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Thermal Analysis of Liquid Hydrogen Turbine Inlet Manifold Using CFD

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ABSTRACT:

This study takes a look at the design process of the air intake system of the Liquid Hydrogen Turbine Inlet Manifold. Differences in turbine outputs and applications require different designs of intake-air manifolds in order to achieve the best volumetric efficiency and thus the best turbine performance. In the present work, the flow characteristics of liquid hydrogen flowing in various designs of air-intake manifold will be studied. The study is done by three dimensional simulations of the flow of air within two designs of air-intake manifold into the turbine by using commercial CFD software, ANSYS. The simulation results are validated by an experimental study performed using a flow bench. The study reveals that the variations in the geometry of the air-intake system can result in a difference of up to 20% in the mass flow rate of air entering the combustion chamber.

The design will be done in a 3D software Catia and analysis carried in FEA software called Ansys.

Keywords: Thermal Analysis, Turbine, CFD.

I. INTRODUCTION

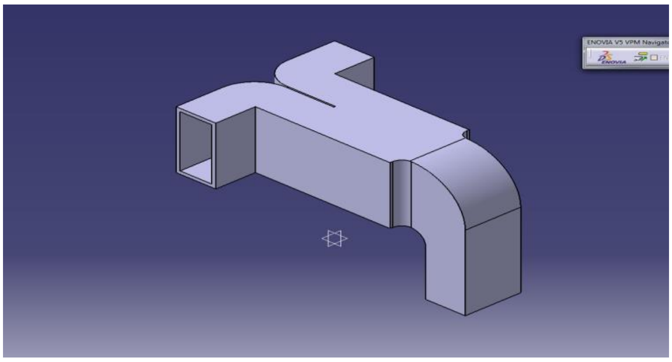
A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. Early turbine examples are windmills and waterwheels.

TURBINE INTAKE MANIFOLD

Intake manifold is generally is a component of internal combustion engine or a turbine, which allows the necessary charge, in case of a internal combustion engine, or a work material like, steam or gas or water or any other fluid, in case of the turbine, to drive the machine to produce some output power. Intake manifolds are generally manufactured with openings for valves to allow the flow.

In this study, we considered the intake manifold of a liquid hydrogen turbine. The intake manifold of a turbine is subjected to high stresses. So, it is necessary, to study the mechanical behavior of body of intake manifolds.

DESIGN OF HYDROGEN TURBINE INLET MANIFOLD ORIGINAL MODEL



DESIGN OF MODIFIED MODEL

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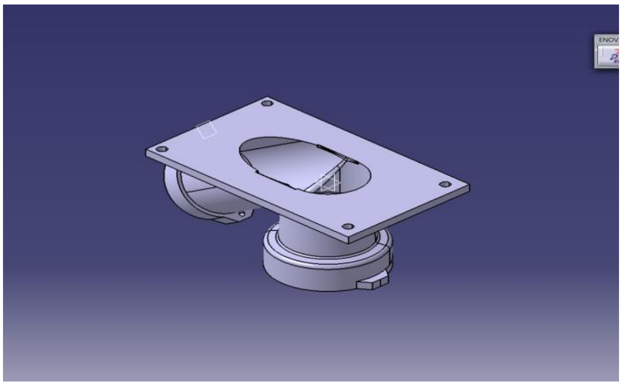
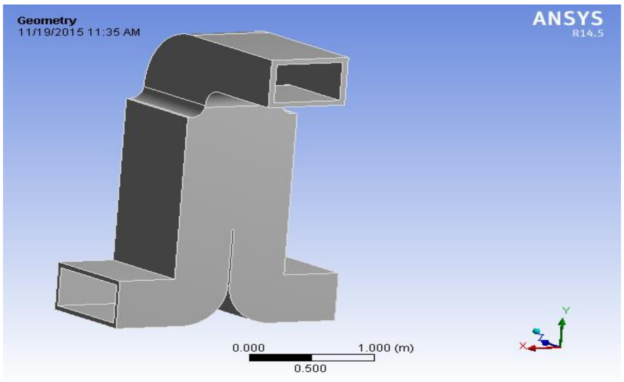
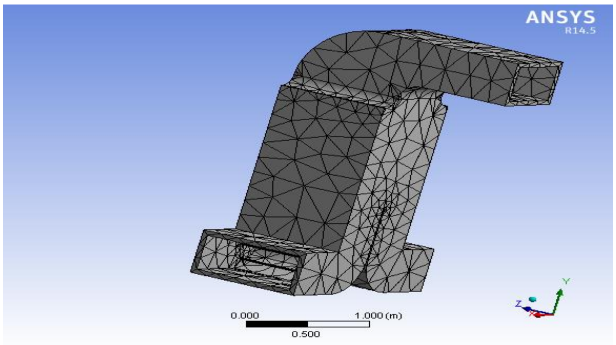


THERMAL ANALYSIS OF ORGINAL MODEL WITH CAST IRON

IMPORT MODEL



MESH MODEL



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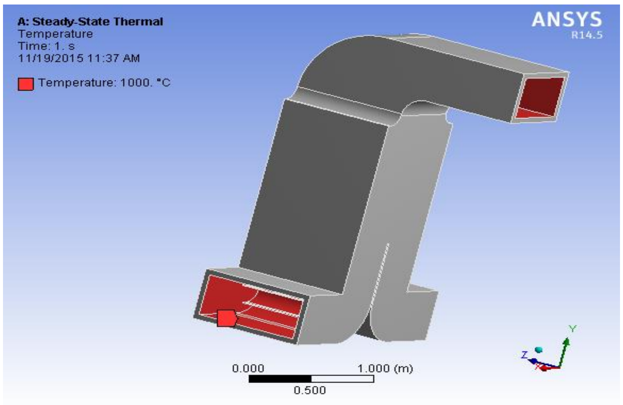

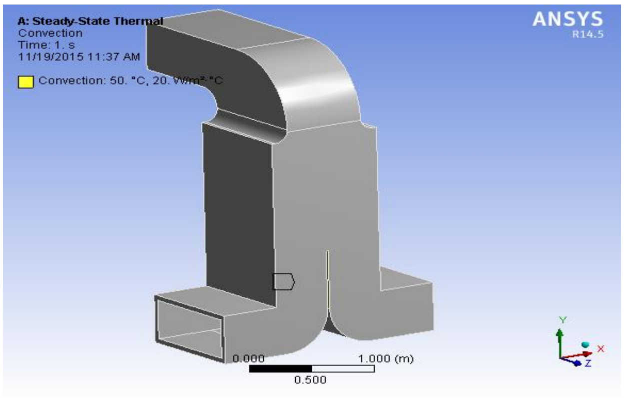

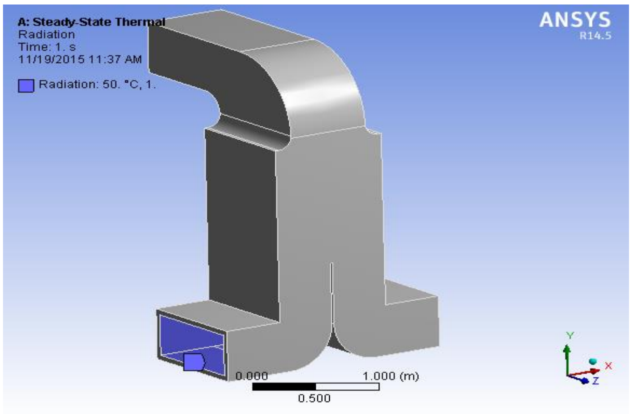

TEMPERATURE

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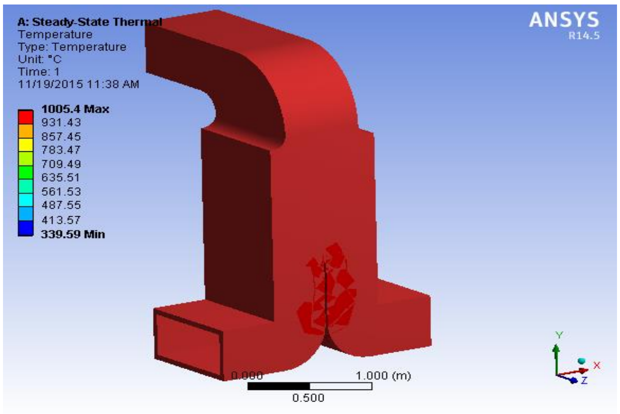
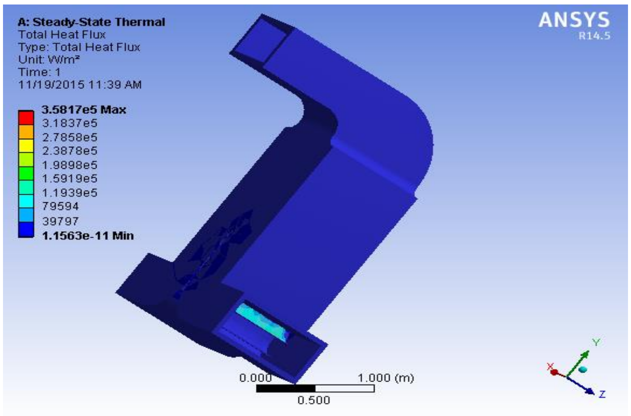
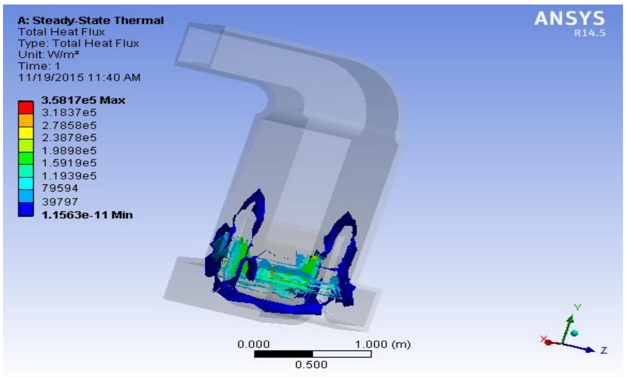
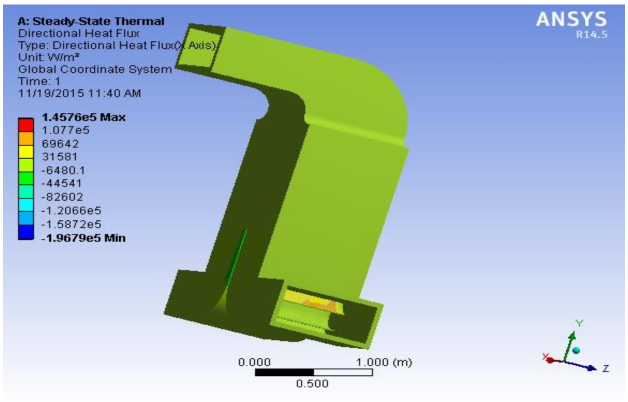


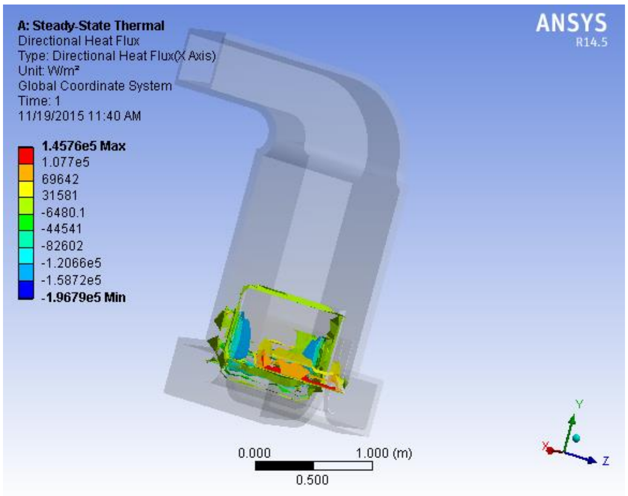
TOTAL HEAT FLUX





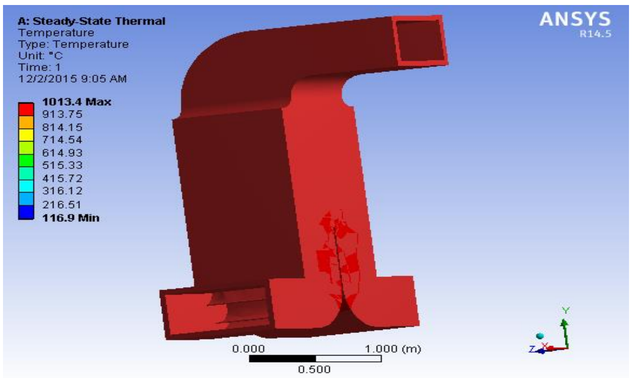
DIRECTIONAL HEAT FLUX





THERMAL ANALYSIS OF ORIGINAL MODEL WITH STAIN LESS STEEL

TEMPERATURE



TOTAL HEAT FLUX

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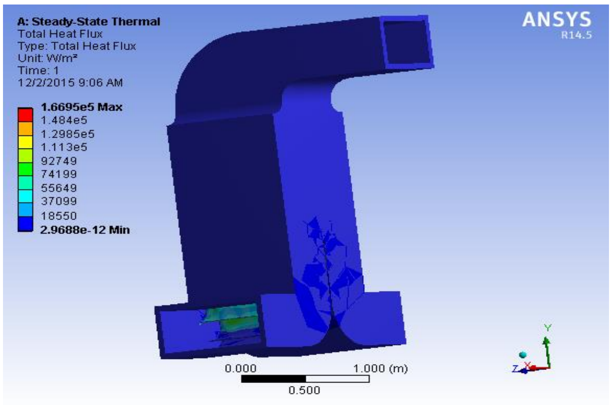
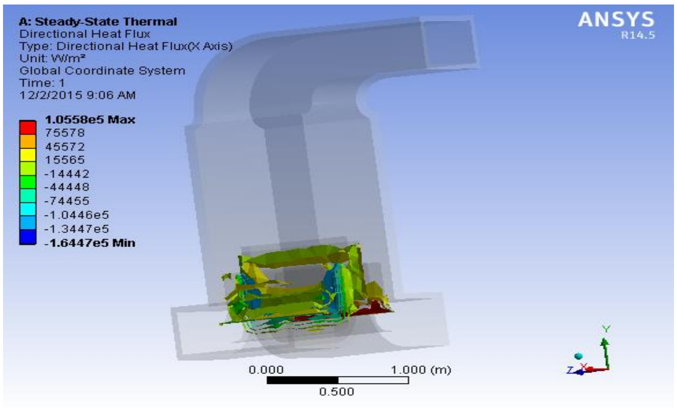
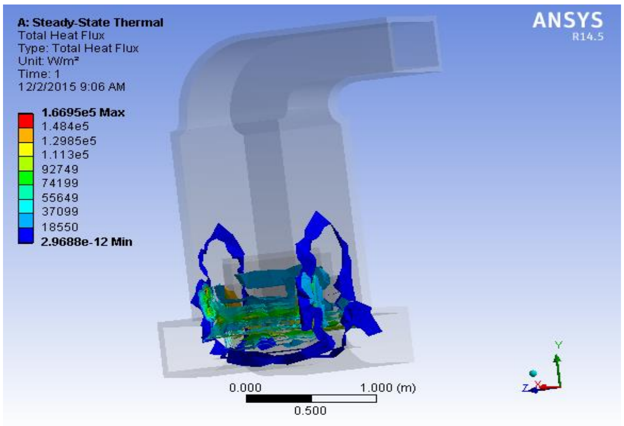
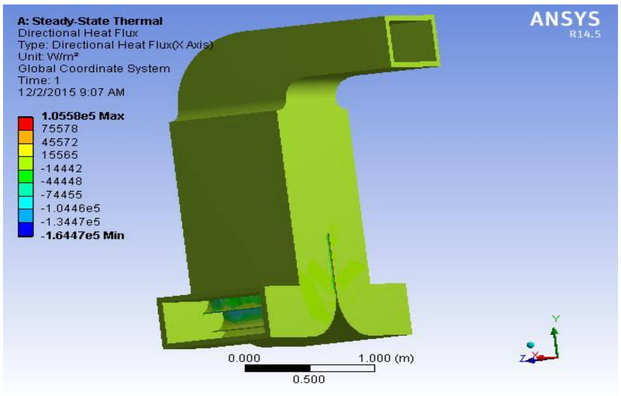




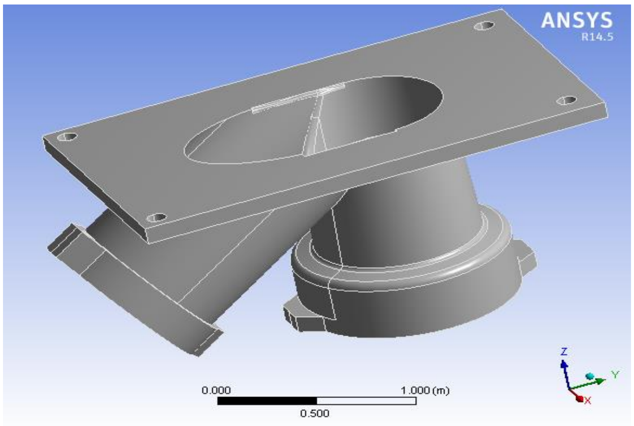


DIRECTIONAL HEAT FLUX



THERMAL ANALYSIS MODIFIED MODEL WITH CAST IRON

IMPORT MODEL



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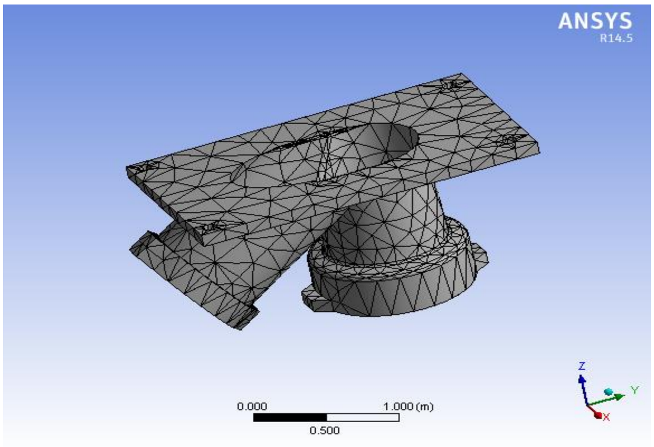
MESH MODEL



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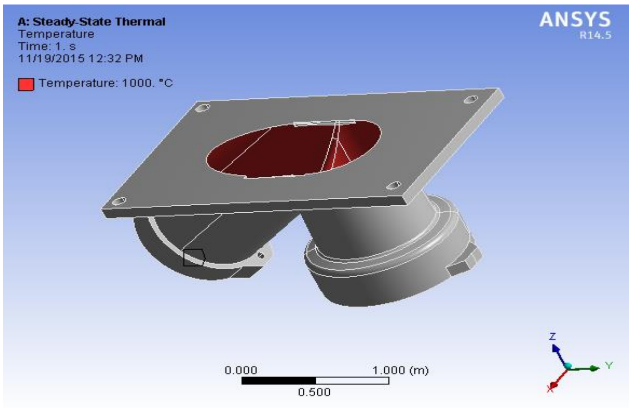

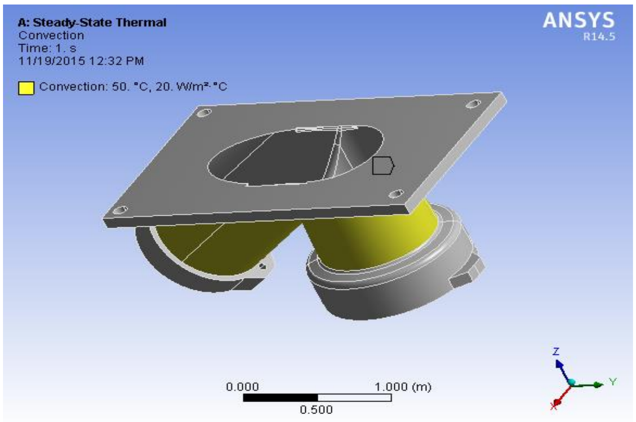

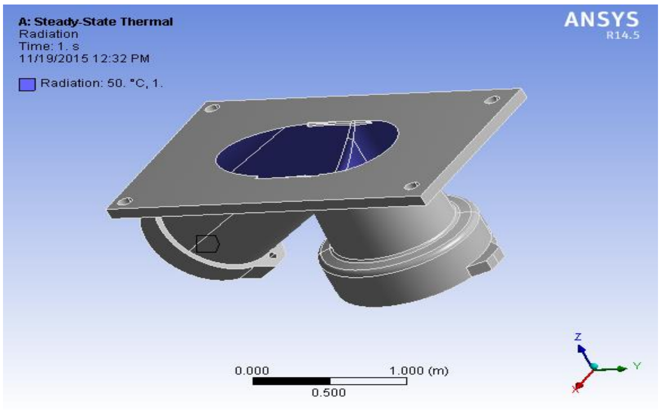

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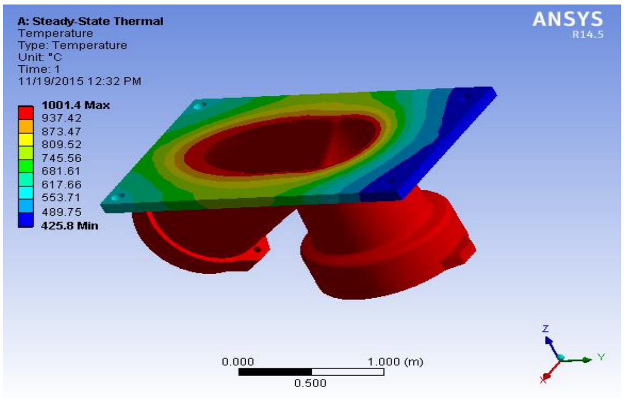

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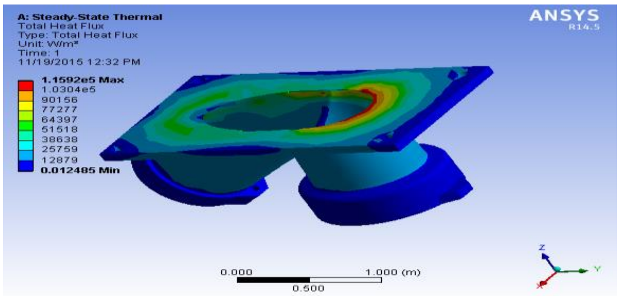

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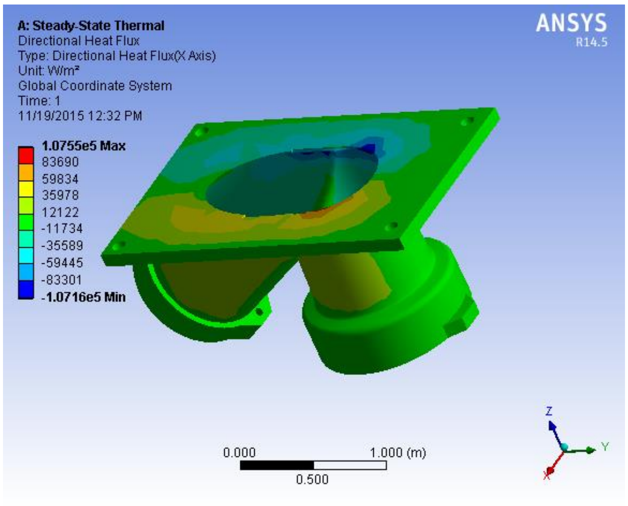
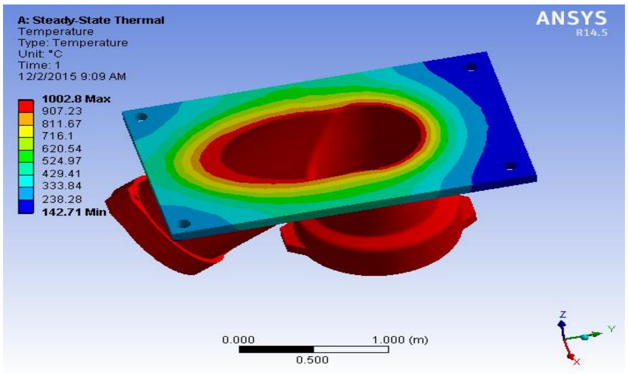
DIRECTIONAL HEAT FLUX

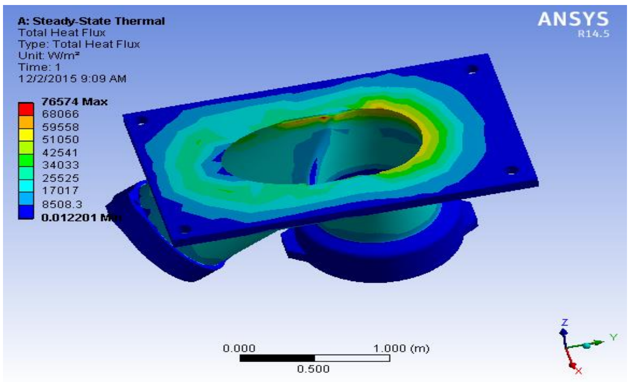


THERMAL ANALYSIS OF MODIFIED MODEL WITH STAIN LESS STEEL

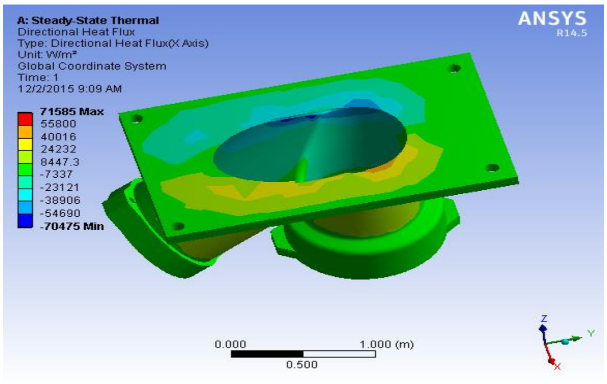
TEMPERATURE



TOTAL HEAT FLUX



DIRECTIONAL HEAT FLUX



CFD ANALYSIS OF ORIGINAL MODEL

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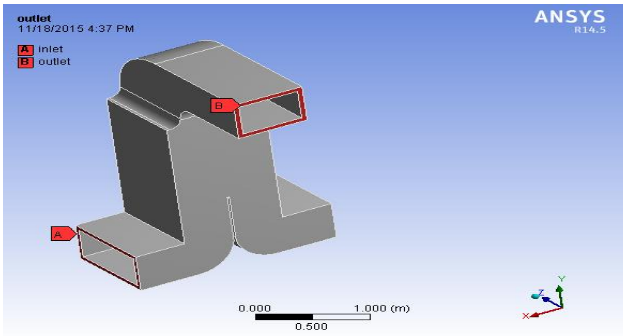
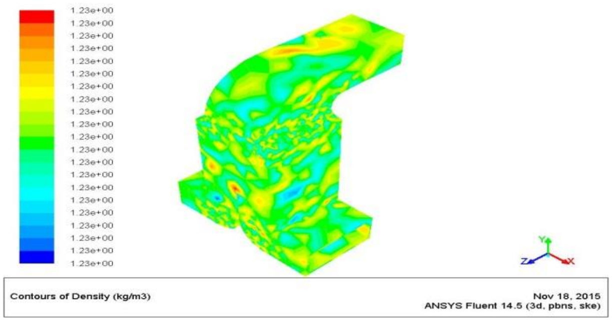


Density



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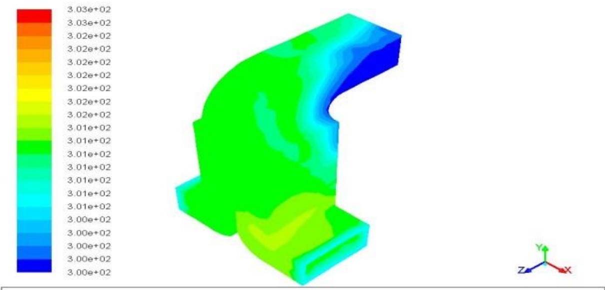
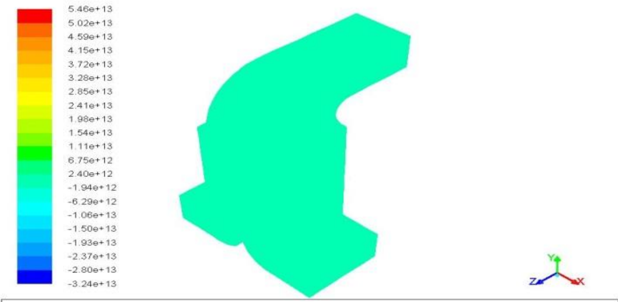
Temperature



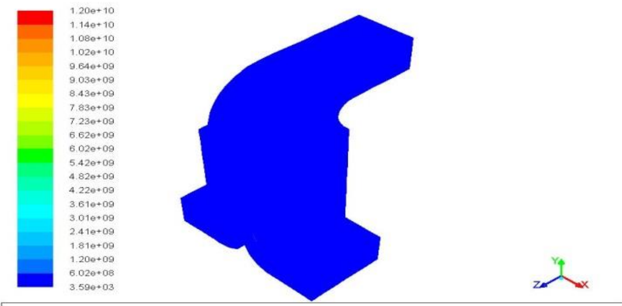
Contours of Static Temperature (k) Nov 18, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

Pressure



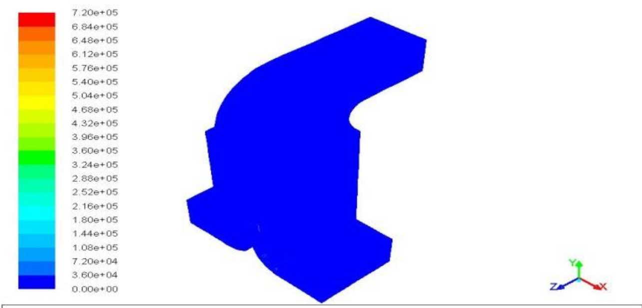
Contours of Static Pressure (pascal) Nov 18, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

Turbulence



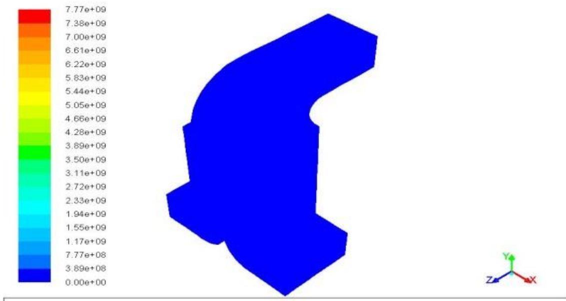
Contours of Turbulent Kinetic Energy (k) (m2/s2) Nov 18, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

Velocity



Contours of Velocity Magnitude (m/s) Nov 18, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

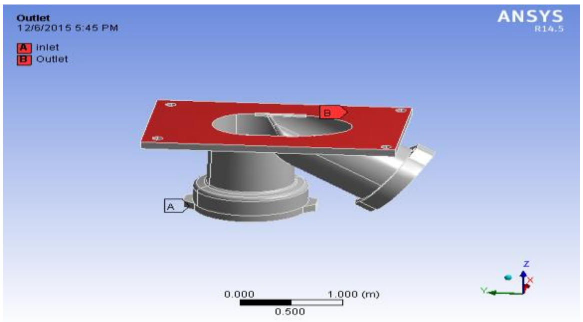
Stress



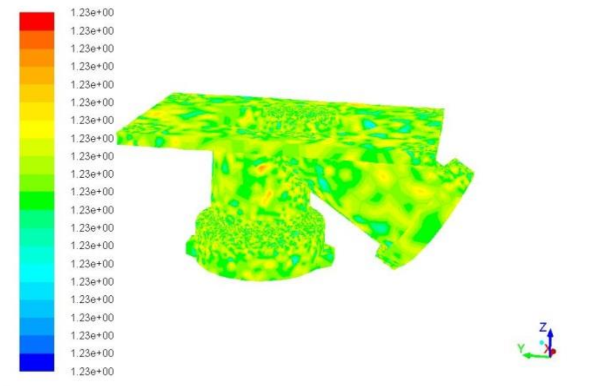
Contours of Wall Shear Stress (pascal) Nov 18, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

CFD ANALYSIS OF MODIFIED TURBINE MODEL

INPUT DATA



DENSITY



Contours of Density (kg/m3) Dec 06, 2015 ANSYS Fluent 14.5 (3d, pbns, ske)

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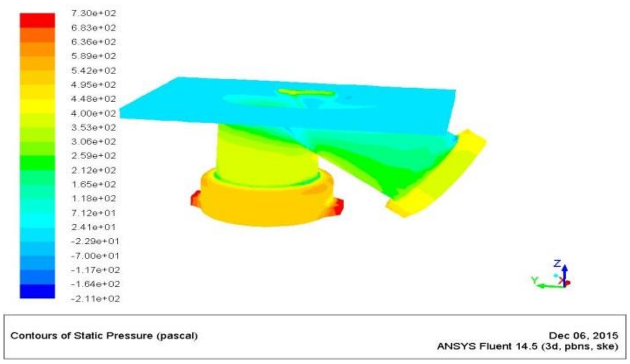
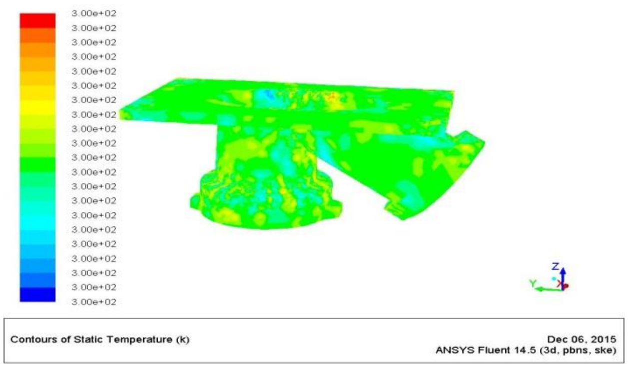
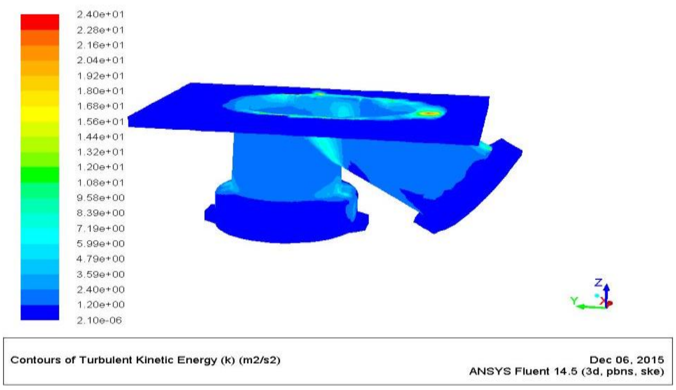
PRESSURE



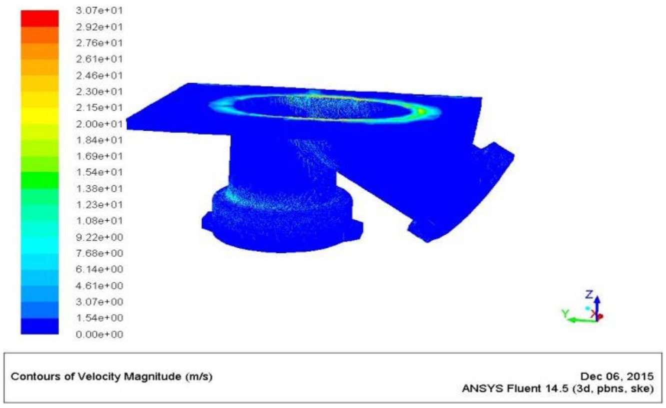
TEMPERATURE



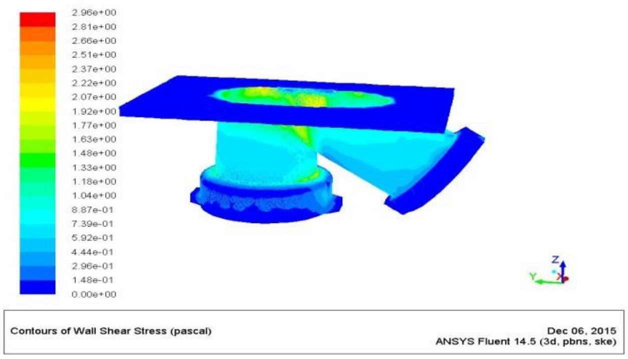
TURBULENCE



VELOCITY



STRESS



RESULTS TABLE

ORIGINAL MODEL

	TEMPERATURE		HEAT FLUX		DIRECTIONAL HEAT FLUX	
	MIN	MAX	MIN	MAX	MIN	MAX
CAST IRON	339.59	1005.4	1.16E-11	3.58E+05	-1.97E+05	1.46E+05
STAINLESS STEEL	-106.6	1013.4	2.9688E-12	69056	-1.6447E+05	1.0558E+05

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MODIFIED MODEL:

	TEMPERATURE		HEAT FLUX		DIRECTIONAL HEAT FLUX	
	MIN	MAX	MIN	MAX	MIN	MAX
CAST IRON	425.8	1001.4	0.012485	1.16E+05	-1.07E+05	1.08E+05
STAINLESS STEEL	142.71	1002.8	0.012201	76574	-70475	71585

CFD Analysis

	PRESSURE		DENSITY	TEMPERATURE		KINETIC ENERGY		VELOCITY MAGNITUDE	SHEAR STRESS
	MIN	MAX		MIN	MAX	MIN	MAX		
ORIGINAL	-3.24E+13	5.46E+13	1.23E+00	3.00E+02	3.03E+03	3.59E+03	1.20E+10	7.20E+05	7.77E+09
MODIFIED	-2.11E+02	7.3E+02	1.23E+00	3.00E+02	3.00E+02	2.10E-06	2.40E+01	3.07E+01	2.96E+00

CONCLUSION

This study takes a look at the design process of the air intake system of the Liquid Hydrogen Turbine Inlet Manifold. Differences in turbine outputs and applications require different designs of intake-air manifolds in order to achieve the best volumetric efficiency and thus the best turbine performance. In the present work, the flow characteristics of liquid hydrogen flowing in various designs of air-intake manifold will be studied. The study is done by three dimensional simulations of the flow of air within two designs of air-intake manifold into the turbine by using commercial CFD software, ANSYS.

Here we have done thermal analysis on the original model and even on the modified model with the materials cast iron and stainless steel, as if we compare the results obtained we have plotted them in a tubular form, so by the results we can conclude that modified model with stainless steel is the best material as it is having very low heat flux and even the directional heat flux.

As we observe here all the results which are obtained here are plotted in to tabular and graph form, as we can observe in all the variants here the modified model is considered as the best model as here there is a lot of difference in stress and velocity and temperature difference. As for the modified model it is very low, so here we can conclude that the modified model is the best model.

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3. GUIDE 2

Mr. Rajasekhar Sanmala, Associate professor, HEAD OF THE DEPARTMENT, Mechanical department, Kakinada institute of technology & science. Divili, AP.