ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Thermal Analysis of an Inline Four Cylinder Engine

Sahukari Mohan Chowdary
M.Tech Student
Department of Mechanical Engineering
KITS, Divilli,
East Godavari(Dist.)
Andhra Pradesh.

Mr.V.V.Rama Krishna
Assistant Professor
Department of Mechanical Engineering
KITS, Divilli,
East Godavari(Dist.)
Andhra Pradesh.

K.Mohan Krishna
Assistant Professor
Department of Mechanical Engineering
KITS, Divilli,
East Godavari(Dist.)
Andhra Pradesh.

Abstract:

The inline four cylinder engine or straight four engine is an internal combustion engine with all four cylinders mounted in a line, or plane on the housing. The one bank of cylinders could also be familiarized in either a vertical or associate degree simple machine with all the pistons driving a typical shaft. Wherever it's inclined, it's generally known as a slant-four. Specification chart or once an abbreviation is employed, associate degree in line four engine is listed either as I4 or L4.

The most objective of the project is a way to develop the paradigm of 4 cylinder engine assembly using CAD tool CATIA. This Engine assembly consists major elements like Cylinder block, Piston, Connecting rod, Crank Shaft, plate, Cam Shaft, Valves, Crank case, oil tank and electrical device with needed dimensions.

The elements that are developed in CATIA are analyzed in ANSYS simulation tool. The thermal analysis of piston, connecting rod, crank shaft is performed for 800k thermal loading and therefore the results of temperature distribution of the elements are shown. Finally the thermal analysis results of the elements area unit compared and therefore the best suited material is chosen.

I. INTRODUCTION

The inline-four engine or straight-four engine is a type of inline internal combustion four cylinder engine with all four cylinders mounted in a straight line, or plane along the crankcase. The single bank of cylinders may be oriented in either a vertical or an inclined plane with all the pistons driving a common crankshaft. Where it is inclined, it is sometimes called a slant-four. In a specification chart or when an abbreviation is used, an inline-four engine is listed either as I4 or L4 (for longitudinal, to avoid confusion between the digit 1 and the letter I)

The inline-four layout is in perfect primary balance and confers a degree of mechanical simplicity which makes it popular for economy cars. However, despite its simplicity, it suffers from a secondary imbalance which causes minor vibrations in smaller engines. These vibrations become more powerful as engine size and power increase, so the more powerful engines used in larger cars generally are more complex designs with more than four cylinders.

INTRODUCTION TO CYLINDER:

A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminum or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless (with a wear-resistant coating such as Nikasil). A sleeveless engine may also be referred to as a "patent-bore engine"

Piston

A piston is seated inside each cylinder by several metal piston rings fitted around its outside surface in machined grooves; typically two for compressional

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

sealing and one to seal the oil. The rings make near contact with the cylinder walls (sleeved or sleeveless), riding on a thin layer of lubricating oil; essential to keep the engine from seizing and necessitating a cylinder wall's durable surface.

Connecting rod

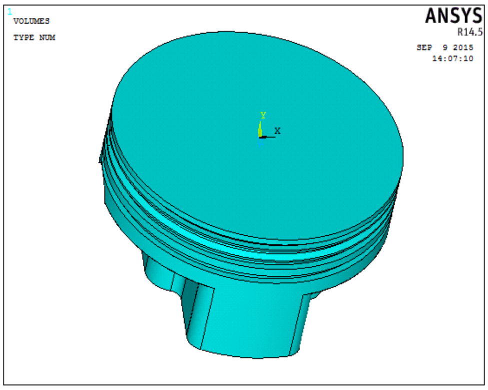
In a reciprocating piston engine, the connecting rod or conrod connects the piston to the crank or crankshaft. Together with the crank, they form a simple mechanism that converts reciprocating motion into rotating motion. Connecting rods may also convert rotating motion into reciprocating motion. Historically, before the development of engines, they were first used in this way.

Crankshaft

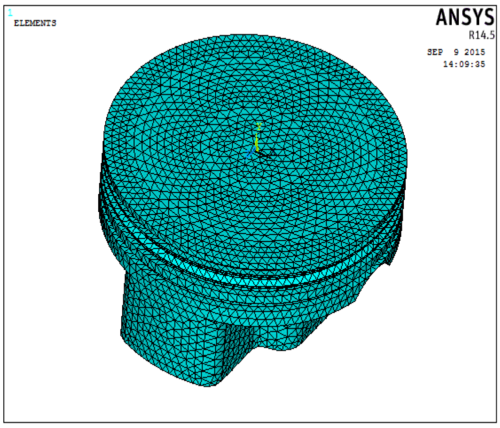
A crankshaft is a mechanical part able to perform a conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.

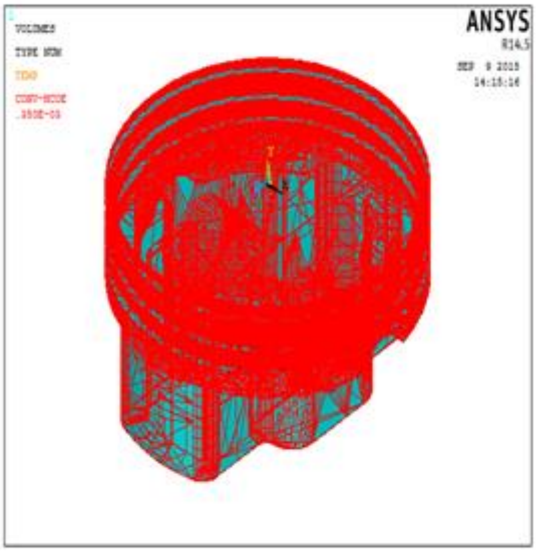
Thermal analysis piston using the material alloy steel

Imported model

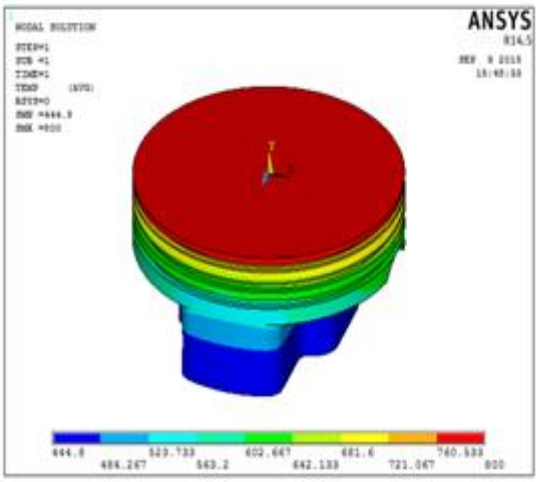


Meshed model



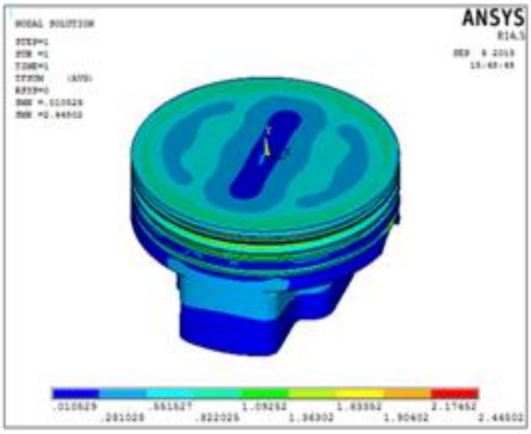


Loads applied model

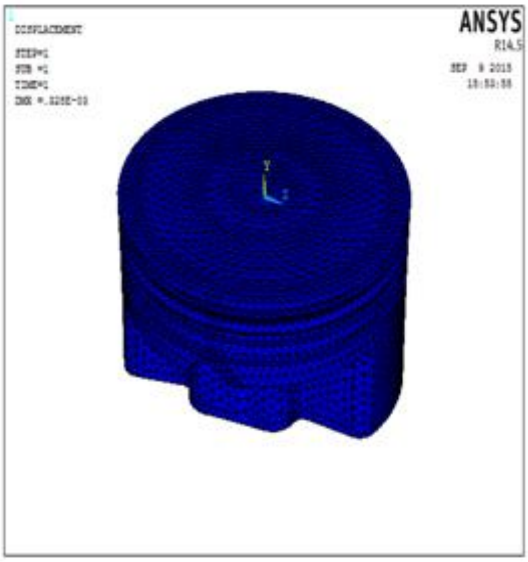


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

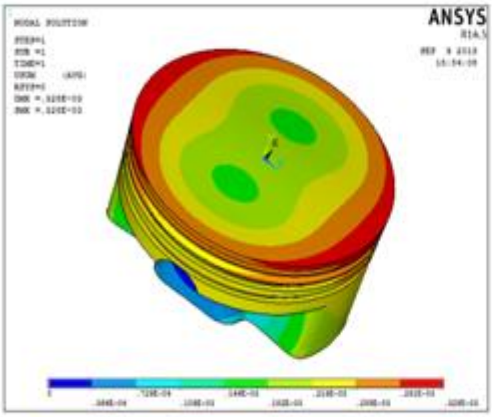
NODAL TEMPERATURE
THERMAL FLUX



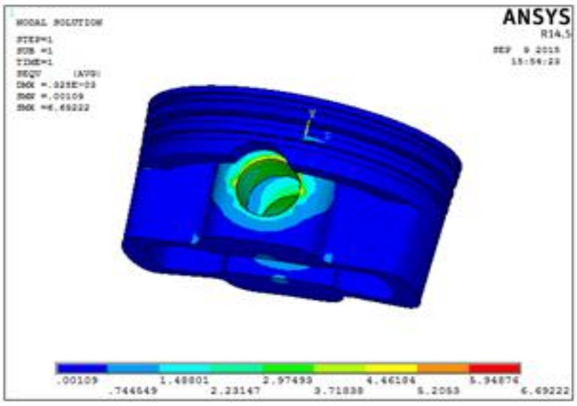
DEFORMATION



DISPLACEMENT VECTOR SUM



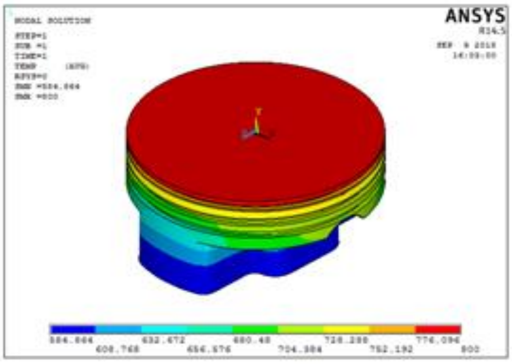
VON MISES STRESS (THERMAL STRESSES)



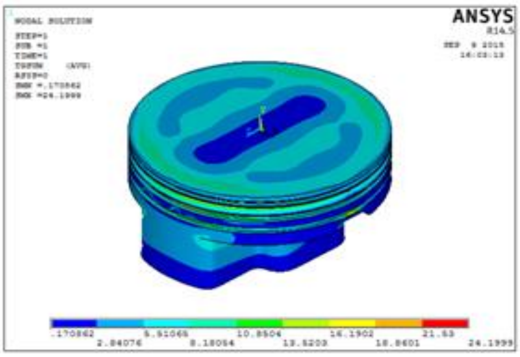
Thermal analysis piston using the material aluminum alloy 5052- o

Material Properties
Conductivity = 0.138
Specific heat = 880
Density = 0.00000268
Young’s Modulus = 70300
Poisson’s Ratio = 0.33

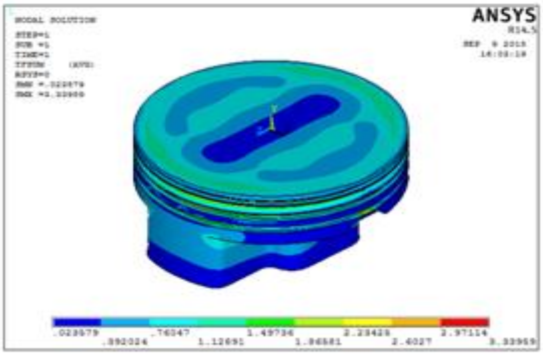
NODAL TEMPERATURE



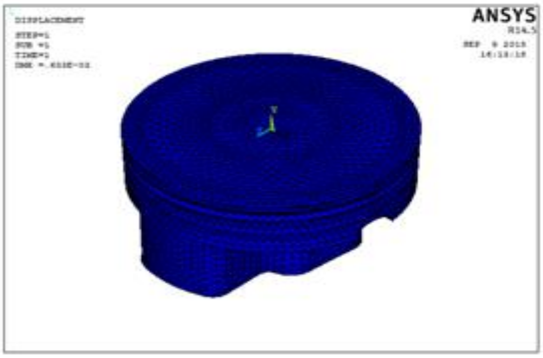
THERMAL GRADIENT



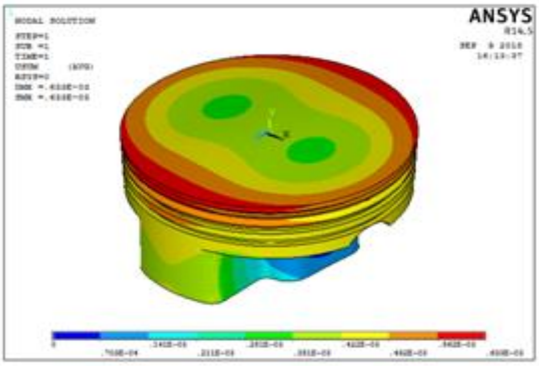
THERMAL FLUX



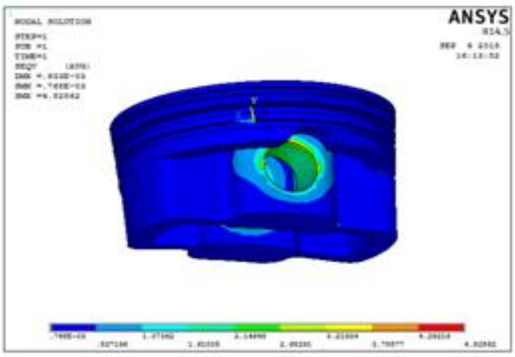
DEFORMATION



DISPLACEMENT VECTOR SUM



VON MISES STRESS (THERMAL STRESSES)



Thermal analysis piston using the aluminum alloy 2014- t6

Material Properties

Conductivity = 0.154

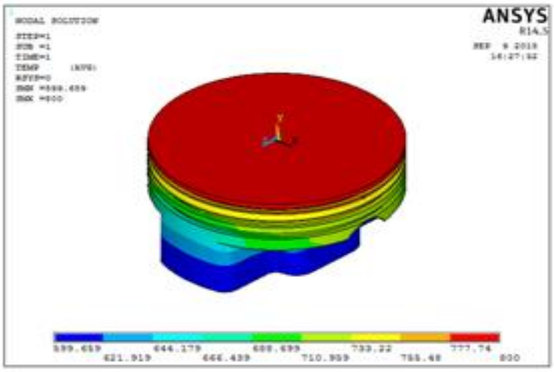
Specific heat = 884

Density = 0.0000028

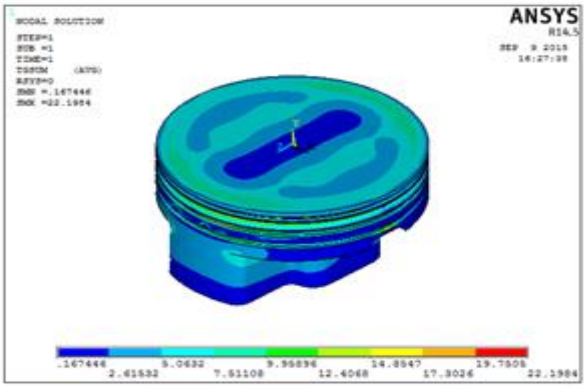
Young's Modulus = 72400

Poission's Ratio = 0.33

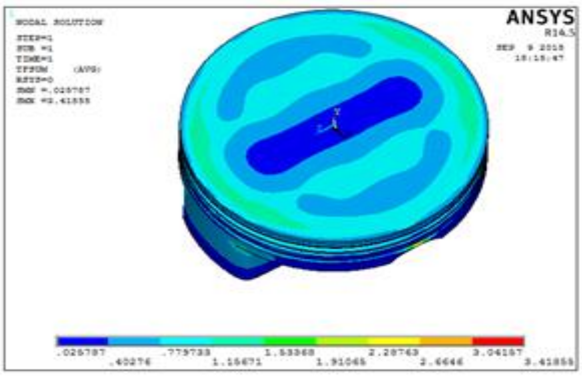
NODAL TEMPERATURE



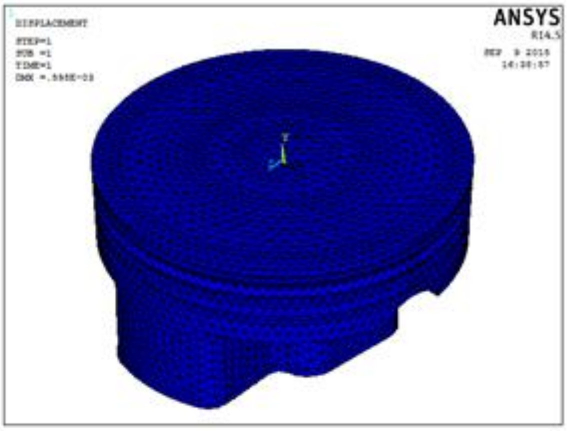
THERMAL GRADIENT



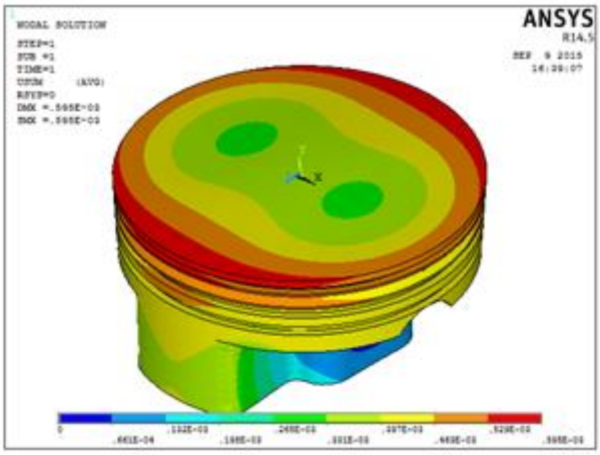
THERMAL FLUX



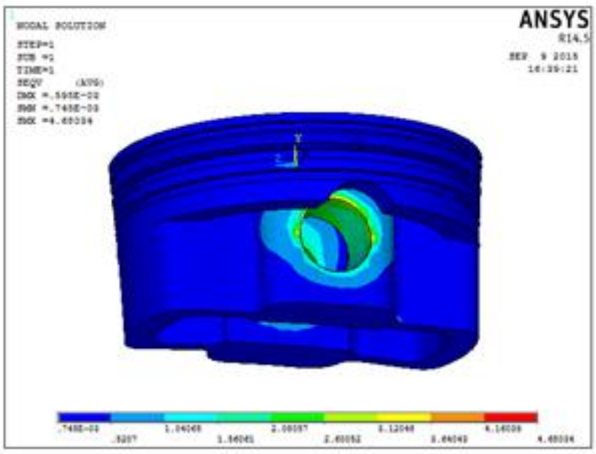
DEFORMATION



DISPLACEMENT VECTOR SUM



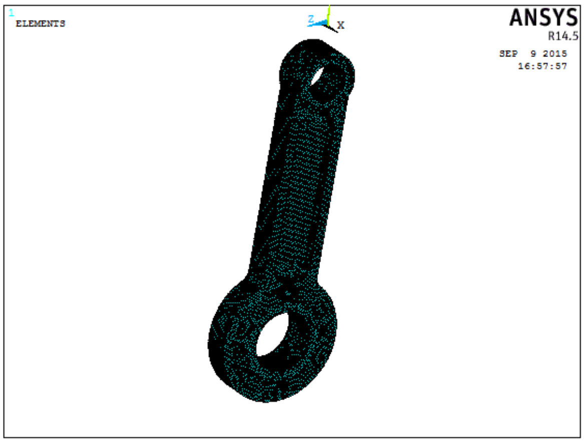
VON MISES STRESS (THERMAL STRESSES)



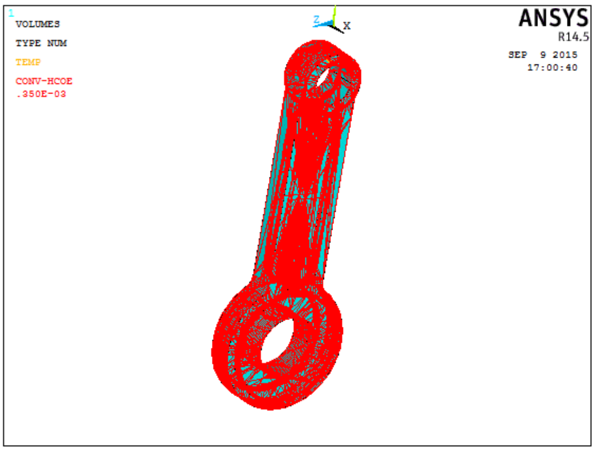
Thermal analysis connecting rod using the material alloy steel

Imported model

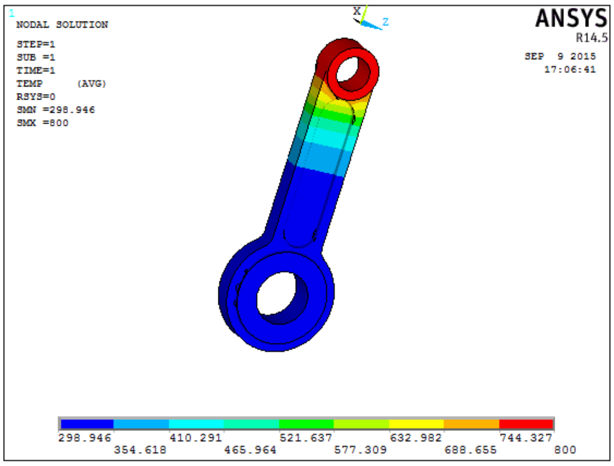
Meshed model



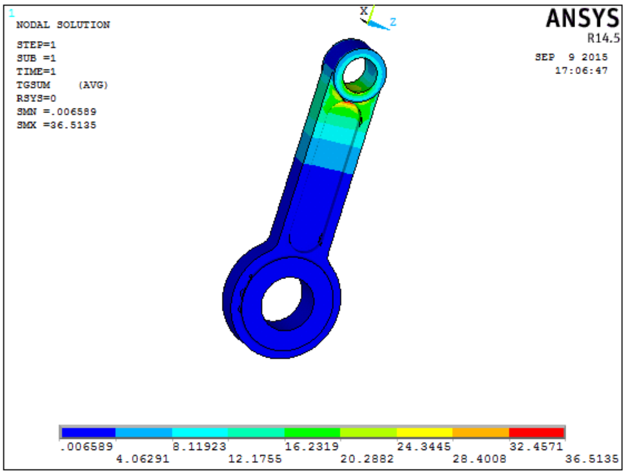
Loads applied model



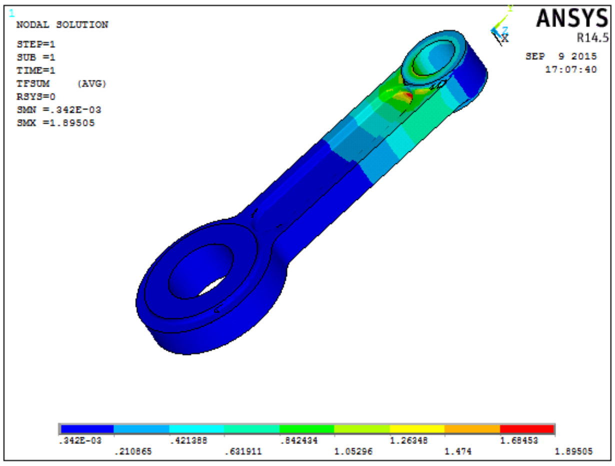
NODAL TEMPERATURE



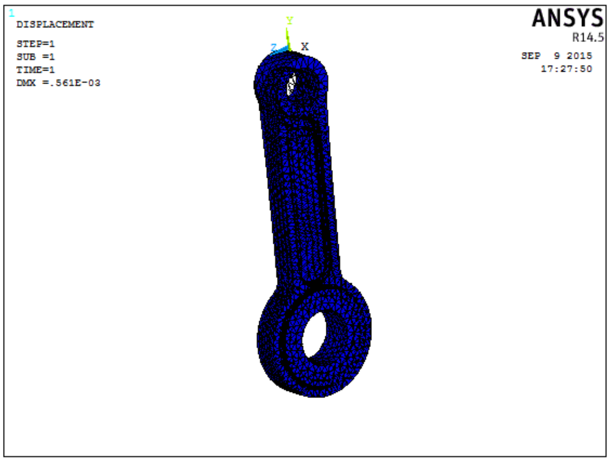
THERMAL GRADIENT



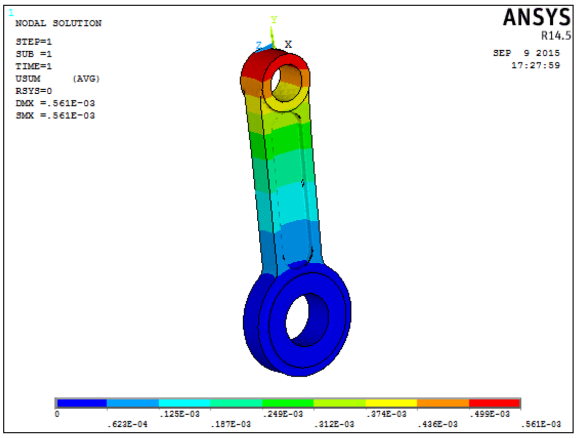
THERMAL FLUX



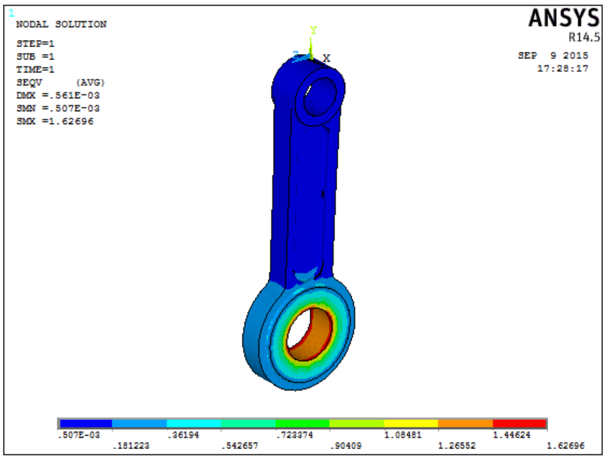
DEFORMATION



DISPLACEMENT VECTOR SUM



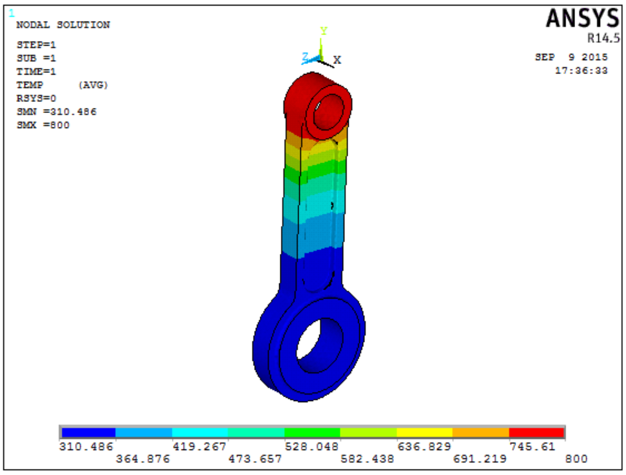
VON MISES STRESS (THERMAL STRESSES)



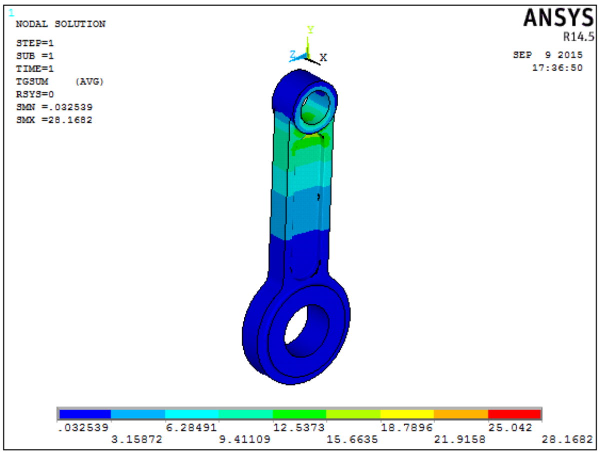
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Thermal analysis connecting rod using the material aluminum alloy 5052- o

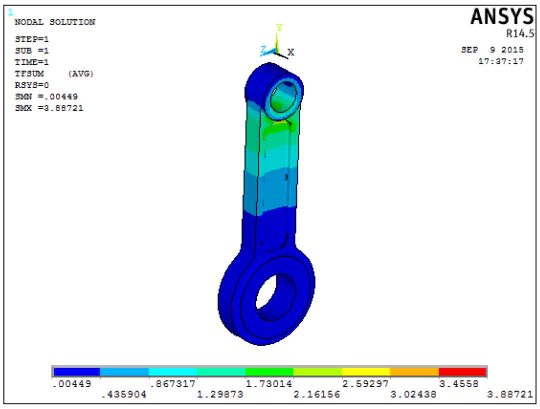
NODAL TEMPERATURE



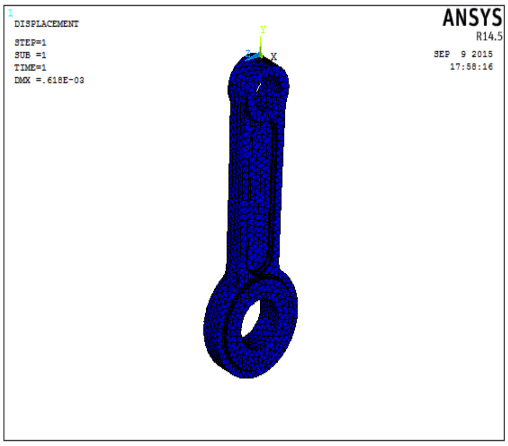
THERMAL GRADIENT



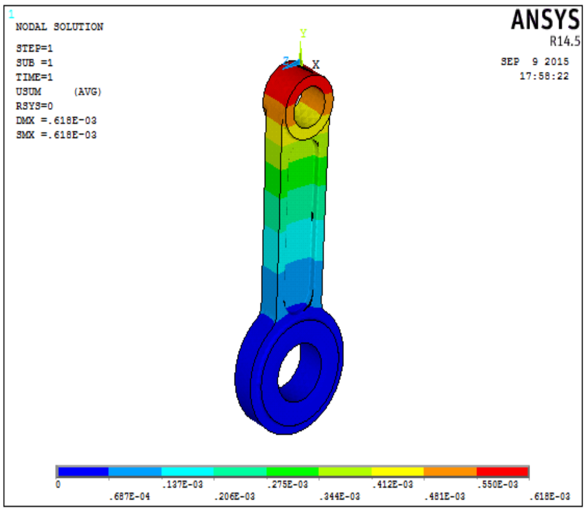
THERMAL FLUX



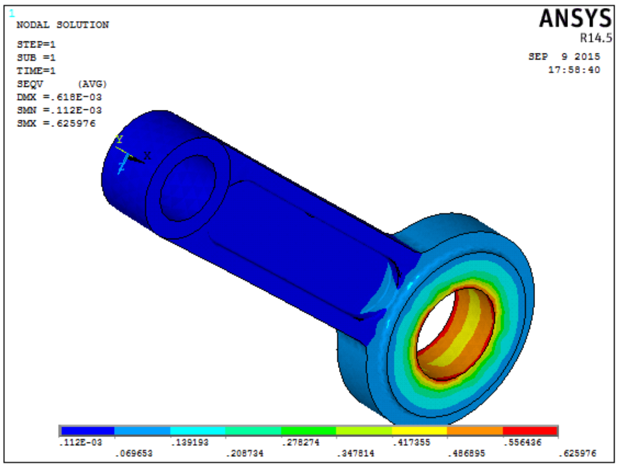
DEFORMATION



DISPLACEMENT VECTOR SUM



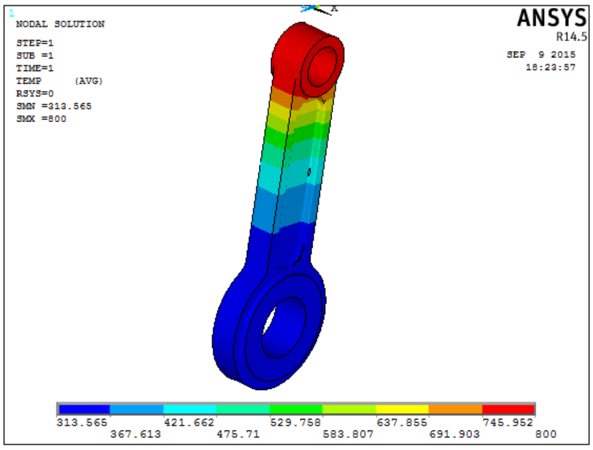
VON MISES STRESS (THERMAL STRESSES)



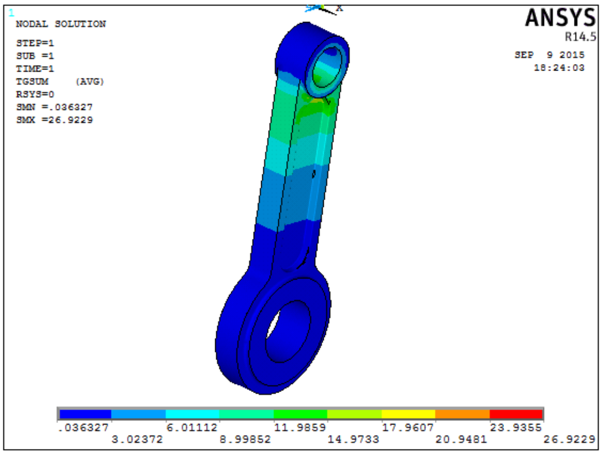
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Thermal analysis connecting rod using the material aluminum alloy 2014 –t6

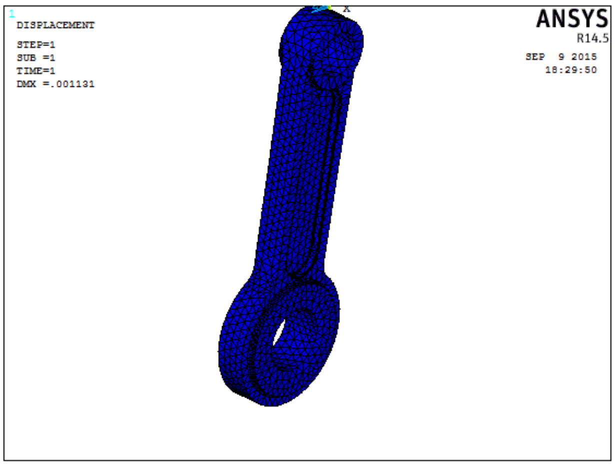
NODAL TEMPERATURE



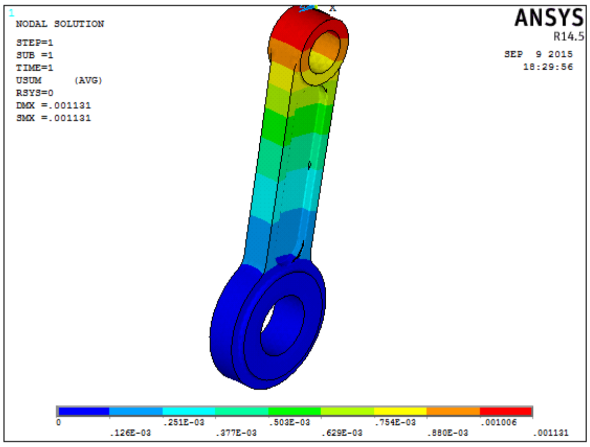
THERMAL GRADIENT



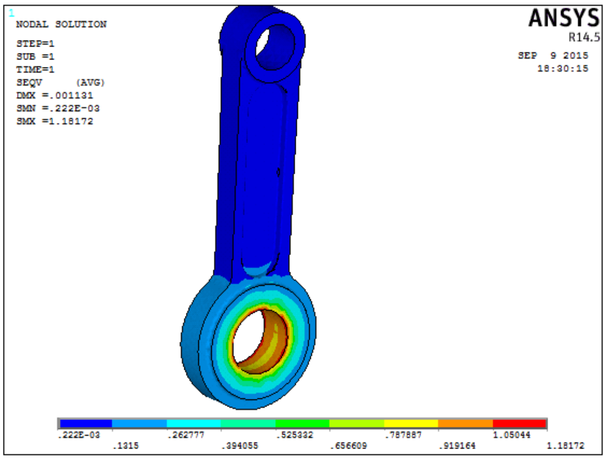
DEFORMATION



DISPLACEMENT VECTOR SUM

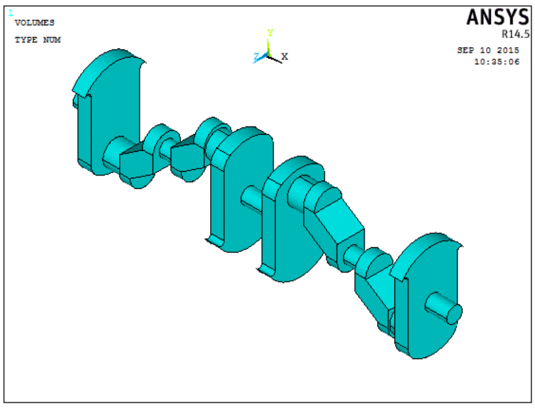


MISES STRESS (THERMAL STRESSES)



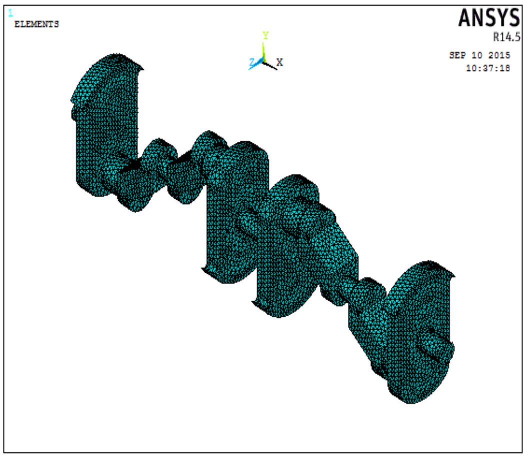
Thermal analysis crank shaft using the material alloy steel

Imported model

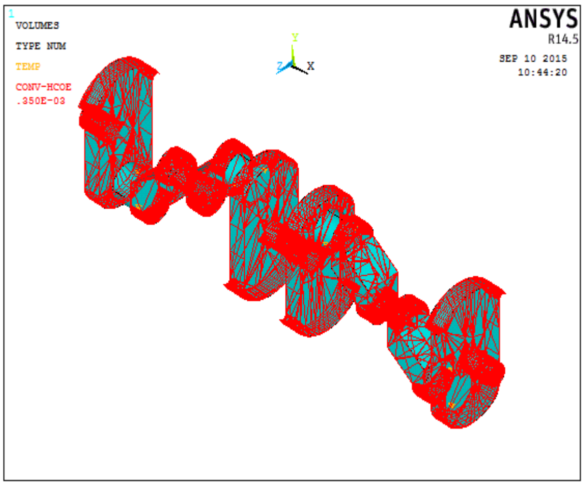


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

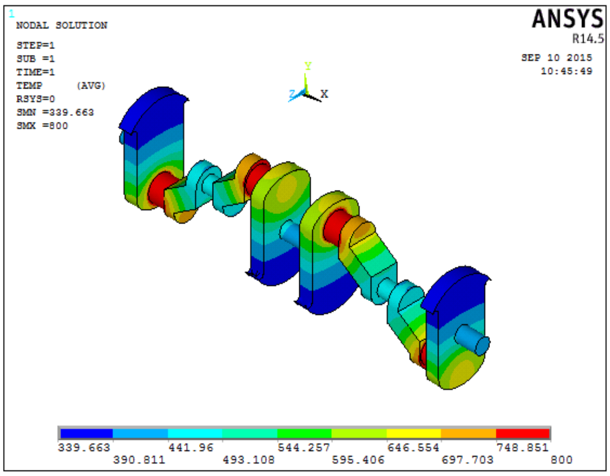
Meshed model



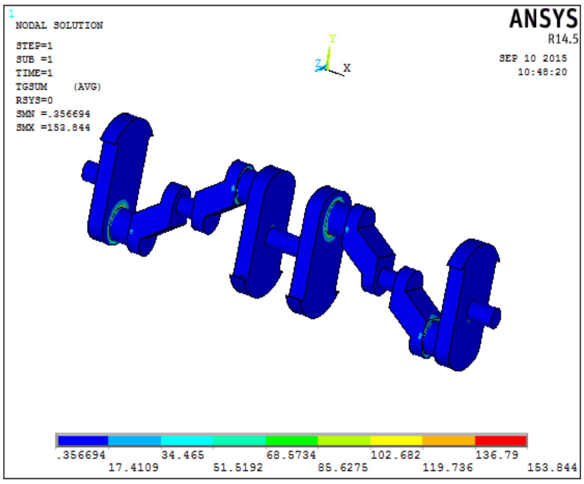
Loads applied model



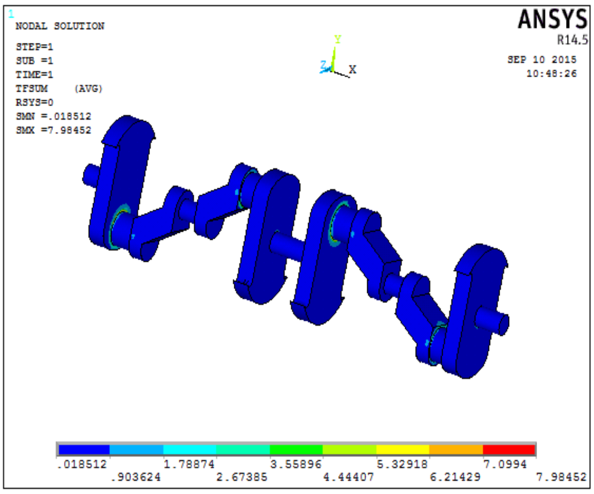
NODAL TEMPERATURE



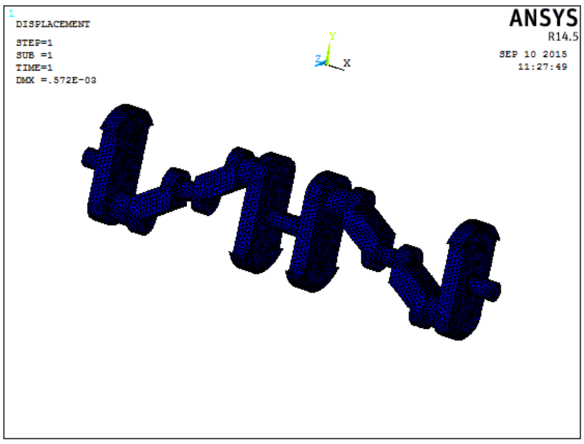
THERMAL GRADIENT



THERMAL FLUX

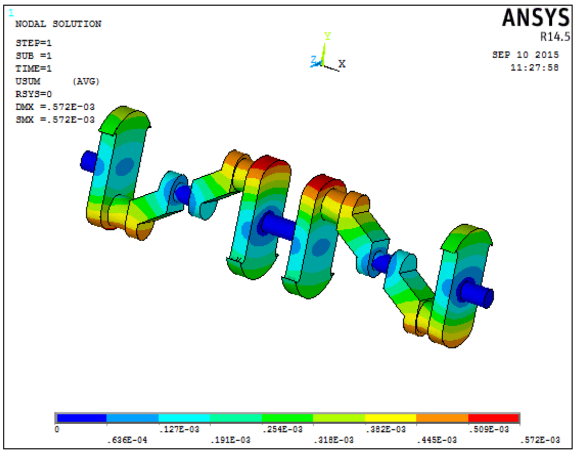


DEFORMATION

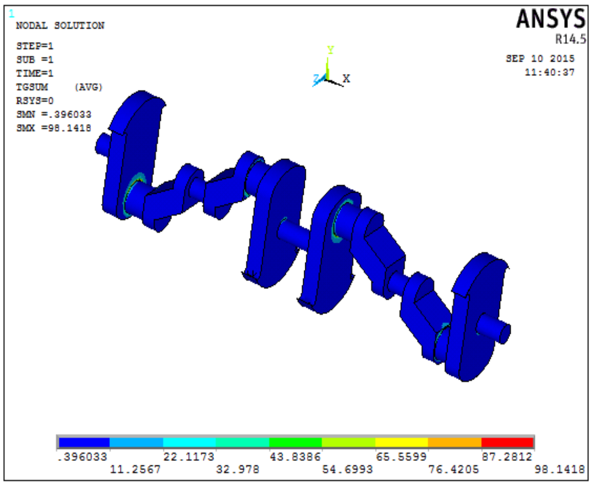


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

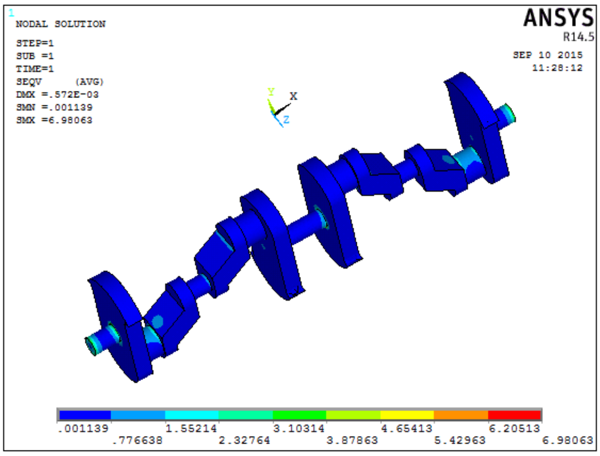
DISPLACEMENT VECTOR SUM



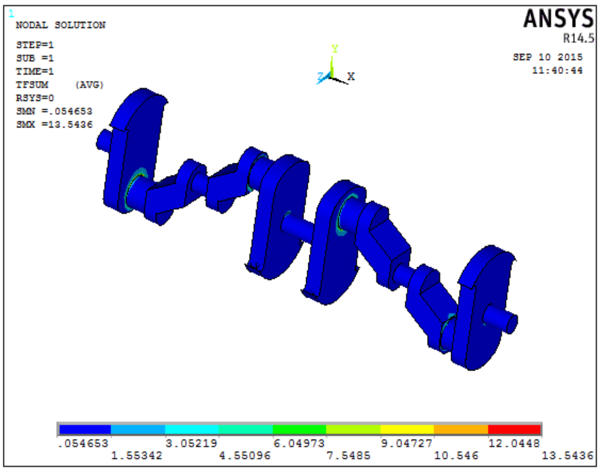
THERMAL GRADIENT



MISES STRESS (THERMAL STRESSES)

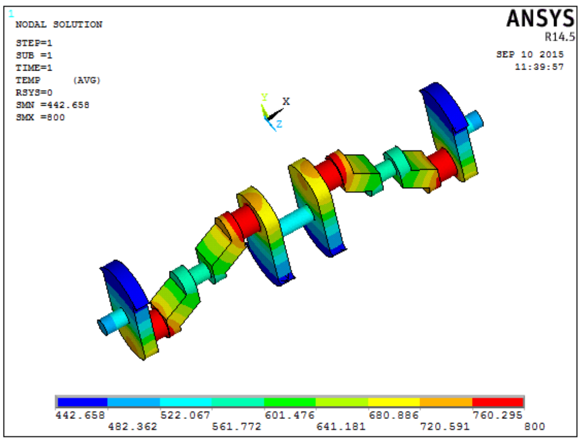


THERMAL FLUX

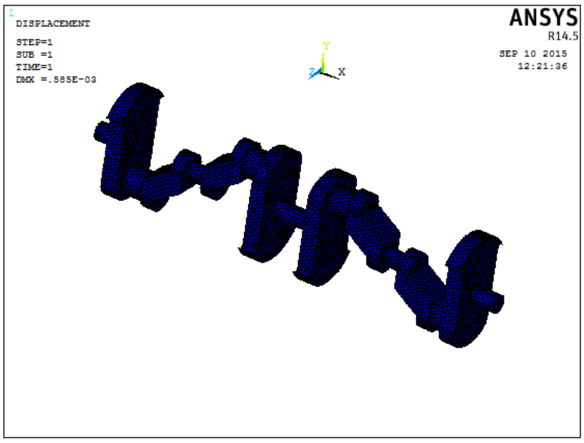


Thermal analysis crank shaft using the material aluminum alloy 5052-o

NODAL TEMPERATURE

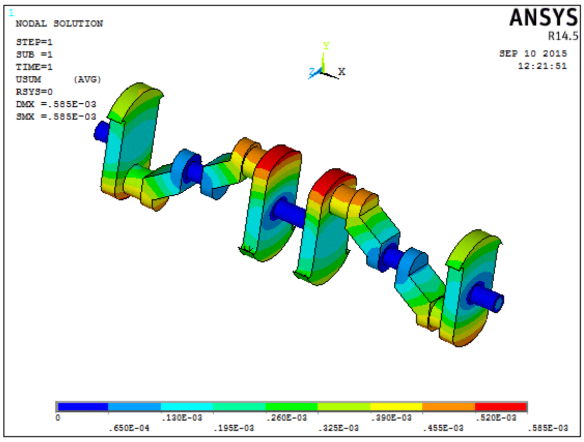


DEFORMATION

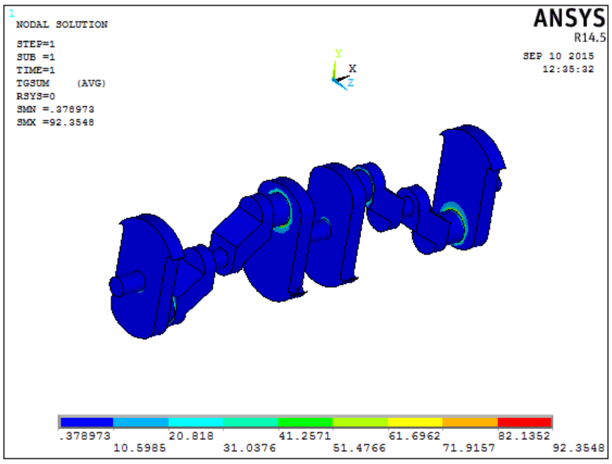


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

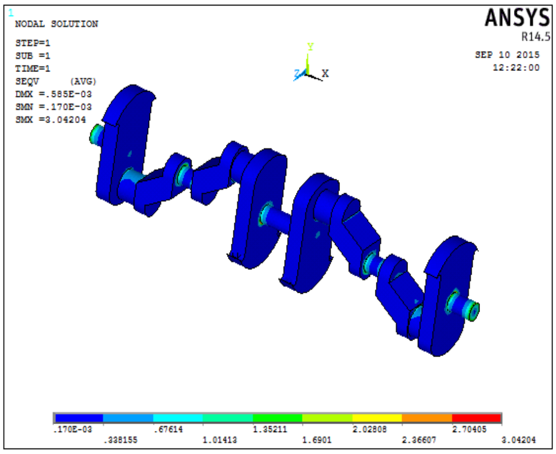
DISPLACEMENT VECTOR SUM



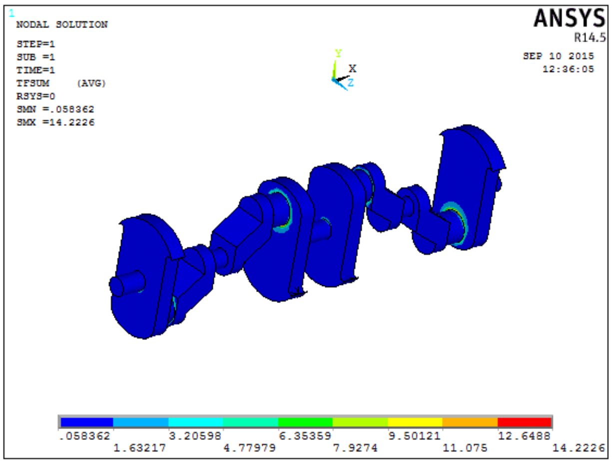
THERMAL GRADIENT



MISES STRESS (THERMAL STRESSES)

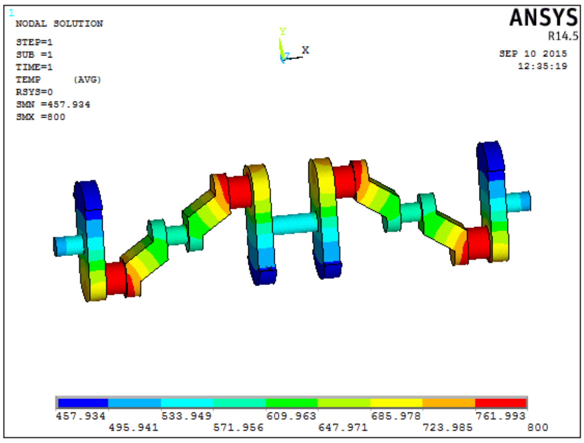


THERMAL FLUX

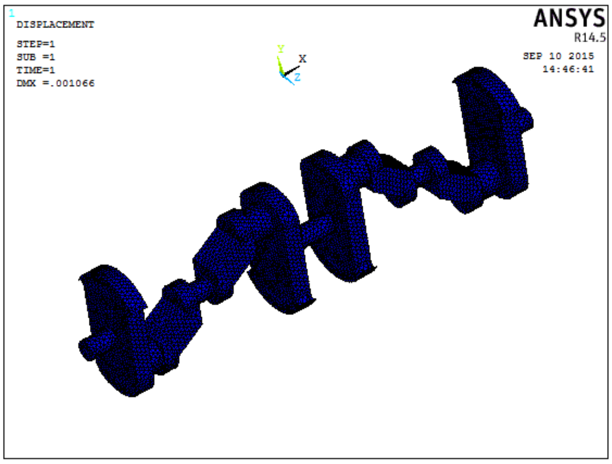


Thermal analysis crank shaft using the material aluminum alloy 2014- t6

NODAL TEMPERATURE

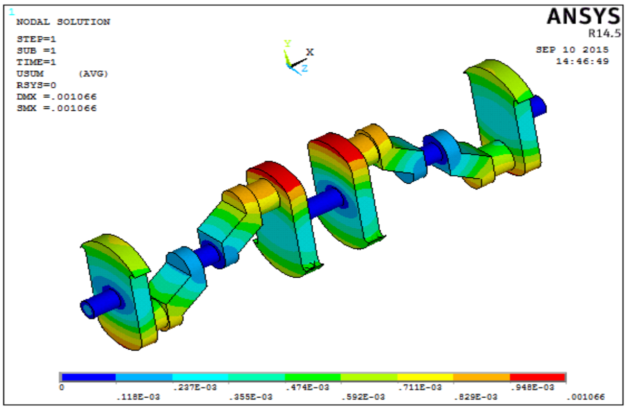


DEFORMATION

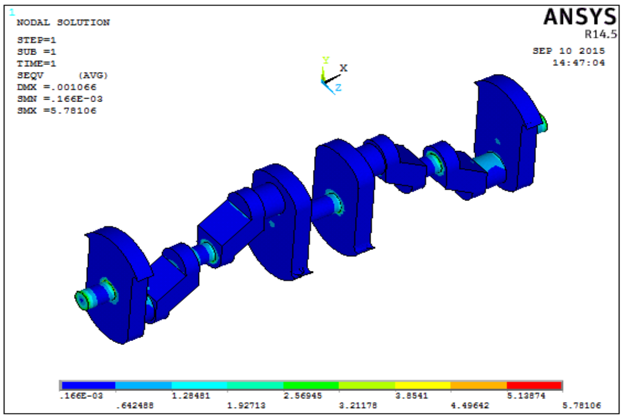


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

DISPLACEMENT VECTOR SUM



MISES STRESS (THERMAL STRESSES)



RESULTS TABLES FOR PISTON

		STEEL	ALUMINUM 5052-O	ALUMINUM 2014-T6
TEMPERATURE		442.422	584.864	599.659
THERMAL GRADIENT	MINIMUM	0.205707	0.170862	0.167446
	MAXIMUM	47.5561	24.1999	22.1984
THERMAL FLUX	MINIMUM	0.010491	0.023579	0.025787
	MAXIMUM	2.42536	3.33959	3.41855
DISPLACEMENT		0.328E3	0.633E-3	0.595E-3
VON MISES STRESS (THERMAL STRESSES)	MINIMUM	0.00109	0.768E-3	0.745E-3
	MAXIMUM	6.69222	4.828262	4.68034

RESULTS TABLES FOR CONNECTING ROD

		STEEL	ALUMINUM 5052-O	ALUMINUM 2014-T6
TEMPERATURE		298.946	310.486	313.565
THERMAL GRADIENT	MINIMUM	0.00662	0.32539	0.36327
	MAXIMUM	41.144	28.1682	26.9229
THERMAL FLUX	MINIMUM	0.344E-3	0.00449	0.005594
	MAXIMUM	2.13537	3.88721	4.14613
DISPLACEMENT		0.561E-3	0.618E-3	0.001131
VON MISES STRESS (THERMAL STRESSES)	MINIMUM	0.507E-3	0.112E-3	0.222E-3
	MAXIMUM	1.62696	0.625976	1.18172

RESULTS TABLES FOR CRANK SHAFT

		STEEL	ALUMINUM 5052-O	ALUMINUM 2014-T6
TEMPERATURE		339.663	442.658	457.934
THERMAL GRADIENT	MINIMUM	0.356694	0.396033	0.378973
	MAXIMUM	153.844	98.1418	92.3548
THERMAL FLUX	MINIMUM	0.018512	0.054653	0.58362
	MAXIMUM	7.98452	13.5436	14.2226
DISPLACEMENT		0.572E-3	0.585E-3	0.001066
VON MISES STRESS (THERMAL STRESSES)	MINIMUM	0.001139	0.17E-3	0.166E-3
	MAXIMUM	6.98063	3.04204	5.78106

CONCLUSION

The thermal analysis of piston, connecting rod, crank shaft of an inline four engine is performed for 800k thermal loading and therefore the results of temperature distribution of the elements are shown.

From the results of thermal analysis carried out on piston, we can conclude that the material Aluminum 2014-T6 has less Thermal gradient, flux and stress compared to other materials. It is considered best material.

From the results of thermal analysis carried out on connecting rod; we can conclude that the material Aluminum 5052-O has less displacement and stress values stress compared to other materials. It is considered best material.

From the results of thermal analysis carried out on crank shaft, we can conclude that the material Aluminum 5052-O has less displacement, Thermal gradient, and flux and stress values stress compared to other materials. It is considered best material.

REFRENCES

1. The 4-Cylinder Engine Short Block High-Performance Manual: Updated and Revised New Des Hammill, Veloce Publishing Ltd, 01-Jan-2012
2. Automotive Engines, S Srinivasan, Tata McGraw-Hill Education
3. Classroom Manual for Automotive Engine Performance, Douglas Vidler, Cengage Learning, 2003
4. Modeling and analysis of an HCCI engine during thermal transients using a thermodynamic cycle simulation with a coupled wall thermal network, Kyoungjoon Chang, University of Michigan, 2007
5. Thermomechanical Fatigue Behavior of Materials: Fourth volume, Issue 1428, Michael A. McGaw, ASTM International, 01-Jan-2003

Author Details

Sahukari Mohan Chowdary
M.Tech Student
Department of Mechanical Engineering
KITS, Divilli,
East Godavari (Dist.)
Andhra Pradesh.

Mr.V.V.Rama Krishna
Assistant Professor
Department of Mechanical Engineering
KITS, Divilli,
East Godavari (Dist.)
Andhra Pradesh.

K.Mohan Krishna
Assistant Professor
Department of Mechanical Engineering
KITS, Divilli,
East Godavari (Dist.)
Andhra Pradesh.