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Thermal Analysis of a in Line 4-Cylinder Engine

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ABSTRACT:

The inline-four cylinder engine or straight four engine is an inside combustion engine with all four cylinders mounted in an exceedingly 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 piston, crankshaft and connecting rod USING CAD tool PRO/ENGINEER. This Engine assembly consists major elements they're Piston, rod Assembly, Crank Shaft, plate, Cam Shaft, Valves, crank case, oil tank and electrical device.

The elements that area unit developed in PRO/ENGINEER are analyzed in ANSYS simulation tool. The thermal analysis of piston, connecting rod and crank shaft is performed for 500, 450, 380°c 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
Inline Four Engine

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 complexdesigns with more than four cylinders.

Today almost all manufacturers of four-cylinder engines for automobiles produce the inline-four layout, with Subaru's flat-four engine being a notable exception, and so four-cylinder is synonymous with and a more widely used term than inline-four. The inline-four is the most common engine configuration in modern cars, while the V6 engine isthe second most popular. In the late 2000s, with automanufacturers making efforts to reduce emissions and increase fuel efficiency due to the high price of oil and the economic recession, the proportion of new vehicles sold in the U.S. with four-cylinder engines (largely of the inline-four type) rose from 30 percent to 47 percent between 2005 and 2008, particularly in mid-size vehicles where a decreasing number of buyers have chosen the V6 performance option.

Inline four engine piston arrangement

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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 istypically cast from aluminum or cast iron before receiving precisionwork. 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"machine

Cylinder block

A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.

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

Piston head

During the earliest stage of an engine's life, its initial breaking-in or running-in period, small irregularities in the metals are encouraged to gradually form congruent grooves by avoiding extreme operating conditions. Later in its life, after mechanical wear has increased the spacing between the piston and the cylinder (with a consequent decrease in power output) the cylinders may be machined to a slightly larger diameter to receive new sleeves (where applicable) and piston rings, a process sometimes known as reboring.

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.

Connecting rod

As a connecting rod is rigid, it may transmit either a push or a pull and so the rod may rotate the crank through both halves of a revolution, i.e. piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two-stroke engines, the connecting rod is only required to push. Today, connecting rods are best known through their use in internal combustion piston engines, such as automotive engines. These are of a distinctly different design from earlier forms of connecting rods, used in steam engines and steam locomotives.

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

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rotational motion; whereas in a reciprocating compressor, it converts the rotational motion intoreciprocating 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.

Crankshaft

It is typically connected to a flywheel to reduce the pulsation characteristic of the four-stroke cycle, and sometimes a torsional or vibrational damper at the opposite end, to reduce the torsional vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsional elasticity of the metal.

Material Data

STAINLESS STEEL

Thermal Conductivity	34.3 W m^-1 C^-1
Density	9010 kg m^-3

Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
	3.17e+011	0.34	3.3021e+011	1.1828e+011

AL5052-H34

Thermal Conductivity	138 W m^-1 C^-1
Density	2680 kg m^-3

Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
	7.03e+010	0.33	6.8922e+010	2.6429e+010

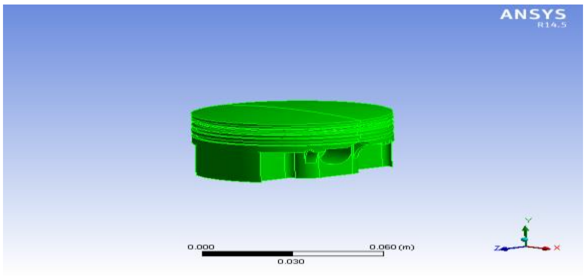
AL7075-O

Thermal Conductivity	173 W m^-1 C^-1
Density	2810 kg m^-3

THERMAL ANALYSIS PISTON USING THE MATERIAL STAINLESS STEEL

Model (A4)

Geometry



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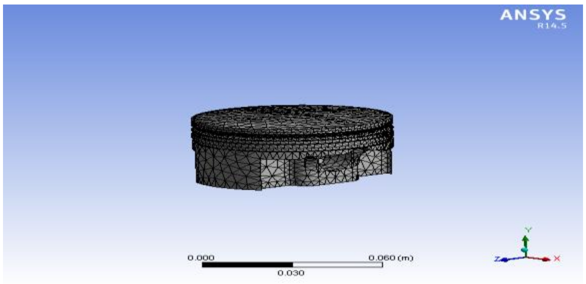

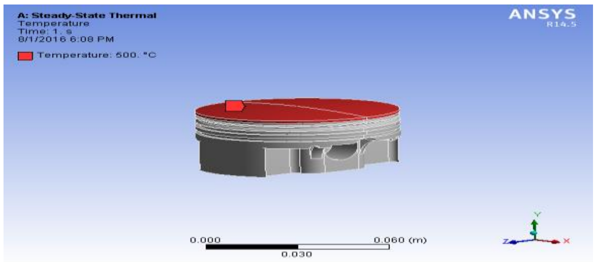

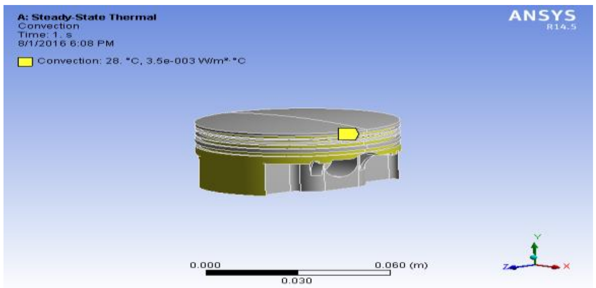

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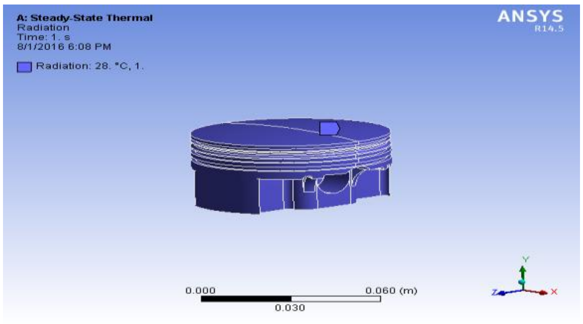

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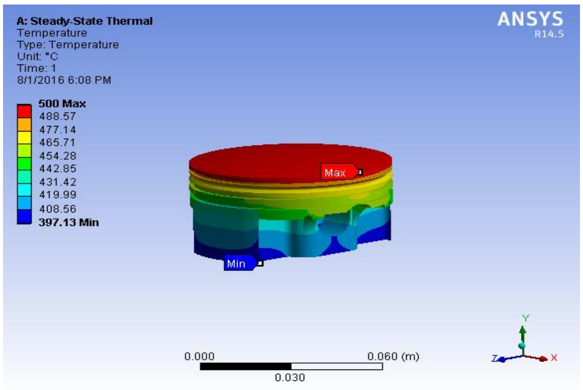

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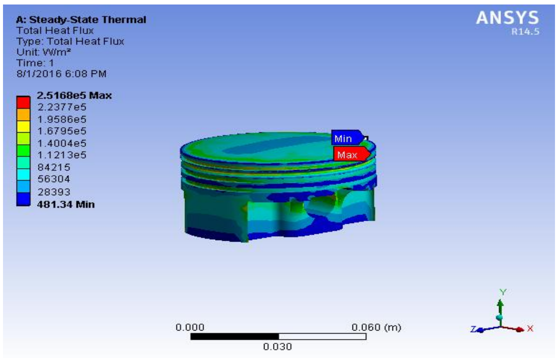

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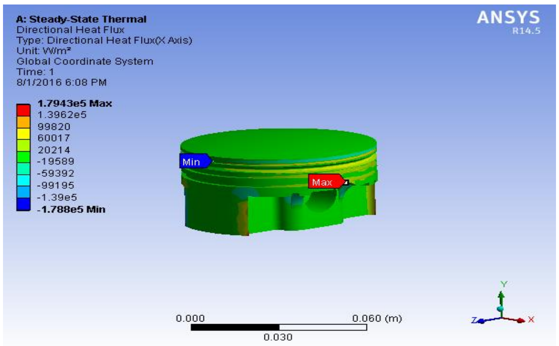

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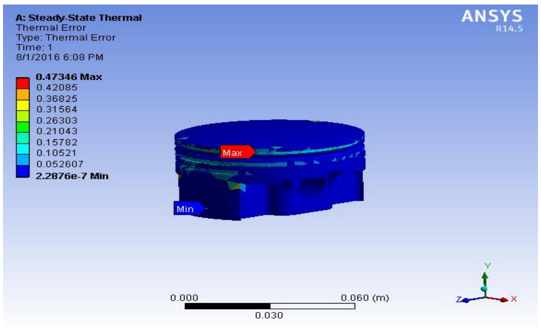
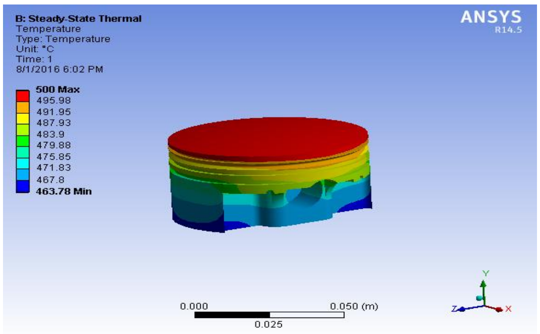


THERMAL ANALYSIS PISTON USING THE MATERIAL AL 5052

TEMPERATURE



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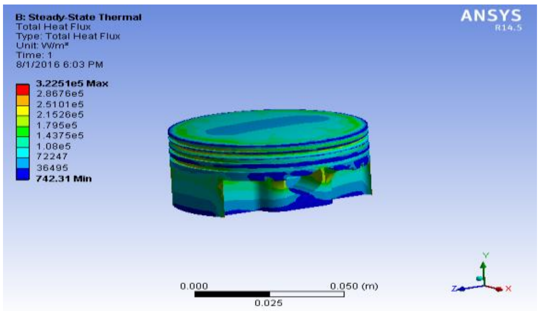

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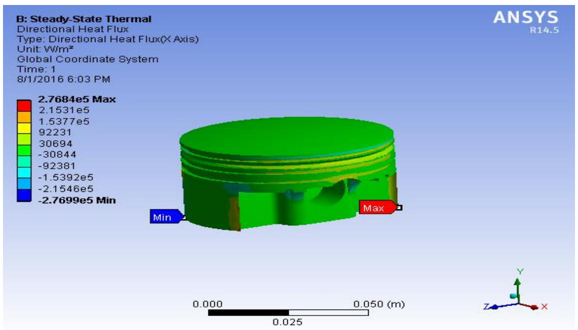

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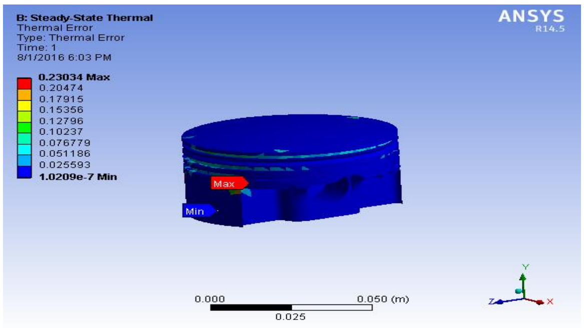
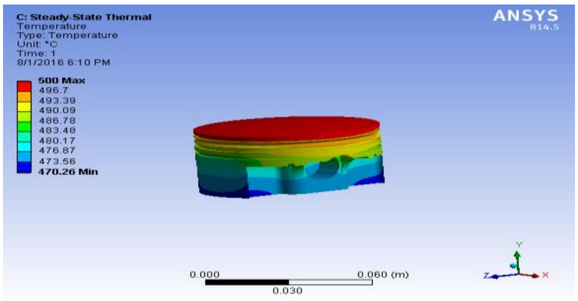


THERMAL ANALYSIS PISTON USING THE MATERIAL AL 7075

TEMPERATURE



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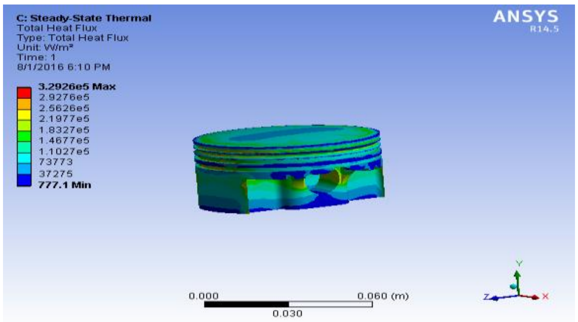

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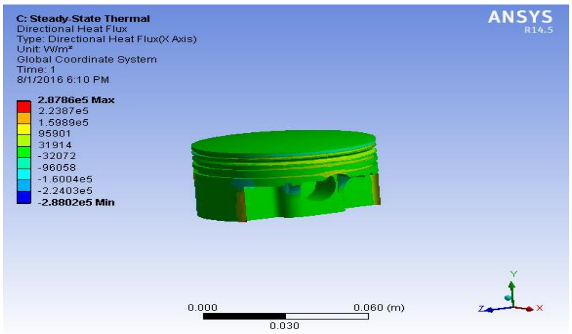

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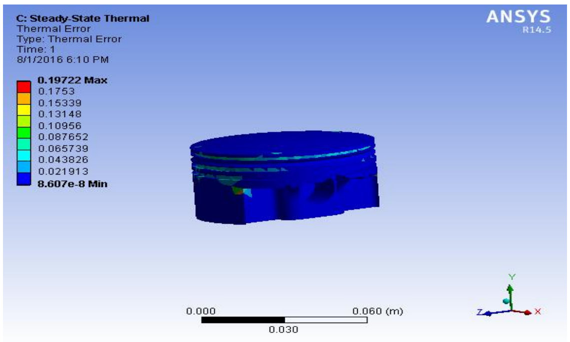
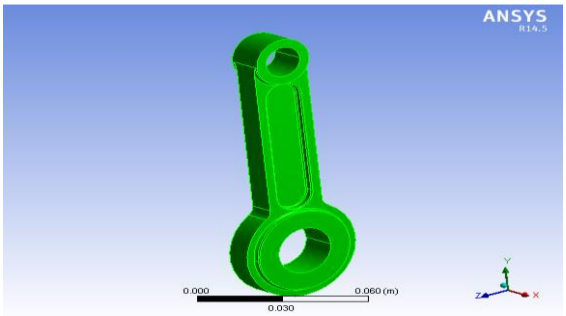


THERMAL ANALYSIS CONNECTING ROD USING THE MATERIAL STAINLESS STEEL

Model (A4)

Geometry



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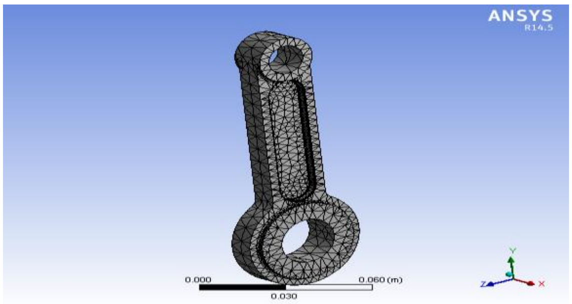

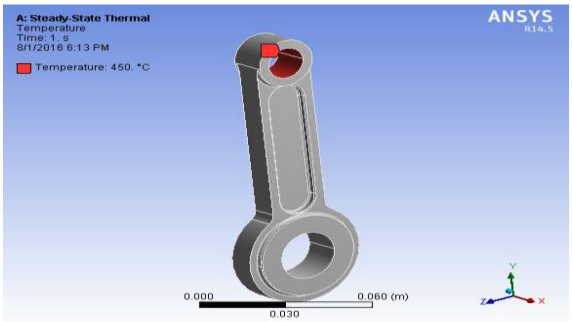

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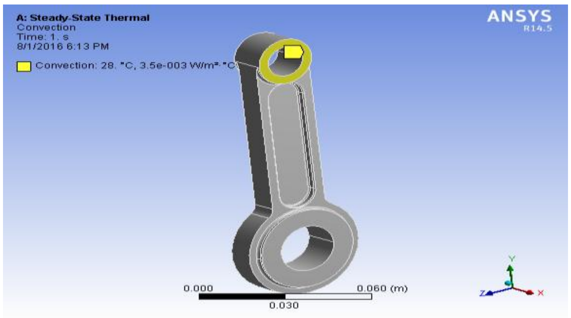

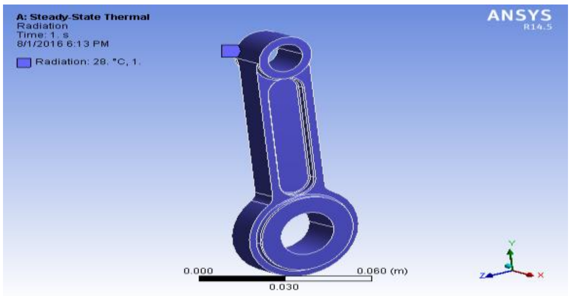

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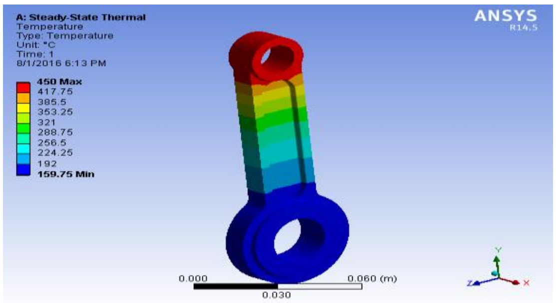

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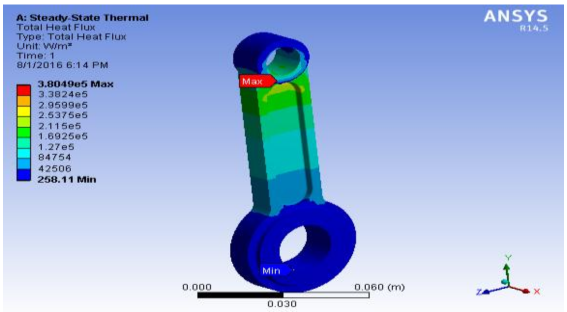

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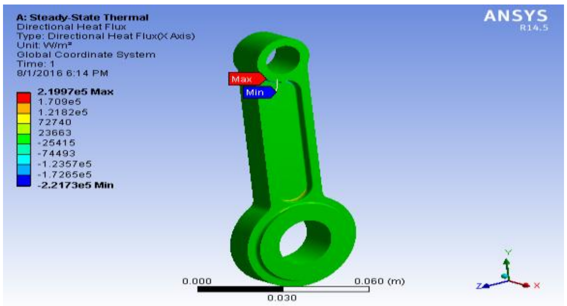

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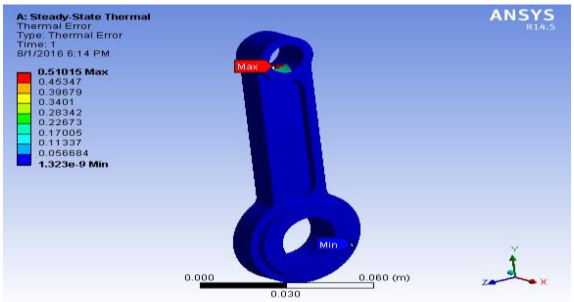
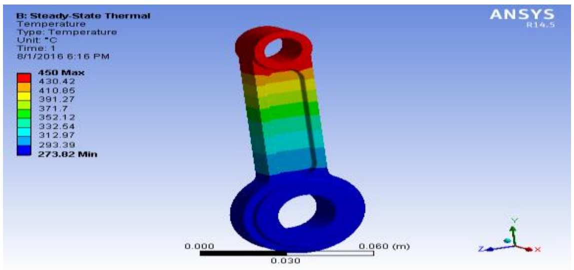


THERMAL ANALYSIS CONNECTING ROD USING THE MATERIAL AL 5052

TEMPERATURE



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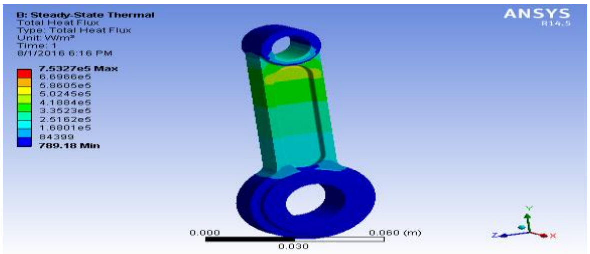

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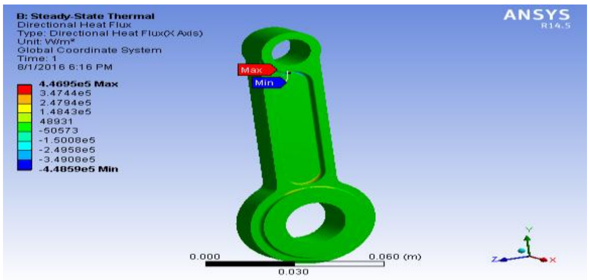

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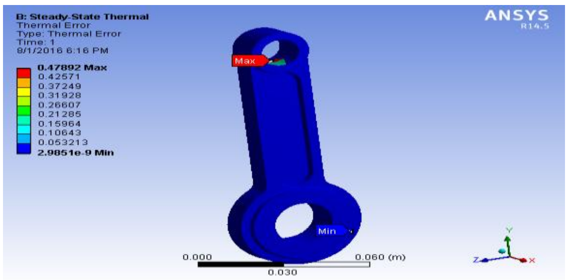

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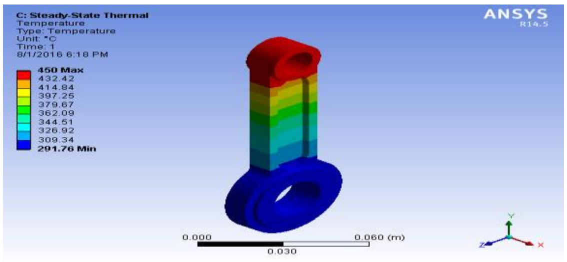
THERMAL ANALYSIS CONNECTING ROD USING THE MATERIAL AL 7075

TEMPERATURE



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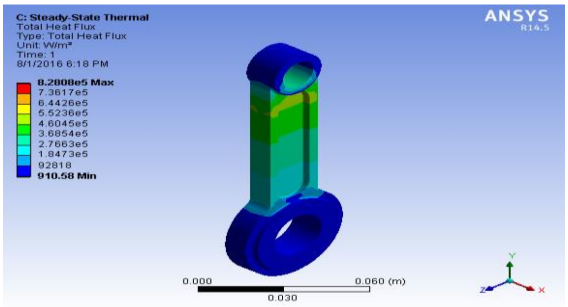

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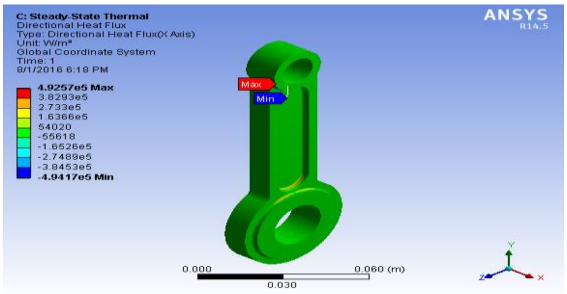

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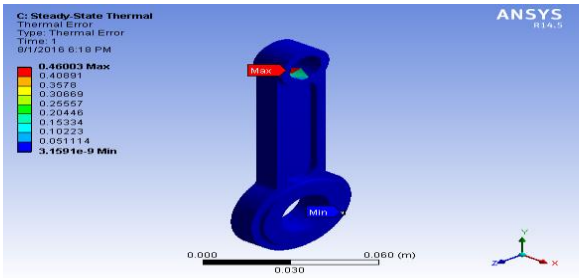
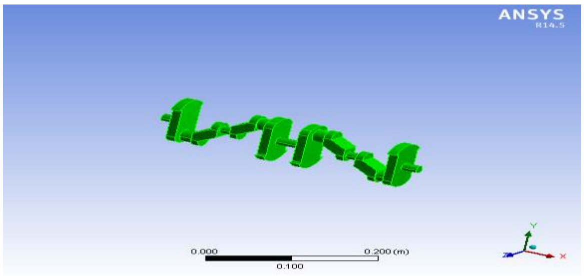


THERMAL ANALYSIS CRANKSHAFT USING THE MATERIAL STAINLESS STEEL

Model (A4)

Geometry



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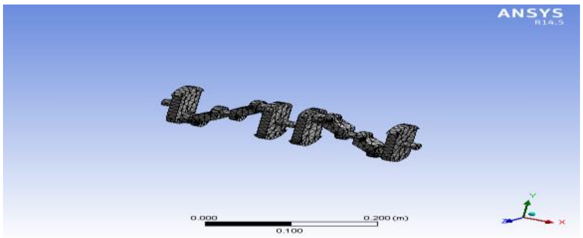
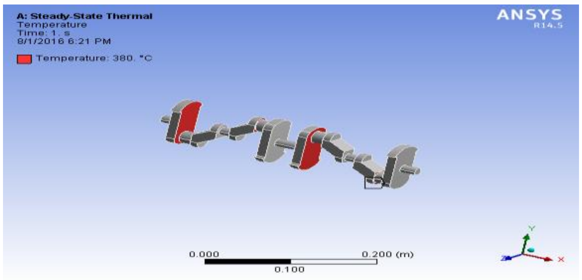
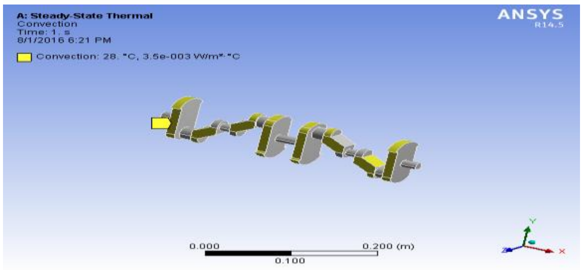
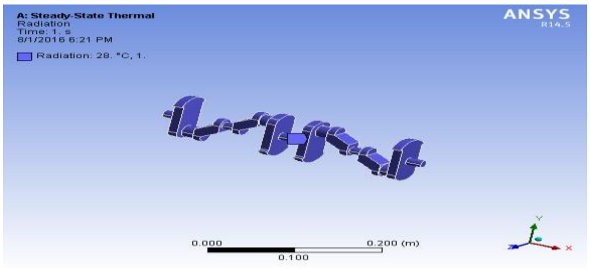
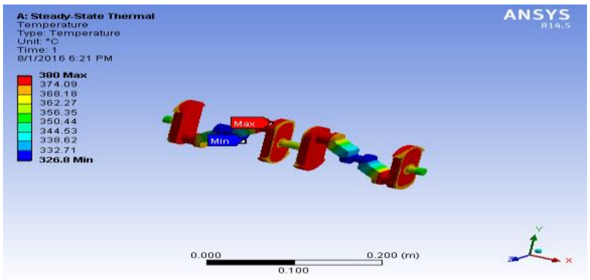








TEMPERATURE



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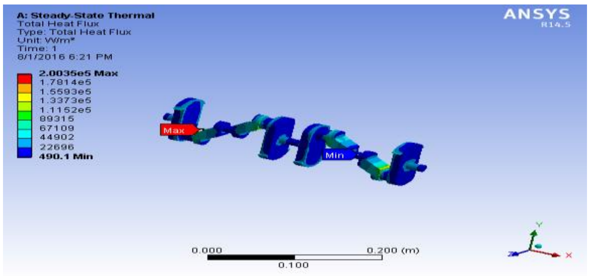

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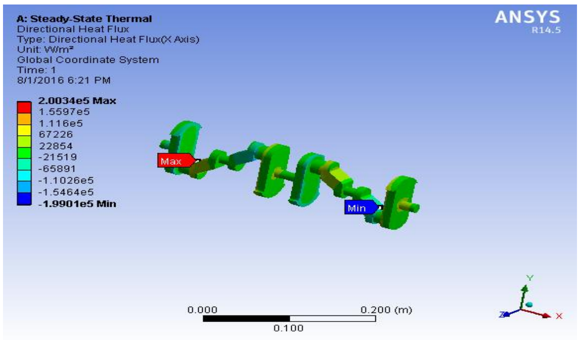

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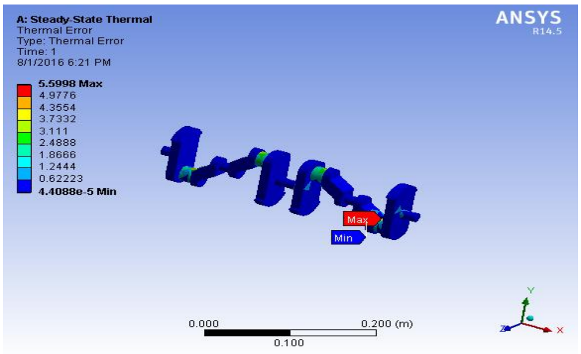
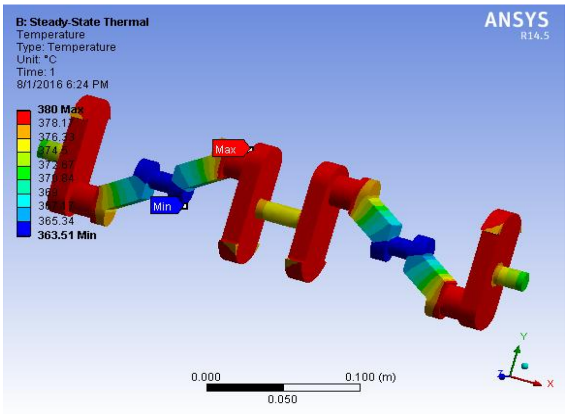


THERMAL ANALYSIS CRANKSHAFT USING THE MATERIAL AL 5052 TEMPERATURE



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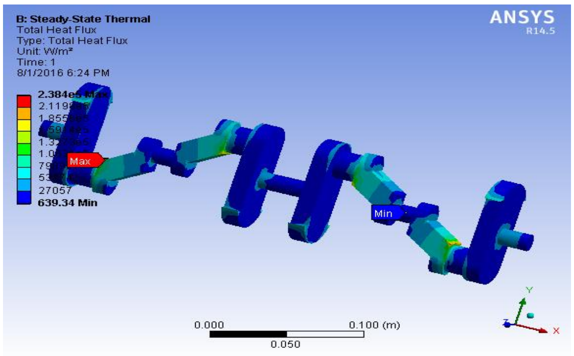

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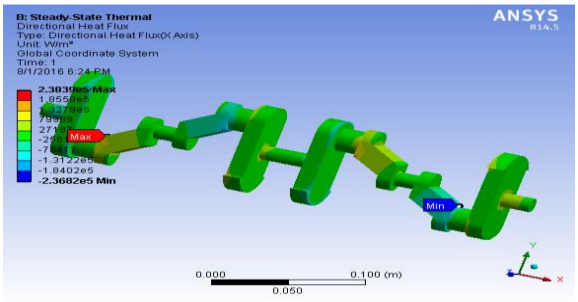

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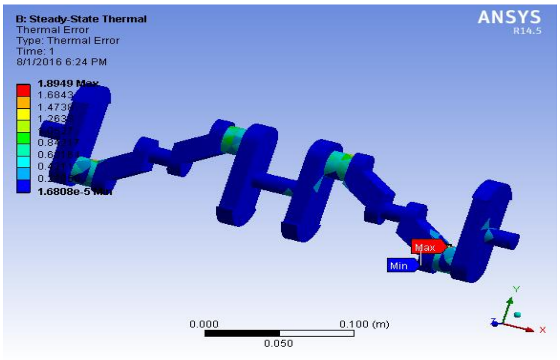
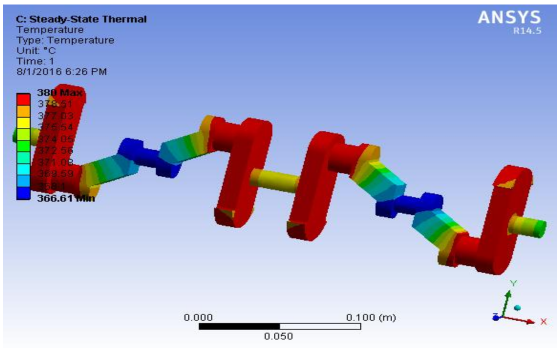


THERMAL ANALYSIS CRANKSHAFT USING THE MATERIAL AL 7075 TEMPERATURE



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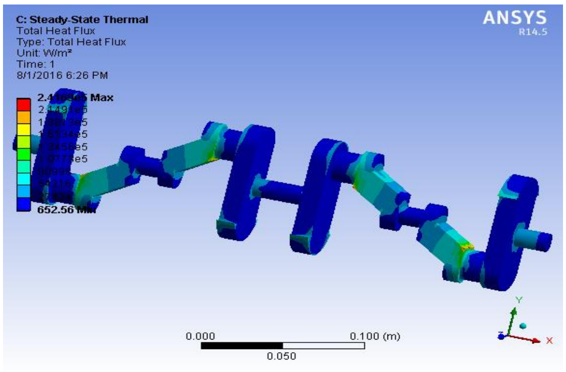

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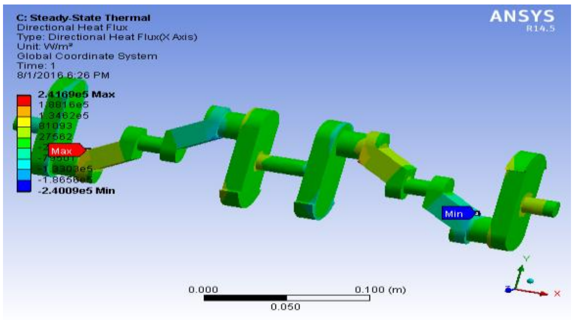

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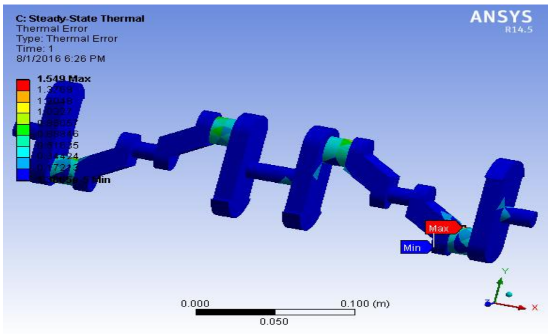

TABLES

Piston

Materials	temperature		Total heat flux		Directional heat flux		Thermal error	
	Min	max	Min	max	Min	max	Min	max
Stainless steel	397.13	500	481.34	$2.5168E^{5}$	$-1.788E^{5}$	$1.7943E^{5}$	$2.2876E^{-7}$	0.47346
Al 5052	463.78	500	742.31	$3.2251E^{5}$	$-2.7699E^{5}$	$2.7684E^{5}$	$1.0209E^{-7}$	0.23034
Al 7075	470.26	500	777.1	$3.2926E^{5}$	$-2.8802E^{5}$	$2.8786E^{5}$	$8.607E^{-8}$	0.19722

Connecting rod

Materials	temperature		Total heat flux		Directional heat flux		Thermal error	
	Min	max	Min	max	Min	max	Min	max
Stainless steel	159.75	450	258.11	$3.8049E^{5}$	$-2.2173E^{5}$	$2.1997E^{5}$	$1.323E^{-9}$	0.51015
Al 5052	273.82	450	789.18	$7.5327E^{5}$	$-4.4859E^{5}$	$4.4695E^{5}$	$2.9851E^{-9}$	0.47892
Al 7075	291.76	450	910.58	$8.2808E^{5}$	$-4.9417E^{5}$	$4.9257E^{5}$	$3.1591E^{-9}$	0.46003

Crank shaft

Materials	temperature		Total heat flux		Directional heat flux		Thermal error	
	Min	max	Min	max	Min	max	Min	max
Stainless steel	326.8	380	490.1	$2.0035E^{5}$	$-1.9901E^{5}$	$2.0034E^{5}$	$4.4088E^{-5}$	5.5998
Al 5052	363.51	380	639.34	$2.384E^{5}$	$-2.3682E^{5}$	$2.3839E^{5}$	$1.6808E^{-5}$	1.8949
Al 7075	366.61	380	652.56	$2.4169E^{5}$	$-2.4009E^{5}$	$2.4169E^{5}$	$1.3865E^{-5}$	1.549

CONCLUSION

The thermal analysis of piston, connecting rod, temperature distribution of the elements are shown.

From the results of thermal analysis carried out on piston, we can conclude that the material Aluminum 7075 has less Thermal flux and error 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 stainless steel has less Thermal flux and error 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 stainless steel has less Thermal flux and error compared to other materials. It is considered best material

Crank shaft of an inline four engine is performed for 500, 450, 380^{O}C thermal loading and therefore the results of

FUTURE SCOPE

The study on this project can be further extended by considering different materials for the components of engine. Also, other components like – cylinder block, cam shaft, crank pin, inlet and exhaust valves can be brought under study for thermo-mechanical behavior.

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