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Structural Analysis on Pelton Wheel Bucket

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ABSTRACT

Pelton turbines are hydraulic turbines which are widely used for large scale power generation. A micro hydel pelton turbine is miniature model of actual pelton turbine which can be used for small scale power generation. This type of turbines converts potential energy of water at height into kinetic energy by allowing the water to fall freely on the pelton runner. This water impact provides necessary torque required for the rotation the runner by overcoming its inertia forces. The rotation of runner develops a mechanical energy which is coupled to the alternator which converts it into electrical energy. The project shows the analysis of the Pelton wheel bucket modelled using CATIA V5 software. The material used in the manufacture of pelton wheel buckets is studied in detail and these properties are used for analysis. The bucket is analyzed using ANSYS Workbench 15.0 .The bucket geometry is analyzed by considering the force and also by considering the pressure exerted on different points of the bucket. Structural analysis was carried out with two different meshes and also six different materials such as Grey Cast Iron; E-glass Fiber; AISI 1018 Steel; CA6nm Steel; Al Alloy; Ti6Al .The best combination of parameters like Von misses Stress and Equivalent shear stress, Deformation, shear stress and weight reduction for turbine bucket were done in ANSYS software. Grey cast iron has more factor of safety, reduce the weight, increase the stiffness and reduce the stress and stiffer than other material. With this analysis we can determine the lifetime and the strength of pelton turbine.

1. INTRODUCTION

Hydro-drive is an old resource of green power. Water from the waterways, lakes, lakes and plants disperses in view of daylight warming. This makes ascent of water vapor against gravitational draw of earth. In the atmosphere, it cools and accumulates into drops of rain and snow, which falls on inclines and mountains. A ton of daylight vitality is still held in the water as gravitational potential vitality. In this way, daylight vitality is a conclusive wellspring of hydro vitality which on a very basic level addresses set away gravitational vitality. It is understood that water unendingly streams on the earth surface to accomplish the sea. This happens accordingly of the round condition of the earth that tenders a trademark gravitational draw on surface water.

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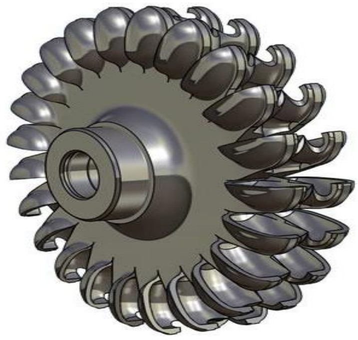
The measure of set away hydro vitality is particularly relating to the stature and measure of the water above sea level. A turbine is the mechanical contraption which exhausts the hydro vitality of a raised water level by strategy for weight vitality (because of a reaction turbine) or by technique for element vitality (by virtue of an inspiration turbine). The hydro energyconsumed by a turbine is gone to the electrical generator shaft as mechanical vitality. APelton-wheel is a digressive stream free-fly drive turbine named after an American specialist, Lesser Pelton. It is fundamental, effective and the primary water fueled turbine which works profitably on high heads in wealth of 450 m. The working weight in this turbine stays air in a manner of speaking. It has fundamental advancement and smooth running components with incredible execution characters. The Pelton wheel separates vitality from the motivation of moving water, rather than its weight like conventional overshot water wheel. Albeit various assortments of motivation turbines existed before Pelton's design, they were less proficient than Pelton's diagram; the water leaving these wheels generally still had speed, and conveyed an extraordinary part of the vitality. Pelton's oar geometry was plot so that when the edge continues running at ½ the rate of the water fly, the water leaves the wheel with low rate, removing most of its vitality, and considering an outstandingly effective turbine. Turbines can be by and large named steam and pressure driven turbines. The pressure driven turbines are turning machines which change over the potential leader of the water into helpful types of vitality, for example, mechanical vitality and electrical vitality. The pressure driven turbines are again sub separated into motivation and response turbines. The pelton wheel turbine which is managed in this diary is a motivation kind of turbine and to be extremely exact this is a Micro hydro turbine. Small scale hydropower plants are a noteworthy wellspring of vitality in the provincial ranges of northern India and Nepal. The pelton turbine comprises of principally the accompanying parts: - 1. Containers 2. Spouts 3. Governors 4. Valves. The can is of the sort of a twofold hemispherical glass fitted onto a runner. The water plane strikes the splitter at the interface of the two sections. The water plane in the wake of striking the splitter it goes through the can profile outwards. The splitters maintain a strategic distance from the water at an edge between 165-175. The effect vitality is changed over into mechanical vitality which is used to turn the runner which will be connected with a generator to make the required AC current.



2. DESIGN STEPS OF A PELTON BUCKET

Considering the underlying working condition of the turbine; the runner container is stationary at starting stage. The water plane leaves the spout at a fast and hits the pail with high dynamic speed. Amid the common running of a pelton turbine a steady fly of water at various speed is kept up for the ceaseless revolution of the runner. Regardless

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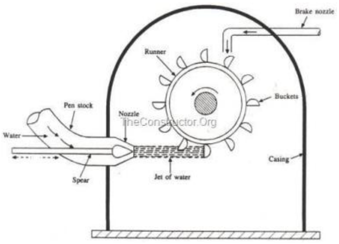
it is the principal stream of water that strikes the container which has the best effect on the can profile, this is by virtue of the main water fly needs to crush the inertia forces of the runner. In fact it is the principal water plane fly which conveys the rotational vitality and torque required for the turn of the runner. This work deals the development of a pelton pail for considering first impact force of water fly.

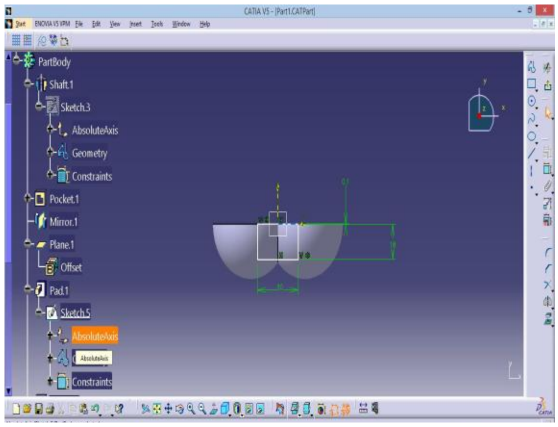
2.1 Pelton Turbine Operating Principle

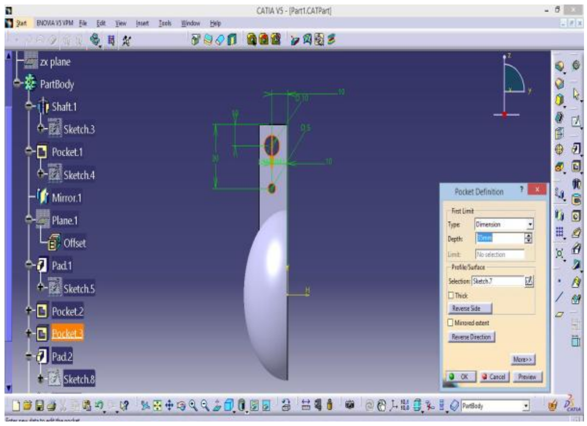
The Pelton turbine is an impulse turbine that only converts kinetic energy of the flow into mechanical energy. The transfer of the total energy from the nozzle exit to the downstream Reservoir occurs at atmospheric pressure. The jet stemming from the injector impinges on buckets, located at the periphery of a wheel.

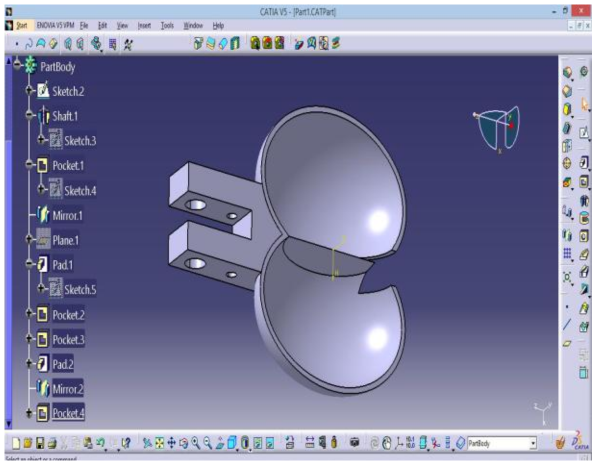


3. INTRODUCTON OF ANSYS WORKBENCH

The ANSYS Workbench represents more than a general purpose engineering tool. It provides a highly integrated engineering simulation platform. Support multi-physics engineering solutions. Provides bi-directional parametric associatively with most available CAD systems. ANSYS represents an application that Provides access to a range of ANSYS Engineering Simulation solutions. It is designed to handle a limited set of relatively simple engineering solutions. Simulation capabilities are limited by the size of engineering and finite element models Finite element models are limited to 1000 elements on single parts or assemblies. Other limitations can be found at It is designed to introduce you to the nature and design of the ANSYS Workbench User Interface. Initially the Geometry is drawn in CATIA and then it is imported to ANSYS, then it is done for Meshing







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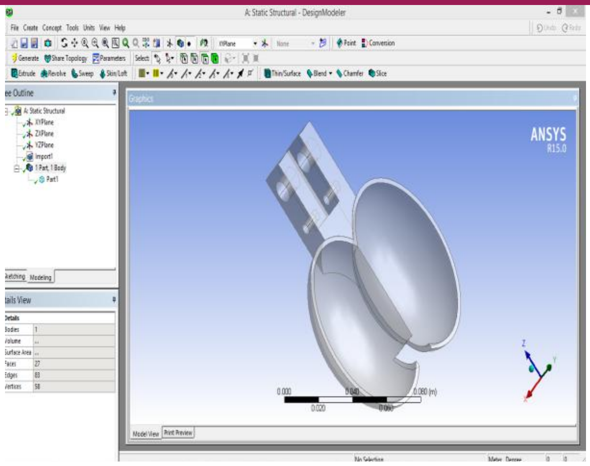
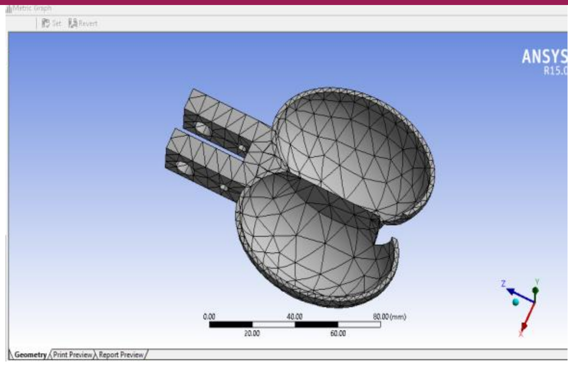
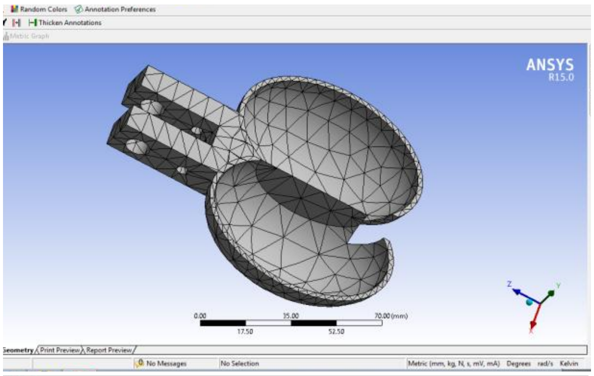
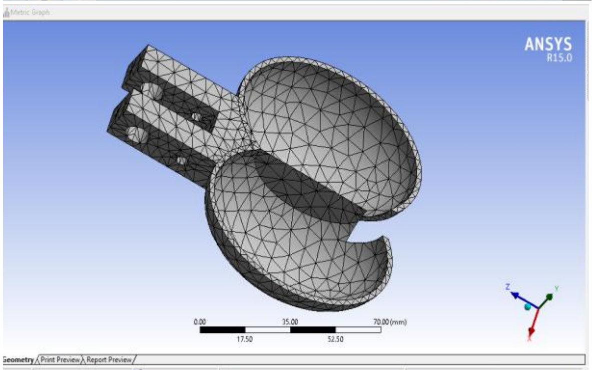
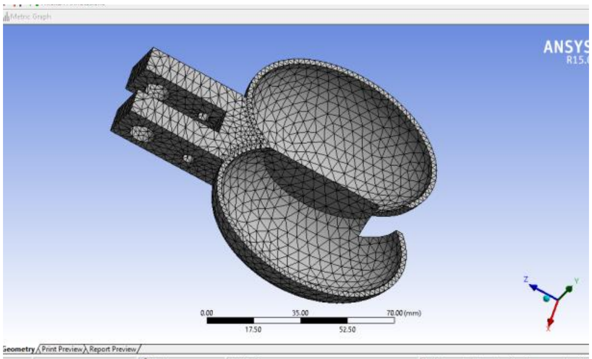










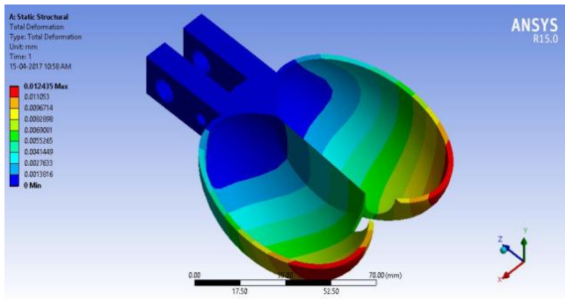
4. RESULTS AND DISCUSSIONS

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.

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; E-glass Fiber; AISI 1018 Steel; CA6nm Steel; Al Alloy; Ti6Al

Case -1: Structural Analysis on Pelton Wheel's Bucket with Various Materials using Coarse Mesh

Material: Grey Cast Iron



The above analysis was conducted on all parts of the bucket using coarse mesh and the results explain the same. The maximum deformation got during the analysis in the pelton wheel's

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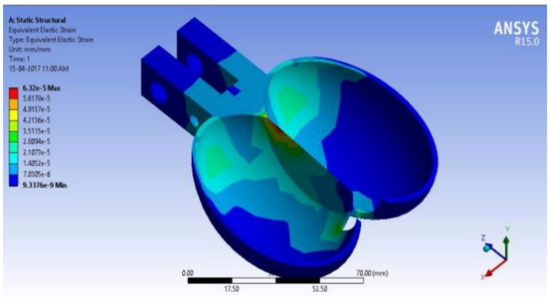
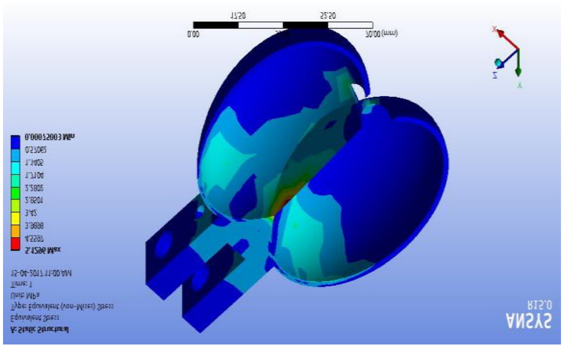
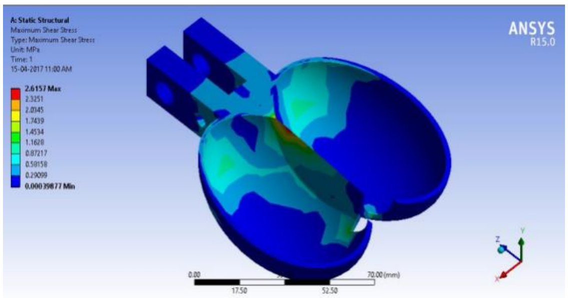
bucket is 0.0124mm and a minimum deformation of about 0.0013mm.



Here in this analysis too coarse mesh is used and got strain about maximum value of 6.32 e^-5 and minimum of about 9.337 e^-9.

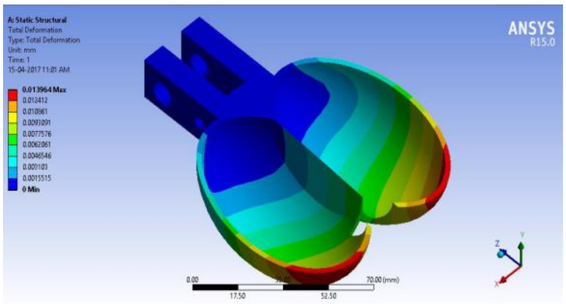


we got maximum stress of about 5.126 MPa and a minimum of 0.00075 MPa and that were clearly shown in the figure here the maximum load is obtained at fixed supports and the mesh considered in this analysis is too coarse mesh.

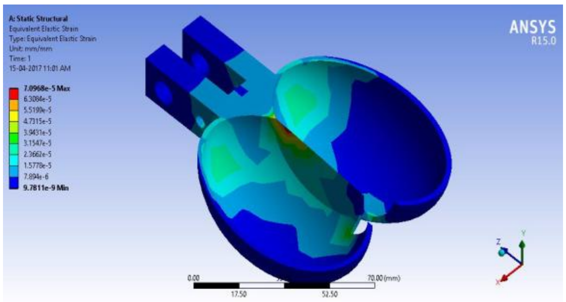


we got maximum shear stress of about 2.615 MPa and a minimum of 0.000398 MPa and that were clearly shown in the figure.

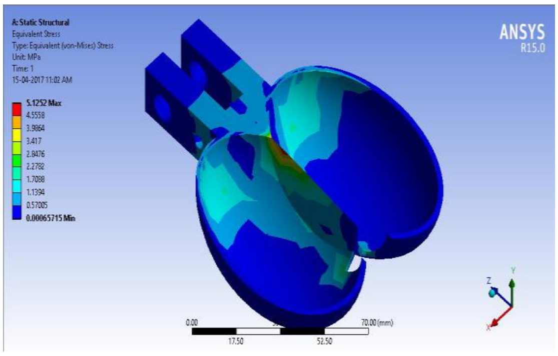
Material: E-Glass Fiber



The maximum deformation got during the analysis in the pelton wheel's bucket is 0.0139 mm and a minimum deformation of about 0 mm



Here in this analysis too coarse mesh is used and got strain about maximum value of 7.09 e^-5 and minimum of about 9.7811 e^-9.



we got maximum stress of about 5.126 MPa and a minimum of 0.00065 MPa and that were clearly shown in the figure here the maximum load is obtained at fixed supports and the mesh considered in this analysis is too coarse mesh.

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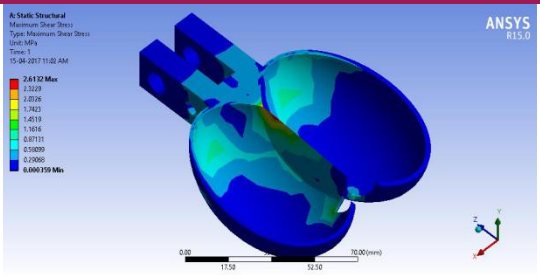
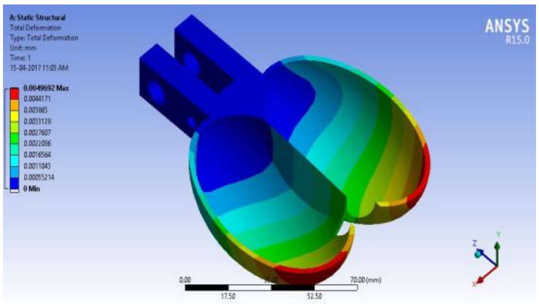
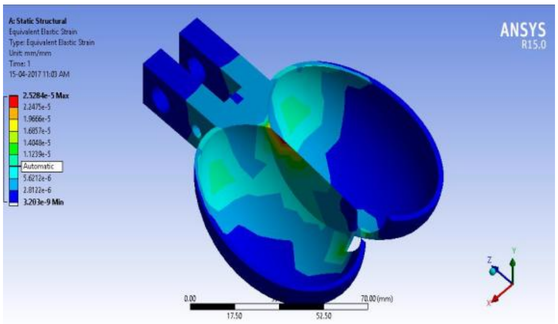


we got maximum shear stress of about 2.613 MPa and a minimum of 0.000359 MPa and that were clearly shown in the figure.

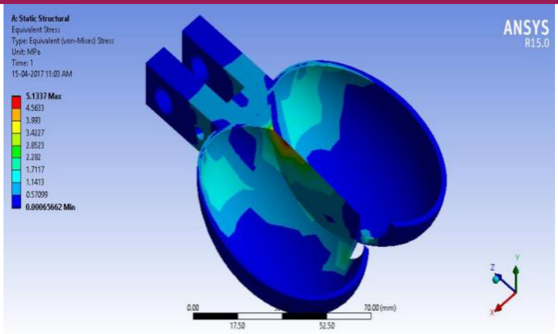
Material:AISI 1018 Steel



The maximum deformation got during the analysis in the pelton wheel's bucket is 0.00496 mm and a minimum deformation of about 0 mm

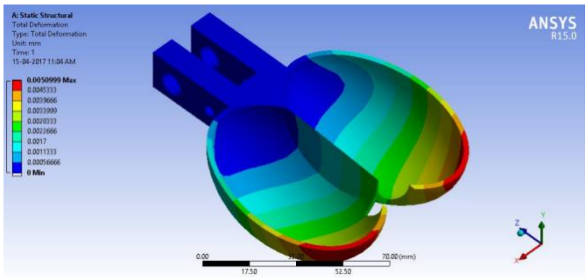


Here in this analysis too coarse mesh is used and got strain about maximum value of 2.528 e^-5 and minimum of about 3.203 e^-9.

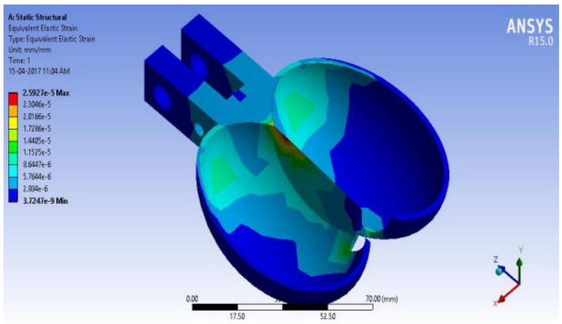


we got maximum stress of about 5.133 MPa and a minimum of 0.00065 MPa and that were clearly shown in the figure here the maximum load is obtained at fixed supports and the mesh considered in this analysis is too coarse mesh.

Material:CA6NM Steel



The maximum deformation got during the analysis in the pelton wheel's bucket is 0.005099 mm and a minimum deformation of about 0 mm



Here in this analysis too coarse mesh is used and got strain about maximum value of 2.59 e^-5 and minimum of about 3.72 e^-9.

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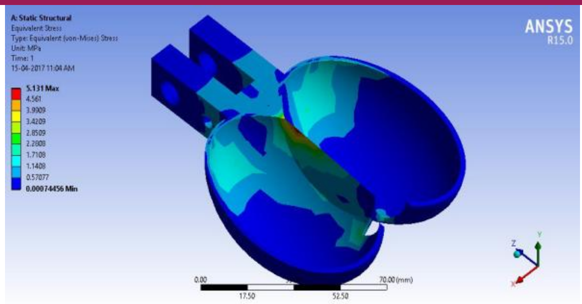
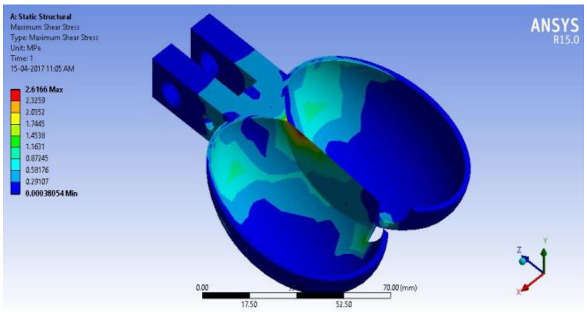
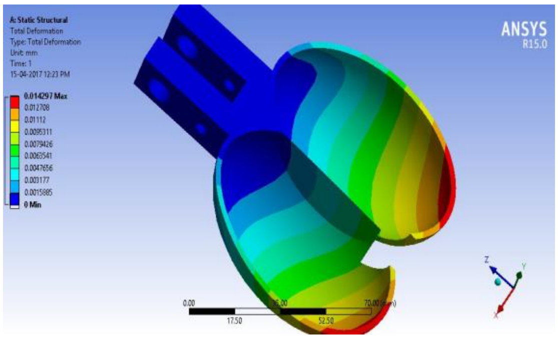


we got maximum stress of about 5.131 MPa and a minimum of 0.00074 MPa

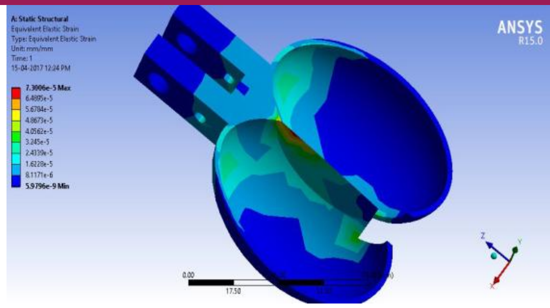


we got maximum shear stress of about 2.615 MPa and a minimum of 0.00038 MPa

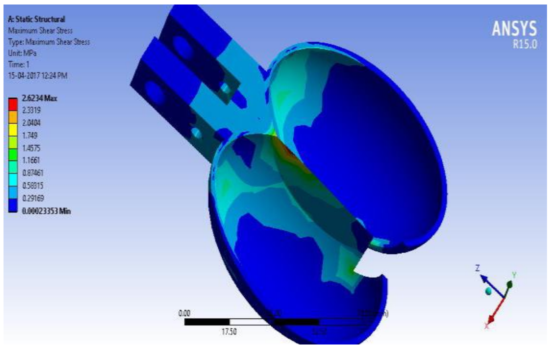
Material:AL Alloy



The maximum deformation got during the analysis in the pelton wheel's bucket is 0.0142 mm and a minimum deformation of about 0 mm

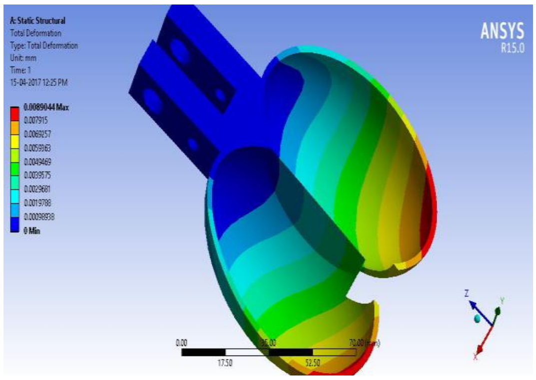


Here in this analysis too coarse mesh is used and got strain about maximum value of 6.32 e^-5 and minimum of about 9.337 e^-9.



we got maximum shear stress of about 2.62 MPa and a minimum of 0.00023 MPa

Material:TI6AL



The maximum deformation got during the analysis in the pelton wheel's bucket is 0.00890 mm and a minimum deformation of about 0 mm

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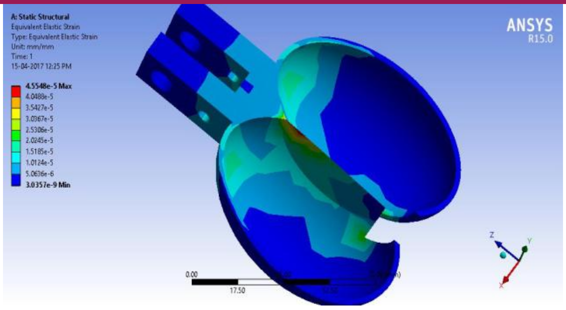
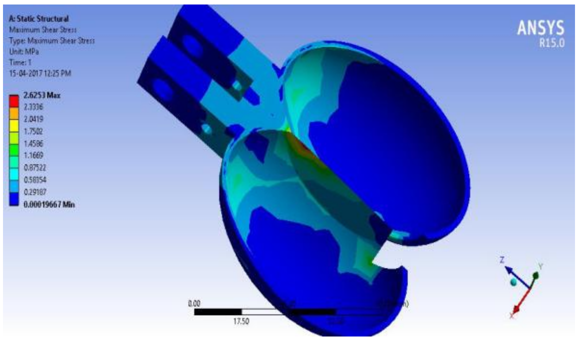


Here in this analysis too coarse mesh is used and got strain about maximum value of 4.554 e^-5 and minimum of about 3.035 e^-9.



We got maximum shear stress of about 2.62 MPa and a minimum of 0.000198 MPa

5. CONCLUSION

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. 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 the outputs total deformation, Equivalent Elastic Strain in bucket, Equivalent Von-Misses stress and Maximum shear stress are calculated. Even though the materials used for analysis are same due to variation in meshing the results varied. Materials used to perform analysis were Grey Cast Iron; E-glass Fiber; AISI 1018 Steel; CA6nm Steel; Al Alloy; Ti6Al. Among the above materials E-glass Fiber have the best performance with fine mesh compare to other materials.

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