 0.026529 Mpa

v) 13cr-4ni

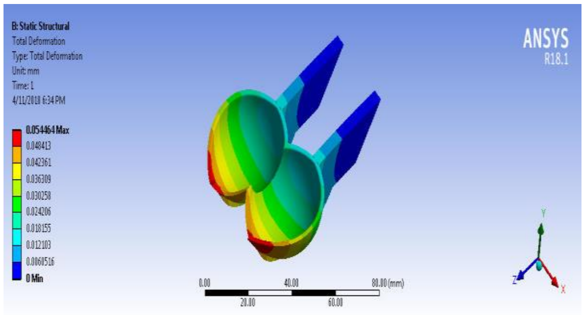


Fig 7.9: Total deformation in 13cr-4ni (fine)

The figure 7.9 shows that the pelton bucket undergoes total deformation of 0.054464 mm and minimum of 0 mm.

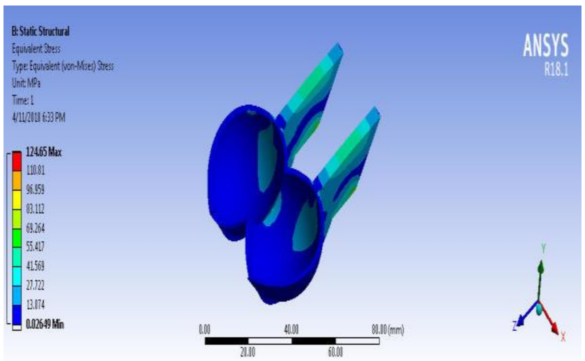


Fig 7.10: von misses stree in 13cr-4ni (fine)

The figure 7.10 shows that the pelton bucket undergoes maximum stress of 124.65 Mpa and minimum of 0.02649 Mpa.

vi)Titanium Alloy Ti-6Al-2Nb-1Ta-0.8Mo

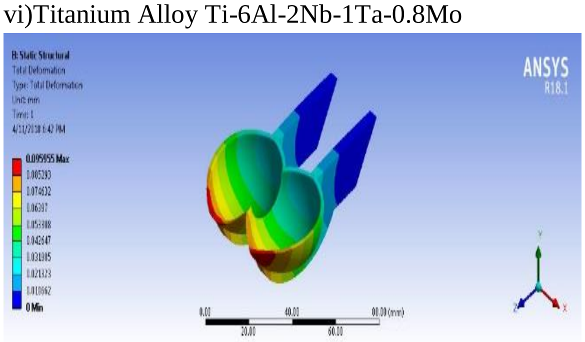


Fig 7.11: Total deformation in Titanium Alloy Ti-6Al-2Nb-1Ta-0.8Mo (fine)

The figure 7.11 shows that the pelton bucket undergoes total deformation of 0.095955 mm and minimum of 0 mm.

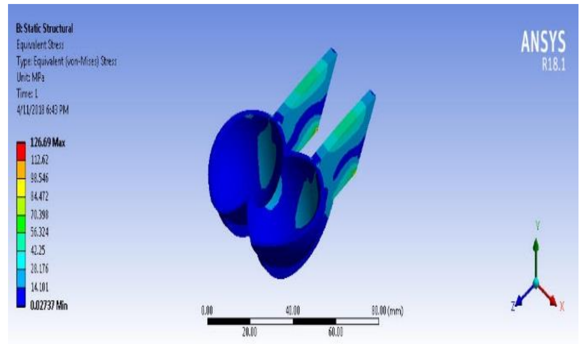


Fig 7.12: von misses stress in Titanium AlloyTi-6Al-2Nb-1Ta-0.8Mo (fine)

The figure 7.12 shows that the pelton bucket undergoes maximum stress of 126.69 Mpa and minimum of 0.02737 Mpa.

Fine mesh result analysis

Materials	Analysis result				
	Total deformation (mm)	Von misses stress (Mpa)	Tensile strength (Mpa)	Factor Of Safety	Cost, (Rs/Kg)
Gray Cast Iron	0. 10212	129.26	276	2.13	56
AISI 1040	0. 056159	128.45	515	4.01	100
E glass fiber	0. 15604	134.75	1700	12.62	322
Aluminum alloy Al 7075	0. 15583	124.76	503	4.03	780
13 cr 4 ni	0. 054464	124.65	720	5.776	200
Ti-6Al-2Nb-1Ta-0.8Mo	0. 095955	126.69	760	6	480

VIII. CONCLUSION

In this project the Pelton wheel bucket model was created by Solid works 2016 software . Then, the model saved in .step formate and was imported to ANSYS software.

The Value of Von- Misses Stresses that comes out from the analysis is far less than material yield

stress so our design is safe and we should go for optimization to reduce the material and cost.
After Performing Static Analysis of the pelton wheel bucket which results shows more realistic whereas static analysis provides an comfortable estimate results. Accurate stresses and deformation are critical input to fatigue analysis and optimization of the Pelton wheel bucket.

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