International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

DESIGN AND OPTIMISATION ANALYSIS OF V6 ENGINE PISTON BY USING CERAMIC COATINGS

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ABSTRACT

A V6 engine is a V engine with six cylinders mounted on the crankshaft in two banks of three cylinders, usually set at either a 60 or 90 degree angle to each other. The V6 is one of the most compact engine configurations, usually ranging from 2.0 L to 4.3 L displacement (however, much larger examples have been produced for use in trucks), shorter than the inline 4 and more compact than the V8 engine. Because of its short length, the V6 fits well in the widely used transverse engine front-wheel drive layout.

The V6 is commercially successful in mid-size cars in the modern age because it is less expensive to build and is smoother in large sizes than the inline 4, which develops increasingly serious vibration problems in larger engines

In this project complete v6 engine is going to be designed by using cad tool (solid-works) and analyzes with cae tool (Ansys workbench), in this process we can say what is the maximum load bearing capacity of each object like pistons, connecting rod,

To increase the engine efficiency here we adding a ceramic coating on the piston top head with 0.15mm thickness, finally comparing results with existing piston with ceramic piston and also discussing how this ceramic going to increase the efficiency of the piston

Piston materials: al-2218, al6065

Ceramics were used: i) zirconium, ii) silicon di oxide

1. Introduction

V6 engine

A V6 engine is a six-cylinder piston engine where the cylinders share a common crankshaft and are arranged in a V configuration.

The first V6 engines were designed and produced independently by Marmon Motor Car Company, Deutz Gasmotoren Fabrik and Delahaye. Engines built after World War II include the Lancia V6 engine in 1950 for the Lancia Aurelia, and the Buick V6 engine in 1962 for the Buick Special. The V6 layout has become the most common layout for six-cylinder automotive engines.

Due to their short length, V6 engines are often used as the larger engine option for vehicles which are otherwise produced with inline-four engines, especially in transverse engine vehicles. A downside for luxury cars is that V6 engines produce more vibrations

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than straight-six engines. Some sports cars use flat-six engines instead of V6 engines, due to their lower centre of gravity (which improves the handling).

Fig: V6 engine

The displacement of modern V6 engines is typically between 2.5 to 3.5 L (153 to 214 cu in), though larger and smaller examples have been produced, such as the 1.8 L (110 cu in) Mazda V6 engine used in the 1991-1998 Mazda MX3, while the largest V6 built was the 7.8 L (476 cu in) GMC V6 used in the 1962 GMC C/K series 6500.

V6 engine main parts discussion

Piston

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors, hydraulic and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings, in an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder

Crank shaft

A crankshaft is a rotating shaft which (in conjunction with the connecting rods) converts reciprocating motion of the pistons into rotational motion. Crankshafts are commonly used in internal combustion engines and consist of a series of cranks and crankpins to which the connecting rods are attached. The crankshaft rotates within the engine block through use of main bearings, and the crankpins rotate within the connecting rods using rod bearings. Crankshafts are usually made from metal, with most modern crankshafts being constructed using forged steel

Connecting rod

A connecting rod, also called a con rod, is the part of a piston engine which connects the piston to the crankshaft. Together with the crank, the connecting rod converts the reciprocating motion of the piston into the rotation of the crankshaft. The connecting rod is required to transmit the compressive and tensile forces from the piston, and rotate at both ends. The predecessor to the connecting rod is a mechanic linkage used by water mills to convert rotating motion of the water wheel into reciprocating motion.

Literature review

The study of the various authors found out that the stress is nothing but force per unit area the stress develop on the mechanical parts of the engine need to be considered for the safe working of the piston it is possible to find out the various stresses acting on the mechanical parts by analytical and experimentation method

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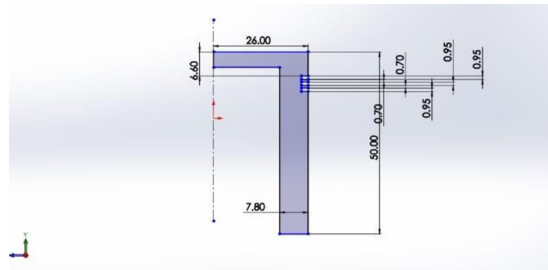
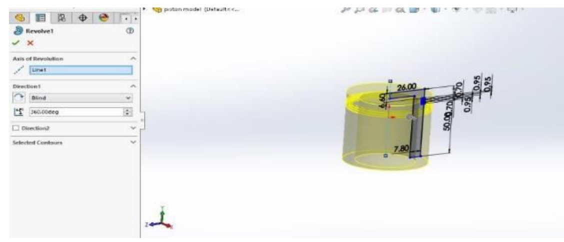
The paper presented by K.Jagdeesh [1] helped to study the various parameters of the piston mainly dealing with the finite element analysis of the vibrating piston who studied the effect of the water waves on the vibrating piston. The acoustic pressure values along the axis of the piston as a junction of distance from the piston and frequency are evaluated. The radiation impedance of the vibrating piston is also evaluated. The results of FE analysis are compared with the theoretical values. Finally he concluded that finite element analysis can be successfully used for simulation of the vibrating piston in the water. Which helped in the design of the solar projection which were important in the naval application also calculations helped to find out useful parameters such as axial pressure, far field pressure, radiation impedance.

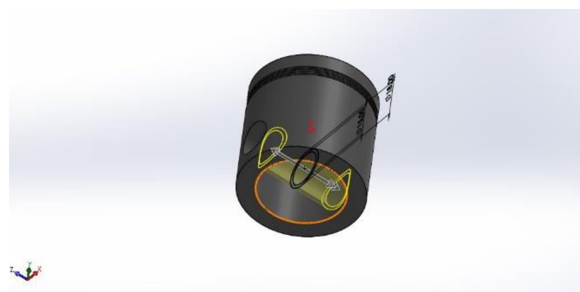
Aim of the project

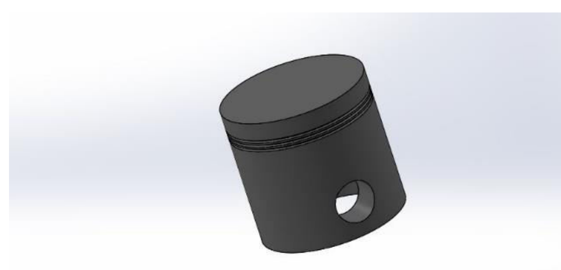
The main aim of the thesis is to suggest optimum piston material for a v6 engine, here designing processed in solid works and analysis processed in Ansys workbench in this process both static and thermal boundary conditions were applied on piston, and here piston materials were considered as al-2218 and a-6065, here with the help of static analysis results calculating maximum pressure bearing capacity values for both piston, and with the help of thermal analysis module calculating total temperature distribution and heat transfer rate values, in order to increase the performance of the piston ceramic layers were applying on both piston and calculating their static and thermal behavior, finally thesis concluded with what changes made when piston were used with and without ceramic layers, and their advantages,

Designing process step by step

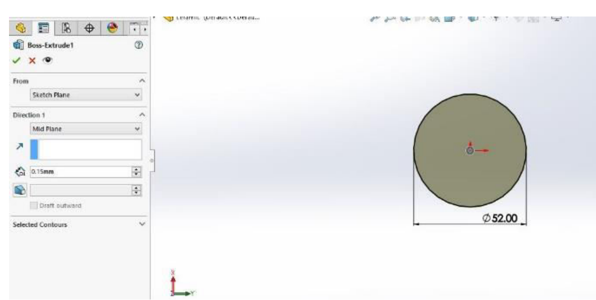








Normal piston



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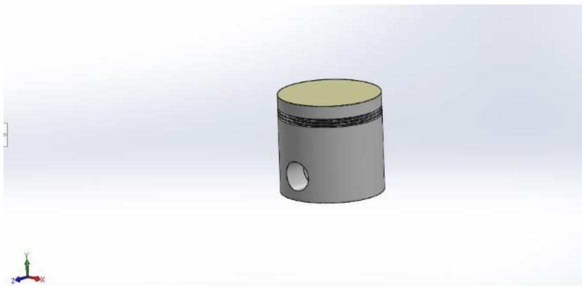
Ceramic layer



Ceramic piston assembly

Material selection

Al-2218

2218 aluminum alloy is an alloy in the wrought aluminum-copper family (2000 or 2xxx series). It is one of the most complex grades in the 2000 series, with at least 88.4% aluminum by weight. Unlike most other aluminum-copper alloys, 2218 is a high work-ability alloy, with relatively low for 2xxx series alloy yield strength of 255 MPa. Despite being highly alloyed, it have a good corrosion and oxidation resistance due sacrificial anode formed by magnesium inclusions, similar to marine-grade 5xxx series alloys. Although 2218 is wrought alloy, owing to granular structure it can be used in casting and been precisely machined after casting. It is easy to weld, coat, or glue.

Good workability, thermal conductivity and dimensional stability make 2218 alloy a material of choice whenever high-precision parts subject to thermal shocks (especially piston engine cylinders and cylinder heads) are needed.

2218 alloy can be heat treated to increase tensile strength in expense of workability, with most common grades been F, T61, T71 and T72.

Alternative names for 2218 alloy are A2218 and A92218.

Chemical Composition

The chemical composition of 2218 alloy is poorly standardized, with several variants in production. All variants include both copper (4%) and magnesium (1.5%) as major alloying elements. Common alloy variants also include 2% of nickel. The alloy composition of 2218 aluminum is:

- Aluminum: 91.35 to 92.95%
- Copper: 3.5 to 4.5%
- Magnesium: 1.2 to 1.8%
- Nickel: 1.7 to 2.3%
- Iron: 1% max
- Silicon: 0.9% max
- Zinc: 0.25% max
- Manganese: 0.5% max
- Tin: 0.25% max
- Chromium: 0.1% max

Al-6065

6065 aluminum is a 6000-series aluminum alloy: there is significant alloying with both magnesium and silicon, and the alloy is formulated for primary forming into wrought products. 6065 is the Aluminum Association (AA) designation for this material. In European standards, it will be given as EN AW-6065. AlMg1Bi1Si is the EN chemical designation. And A96065 is the UNS number.

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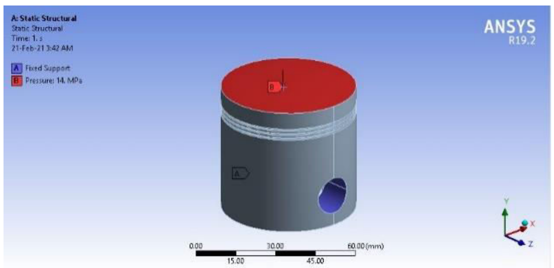
Ansys process

Boundary conditions

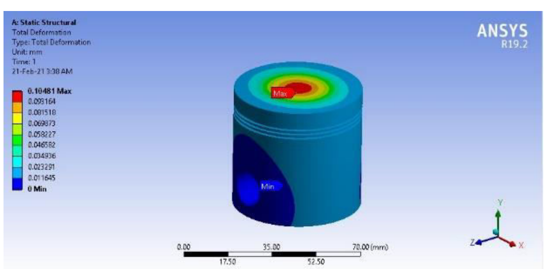


Select TDC of the piston and apply pressure value 14Mpa on it, and the chose fixed support and fix it

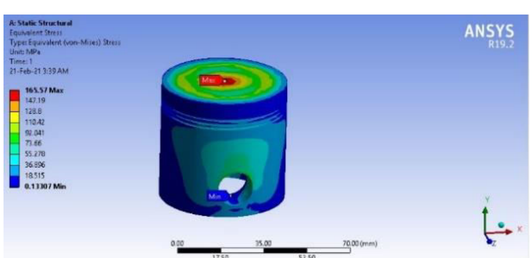
Static analysis process V6 engine piston

Al-2218

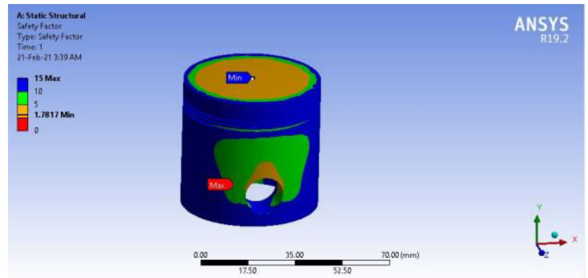
Deformation



Stress



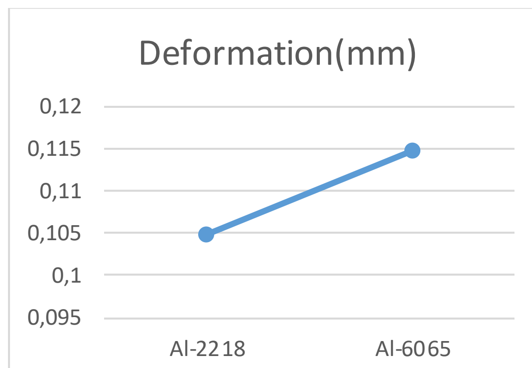
Safety factor

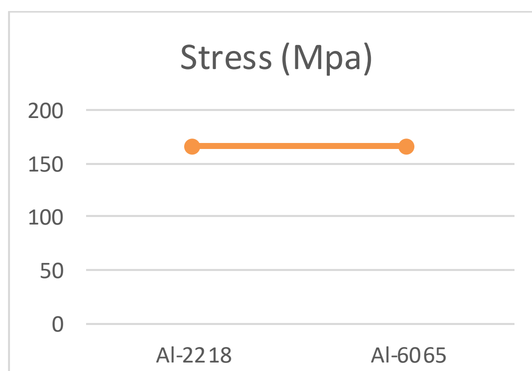


Tables

	Al-2218	Al-6065
Deformation(mm)	0.10481	0.11467
Stress (Mpa)	165.57	165.57
Strain	0.0023469	0.0025678
Safety factor	1.7817	2.1139

Graphs





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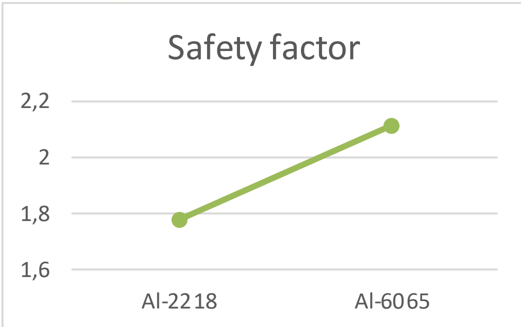
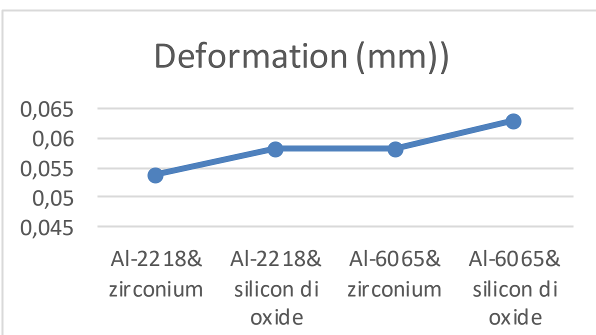


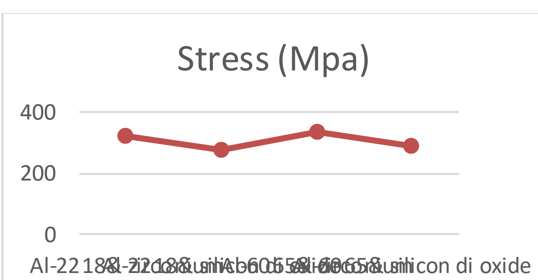
V6 engine piston with ceramic coating static analysis results

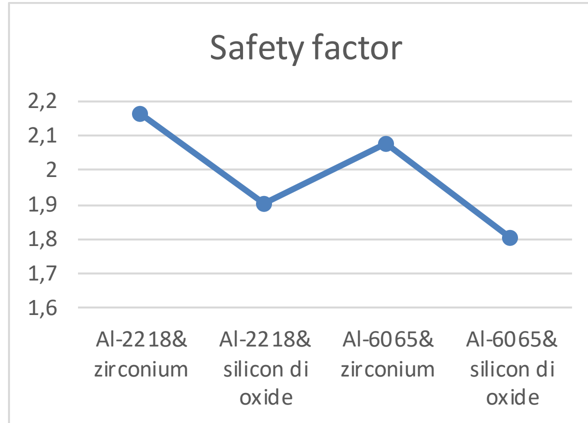
Tables

	Al-2218& zirconium	Al-2218& silicon di oxide	Al-6065& zirconium	Al-6065& silicon di oxide
Deformation (mm))	0.053983	0.058263	0.058227	0.062883
Stress (Mpa)	320.63	276.05	334.54	290.59
Strain	0.0014386	0.0015046	0.001561	0.0016332
Safety factor	2.1676	1.9018	2.0775	1.8067

Graphs





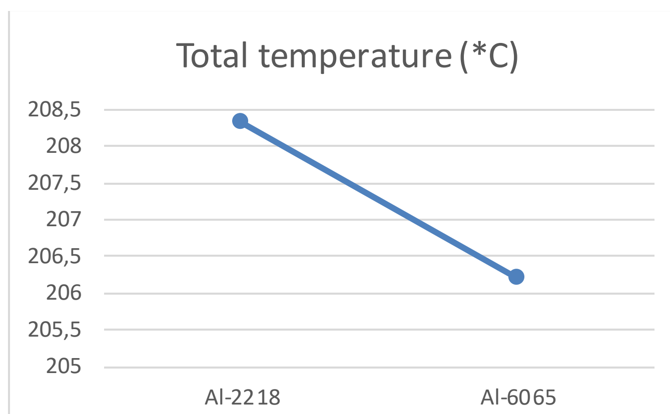


Thermal analysis

Tables

	Al-2218	Al-6065
Total temperature (*C)	208.33	206.2
Heat flux (w/mm^2)	0.28871	0.29149

Graphs



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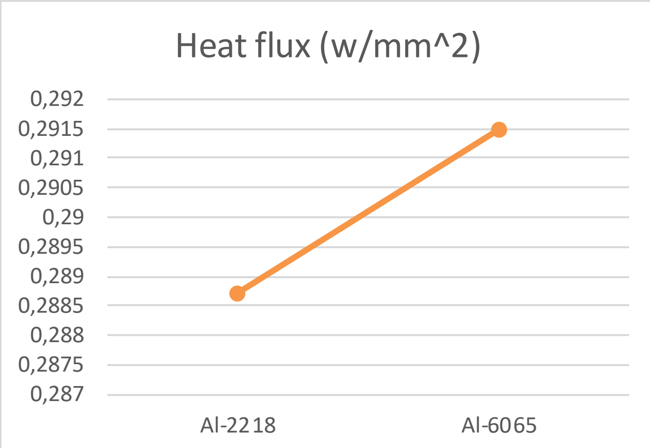
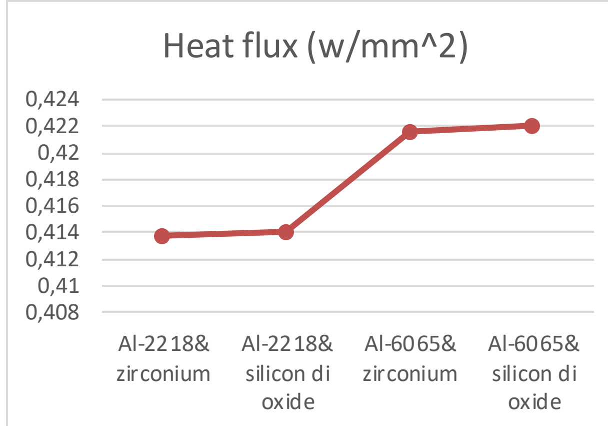


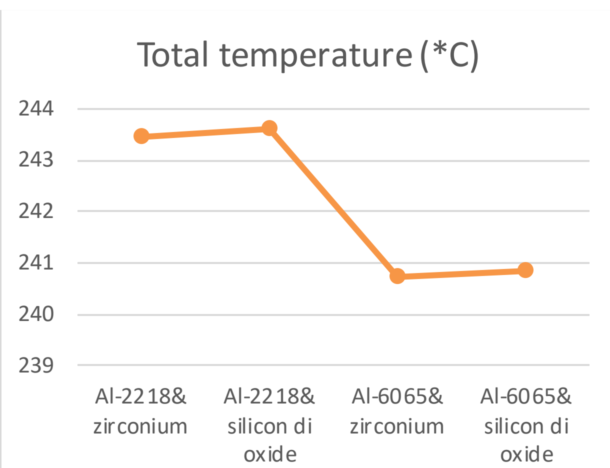


Ceramic layer piston thermal analysis results

Tables

	Al-2218& zirconium	Al-2218& silicon di oxide	Al-6065& zirconium	Al-6065& silicon di oxide
Total temperature (*C)	243.46	243.61	240.71	240.85
Heat flux (w/mm^2)	0.41372	0.4141	0.42165	0.42198

Graphs



Conclusion

In this thesis v6 engine piston were made with the help of solid works and then analyzing with the help of Ansys workbench , in this process both static and thermal boundary conditions were applied on piston, and here piston materials were considered as al-2218 and a-6065, from static analysis results it is clear that both materials can withstand maximum amount of pressure value 14Mpa on it, at this loading condition both pistons are having safety factor value above 1.5 so that this applied boundary condition is allowable load for designed model, among both materials al-6065 material is having better strength values than al-2218 material, from thermal analysis results it is observe that both material are having near to near total temperature distribution values and heat transfer rate values,

In order to increase the thermal efficiency of the piston here ceramic layers zirconium and silicon di oxide coatings were applied on both piston and calculate their static and thermal loading behavior on it, when ceramic layers were applied on TDC of the piston it is observe that the total amount of stress distribution values are increased compare to normal piston, but all these stress values below ceramic layers yield limit values, so that these excess amount of stress cant damage the piston, and when it comes to ceramic layers thermal analysis results al-6065 material with silicon di oxide is having better total temperature distribution with optimum heat transfer rate values compare to remain combinations, and this al-6065 piston is having better strength values in static conditions also, it means if al-6065 material were used in static condition the durability of the object will increases for normal piston, and when it applied with silicon di oxide coating on it the thermal efficiency values also increases,

Finally thesis concluded with al-6065 piston with silicon di oxide ceramic coatings were improve the performance of the piston in both static and thermal boundary conditions,

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