Design and Analysis of V8 Engine Cylinder Block & Piston using Different Materials

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Abstract: **Now a days all are using automobile vehicles, in that V8 engines have been regarded as the most power full engines in automotive industry because of its high horsepower and better performance. it is used in racing cars, airplanes and marine applications. The majority of v8 engines use a V-angle (the angle between two banks of cylinders) of 90^0, which makes in good balance and low vibrations. But heat losses are a major limiting factor for the efficiency of internal combustion engines. Furthermore, heat transfer phenomena cause thermally induced mechanical stresses compromising the reliability of engine components. In this project, V8 engine cylinder block & piston are modeled by using CATIA V5. This model is imported to ANSYS and done the steady state Thermal analysis for calculate thermal stress, temperature distribution, thermal conductivity by comparing with different materials by using ANSYS. From the result we optimize the best material for engine cylinder block and piston.**

Index Terms: cylinder block, piston, CATIA, ANSYS, thermal analysis, V8 engine.

I.INTRODUCTION

1.1 INTRODUCTION:

A heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work. Heat engines can be further divided into two types.

External combustion: In a steam engine the combustion of fuel takes place outside the engine and the steam thus formed is used to run the engine. Thus, it is known as external combustion engine.

Internal combustion: In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.

1.2 WORKING OF INTERNAL COMBUSTION ENGINE:

An internal combustion engine (ICE or IC engine) is a heat engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. This force moves the component over a distance, transforming chemical energy into kinetic energy which is used to propel, move, or power whatever the engine is attached to. This replaced the external combustion engine for applications where the weight or size of an engine was more important in figure 1.

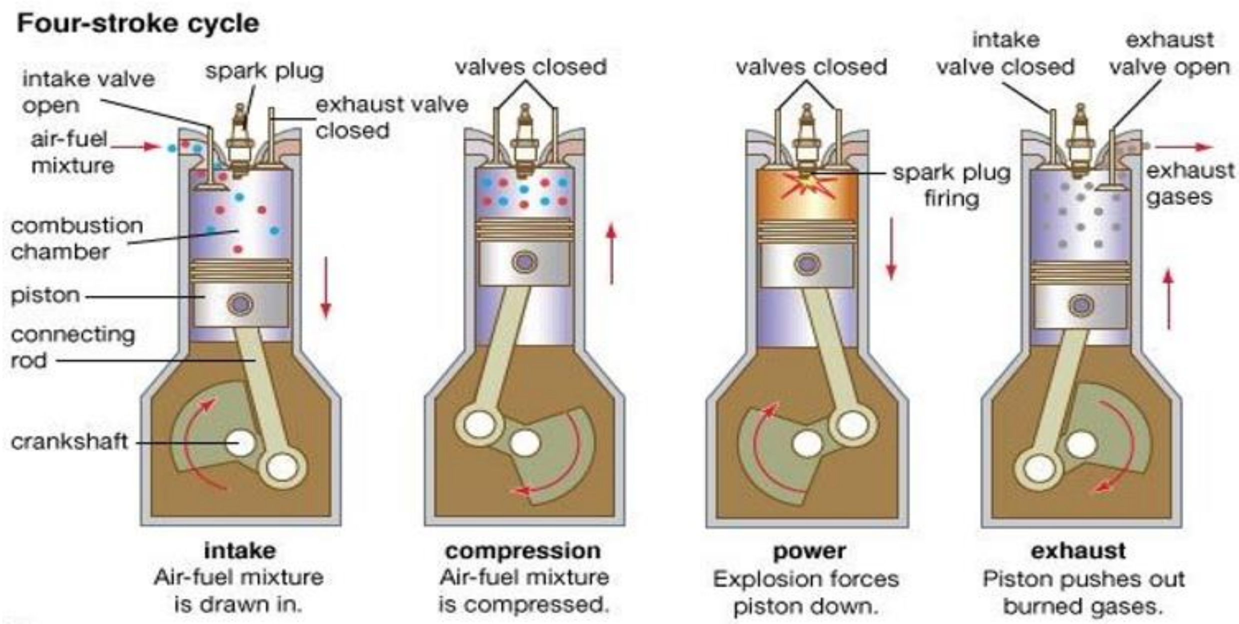

Fig.1: Internal combustion engine

1.3 V8 ENGINE:

A V8 engine is a V engine with eight barrels mounted on the crankcase in two banks of four chambers, much of the time set at a privilege plot to one another yet frequently at a narrower edge, with each of the eight cylinders driving a typical crankshaft. There are two major types of V8 engine engines, which differ by crank shaft. Flat plane the flat plane V8 is like two inline four chambers imparting a solitary crankshaft. At the point when seen from one end, the crankshaft seems to structure a level shape and the same sort of flat plane V8 engine Cross plane The other, significantly more regular sort is the cross plane V8 is demonstrated in Fig which Cadillac concocted in 1923. The principal and fourth wrench pins are 180° separated, and the inward two are 180° separated from one another, and 90° separated from the pins on each one as shown in the figure 2.

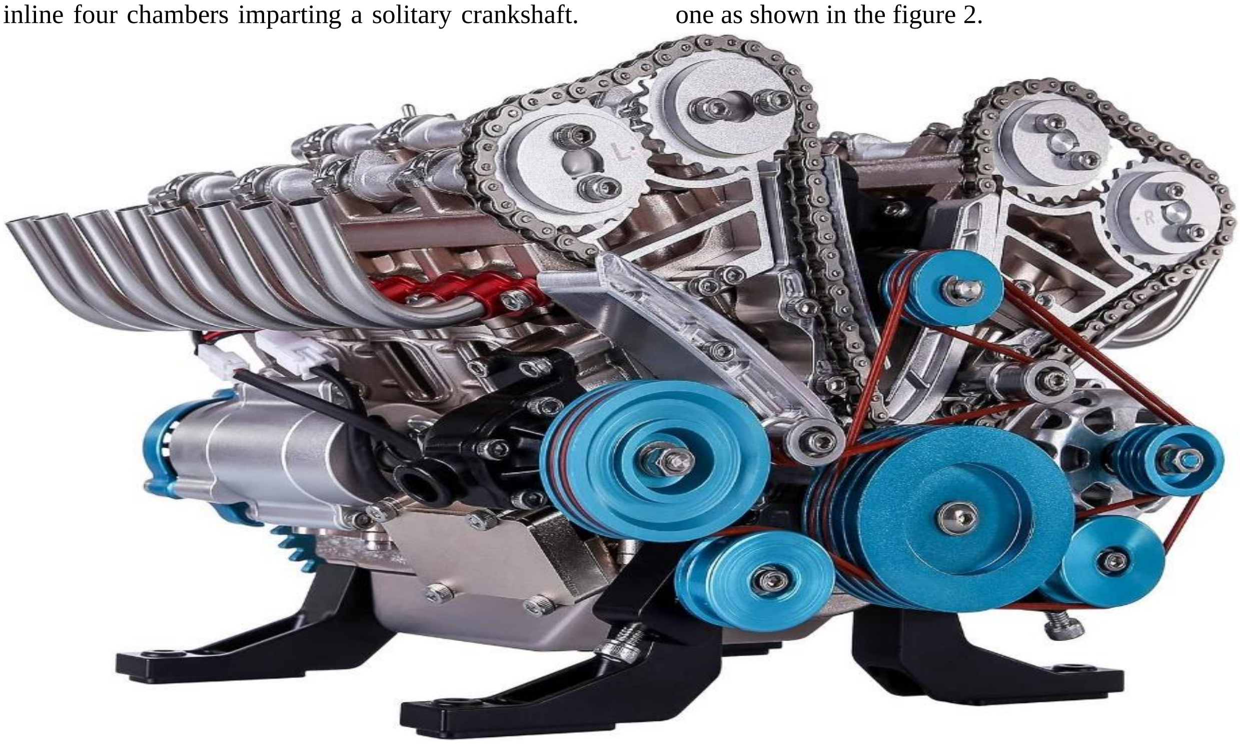

Fig.2: V8 engine

II.LITERATURE REVIEW

R.S. Khurmi, J.K. Gupta [1] the machine design text will used for design calculation of cylinder block and piston in the chapter 32 Internal Combustion Engine Parts in the fourth edition of the textbook. C. P. Kothandaraman, S. Subramanyan [2] it is a data handbook of heat and mass transfer in this we can use the properties of the material and heat flux formulas. S. Md. Jalaludeen [3] it is a data handbook of machine design in this we can used several formulas to calculate the design parameters of the cylinder block and piston. Yash Dhamecha et.al. [4] The Finite Element Method (FEM) was used to conduct a comparative study of pistons made of three different materials. The dimensions are obtained, and a 3-D CAD model in CREO 3.0 is prepared. The results predict the maximum stress and critical region on the pistons using FEA. Due to the following reasons, its Factor of Safety (F.O.S.) is the highest among the three materials: The total deformation of Al-GHS 1300 alloy is the least. The mass of the Al-GHS-1300 alloy is also the least. Vadde Mallikarjuna et.al. [5] A v8 engine has 8 cylinders and 8 pistons. The shape of the engine is "V," so it is called a v8 engine. The engine can produce a high amount of horsepower at a high speed that it can obtain from the cylinder once it has been heated. That heat is transferred to the surroundings, and the authors can study that heat transfer for different materials like aluminum, FU 4270, and FU 2451. They are calculating heat transfer only for the cylinder block. in that thermal stress, temperature distribution, and heat flux are lower in the FU 4270 material, so this is the best material for quick transient heat exchange between the burning chamber and the cylindrical wall. Pathipati Vasu et.al. [6] The piston is the "heart" of an automobile engine. It’s one of the key components of the engine, and it’s working hard. The function of the piston is to bear the gas pressure and make the crankshaft rotate through the piston pin. Pistons work at high temperatures, high pressures, and high speeds under poor lubrication conditions. In this paper, the authors can select five different materials, like alkali-soluble graphite (Al-SiGe), A7075, A6082, A4032, and AL-GHY 1250. The author can analyse the piston with these five materials. The analysis of the piston is done using structural and thermal analysis using ANSYS workbench software. The piston is drawn on the CATIA V5 software using standard dimensions and then imported into the ANSYS workbench software. T. Rohith Goud et. al. [7] Today's motors are a basic part of a vehicle that are inherent in various designs and are extensively more mind-boggling than early car engines. Regular segments found in a motor incorporate pistons, camshafts, timing chains, rocker arms, and other parts. Thermally, aluminum alloy is the best material for engine blocks. S. Srikanth Reddy et.al. [8] Automobile components are in great demand these days because of the increased use of automobiles. The piston is an important part of the engine, and it transfers force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In this paper, the analysis of a piston made of aluminium-Silicon alloy materials is investigated. The first thermal analysis is investigated on an aluminium-silicon alloy, and the second analysis is investigated on a piston coated with zirconium material using ANSYS workbench software. Rupa Athimakula et.al. [9] V8 engines have eight combustion chambers. There are two banks of four combustion chambers because there are four combustion chambers in each bank. The first V8 engine was used in 1920. In 1920, the V8 engine was used to conduct an experiment on it. They can obtain a result and compare it to the emissions of V6 and V12 engines. As a result, since the 1920s, most V8s have used the somewhat more complicated cross-plane crank shaft with large stabilizers to eliminate vibrations. This results in an engine that is simpler than a V6 and far less expensive than a V12 engine. G. Kolhe et.al. [10] Today finite element analysis is very important tool in engineering analysis field. The aerospace engineer is interested in designing auto engines, rolling mills, and machine tools, whether in mechanical engineering or in aerospace engineering. Cast iron alloys are used because they contain good mechanical properties, low cost, and availability compared with other metals. Ikpe Aniekan Essienubong et.al. [11] A piston is a component of reciprocating internal combustion (IC) engines. It is the moving component that is contained by a cylinder, which, with the help of the piston rings, achieves an airtight condition for an effective combustion process. Dilip Kumar Sonar et.al. [12] Engine pistons are among the most complex components in the automotive and industrial fields. Damage mechanisms are caused by a variety of factors, the most common of which are wear, temperature, and fatigue. However, more than wear and fatigue, piston damage is mostly caused by stress development, specifically thermal stress and mechanical stress. Lokesh Singh et.al. [13] The piston is the most significant part of the engine in the vehicle industry, and it is subjected to high mechanical and thermal strains. In this study, a detailed stress analysis of a piston is performed under various thermal and structural boundary conditions that are applied to the piston's finite element model. The study yields structural, thermal, and coupled thermo-mechanical stresses, as well as a temperature gradient. Balahari Krishnan S et.al. [14] Piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston such as piston side wear, piston head cracks and so on. These improvements include increased use of lightweight materials, such as advanced ultrahigh tensile strength steels, aluminium and magnesium alloys, polymers, and carbon-fibre reinforced composite materials. Ch.Venkata Rajam et.al. [15] Design, Analysis and optimization of piston which is stronger, lighter with minimum cost and with less time. Since the design and weight of the piston influence the engine performance. Analysis of the stress distribution in the various parts of the piston to know the stresses due to the gas pressure and thermal variations using with Ansys. The Piston of an engine is designed, analyzed, and optimized by using graphics software. The CATIA V5R16, CAD software for performing the design phase and ANSYS 11.0 for analysis and optimization phases are used. Tumpala Uma Santhosh [16] This project mainly deals with the design and analysis of piston. In this project the piston is modelled and assembled with the help of CATIA software and the component is meshed and analysis is done in ANSYS software and the thermal and static behaviour is studied and the results are tabulated. The various stresses acting on the piston under various loading conditions has been studied. K.E.Viany Kumar et.al. [17] Heat losses are a major limiting factor for the efficiency of internal combustion engines. Furthermore, heat transfer phenomena cause thermally induced mechanical stresses compromising the reliability of engine components. Today, predictions are increasingly being done with numerical simulations at an ever earlier stage of engine development. These methods must be based on the understanding of the principles of heat transfer. In the present work V type multi cylinder engine assembly is modelled by CATIA V5. K. Sathish Kumar [18] In this Paper the stress distribution is evaluated on the four-stroke engine piston by using FEA. The finite element analysis is performed by using FEA software. The couple field analysis is carried out to calculate stresses and deflection due to thermal loads and gas pressure. The materials used in this project are aluminium alloy, and SIC reinforced ZrB2 composite material. In this project the natural frequency and Vibration mode of the piston and rings were also obtained and its vibration characteristics are analyzed. With using computer aided design (CAD), CREO software the structural model of a piston will be developed. Preeti Kumari et.al. [19] Piston is a reciprocating part of engine which converts thermal energy into mechanical energy. There is thermo-mechanical load on the Piston. There is fatigue failure due to cyclic thermal and mechanical loading. by changing the geometry of the piston and it is suggested that which piston is better for same thermal load. Steady state thermal analysis of the Piston has been done in ANSYS 14.5. Thermal analysis shows the thermal load on different areas of the piston. Sreeraj Nair K et.al. [20] The main aim of this work is to predict the design performance based on the stress/strain and behavior of cylinder head under various operating conditions. The effects of engine operating conditions such as combustion gas maximum internal pressure, components on the stress and thermal stress behavior of the cylinder head have been analyzed.

By considering all the above-mentioned journals, as per our knowledge, we observed that they can be used in material selection, design calculation, modelling, analysis, and theoretical calculation.

III. DESIGN AND ANALYSIS

3.1 MATERIAL SELECTION:

3.1.1 Material selection for cylinder block: We take two materials to design and analysis of the cylinder block, are as follows

1. Al 2218: The chemical composition of 2218 alloy is poorly standardized, with several variants in production. In this alloy both copper (4%) and magnesium (1.5%) as major alloying elements. Properties of Al 2218 are Thermal conductivity (k): 140 W/m*K, Tensile strength (σ): 330 MPa.

2. Al 6061: The Aluminium alloy containing magnesium and silicon as its major alloying elements, it was developed in 1935. It has good mechanical properties and exhibits good weldability. It is one of the most common alloys of aluminium for general purpose use. Properties of Al 6061 are Thermal conductivity (k): 151-202 W/m*K, Tensile strength (σ): 124-290 MPa.
3. Al 5052: Aluminium 5052 is an Aluminium magnesium alloy which can be hardened by cold work, it is not heat treatable to higher strength. It is about mid-way through the series of Aluminium magnesium alloys for alloying content and strength. Properties of Al 5052 are Thermal conductivity (k): 138 W/m*K, Tensile strength (σ): 195-295 MPa.

3.1.2 Material selection for piston: We take two materials to design and analysis of the piston, are as follows,

1. ALSIC–9: Aluminium silicon carbide (ALSIC) is a metal matrix composite consisting of Aluminium matrix with silicon carbide particles, containing 37 vol.% of Aluminium alloy and 63 vol.% silicon carbide. Its thermal conductivity is 190–200 W/m K. ALSIC is a Light weight, High stiffness, Low thermal expansion, and high thermal conductivity.
2. Al 6063: Al6063 is an Aluminium alloy with magnesium and silicon as the alloying elements. It has generally good mechanical properties and is heat treatable and weldable. Its Thermal conductivity (k): 201-218 W/m*K & Tensile strength (σ): 145-186 MPa.
3. Al 2618: Aluminium / Aluminum alloys have high ductility and corrosion resistance. At subzero temperatures, their strength can be increased. However, their strength can be reduced at high temperatures of about 200-250°C. Aluminum 2618 alloy is an age hard enable alloy containing magnesium and copper. It has a Thermal conductivity (k): 146 W/m*K, and Tensile strength (σ): 441 MPa.

3.2 DESIGN CALCULATION: from the machine design book we can calculate the dimensions of cylinder block and piston in table 1 and 2.

TABLE.1: Design calculation for cylinder block

S.NO	DESIGN PARAMETER	DESIGN SYMBOL	CALCULATED VALUE
1	Thickness of the cylinder	t	9.74 mm
2	Thickness of the cylinder head	t_h	24.41 mm
3	Length of the cylinder	Lc	192.475 mm
4	Thickness of liner	t_1	2.69 mm
5	Thickness of jacket wall	t_j	4.256 mm
6	Water space between cylinder and jacket	t_w	13.14mm
7	Thickness of flange	t_f	12.662 mm

TABLE.2: Design calculation for piston

S. NO	DESIGN PARAMETER	DESIGN SYMBOL	CALCULATEDVALUE
1	Thickness of piston head	t_h	3.95 mm
2	Radial thickness of the ring	t_1	1.01 mm
3	Axial thickness of the ring	t_2	2 mm
4	The maximum thickness of the piston barrel	t_3	9.3 mm
5	Width of the top land	b_1	4.345 mm
6	Width of other ring lands	b_2	1.785 mm
7	Length of the piston	L	63.94 mm
8	Outside diameter of the piston pin	d_o	46.35 mm
9	Inside diameter of the piston pin	d_i	27.81 mm

3.3 MODELING:

3.3.1 Modeling of cylinder block:

The V8 engine cylinder block is drawn in the CATIA V5 software. In this software we can use several types of commands like line, mirror, etc., of the figures 3, 4, 5 and 6.

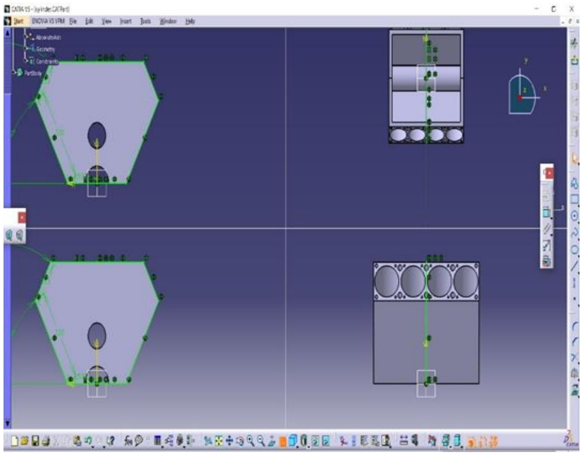

Fig.3: Drawing of V8 engine cylinders

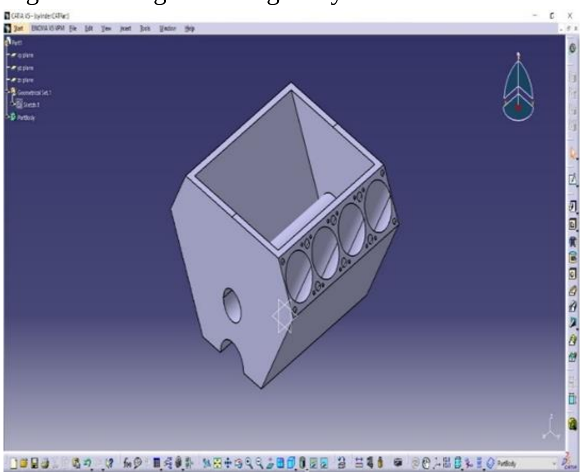

Fig.4: V8 engine viewing at different planes

3.3.2 Modeling of piston: the piston is also draw in CATIA V5 software and here also using same commands like cylinder block.

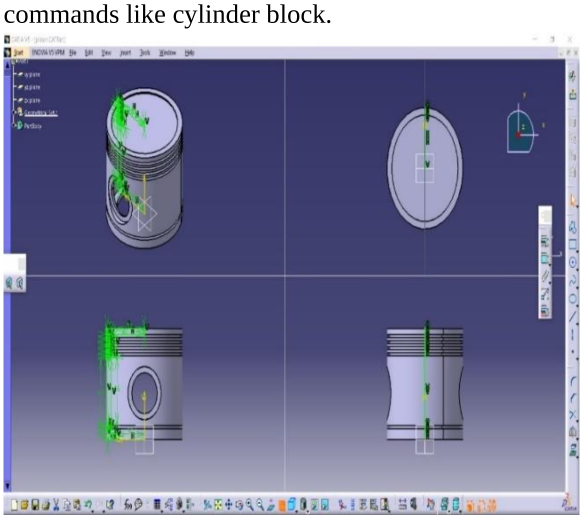

Fig.5: Drawing V8 engine piston

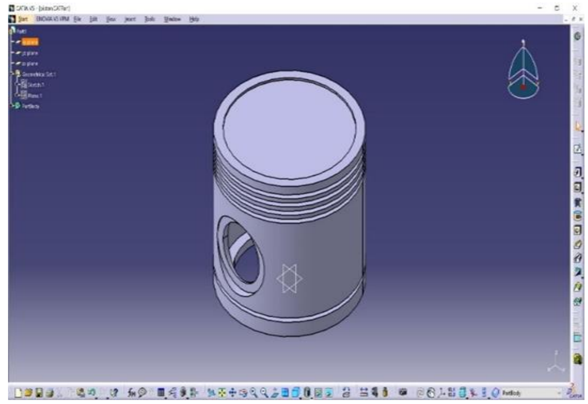

Fig.6: V8 engine piston

3.4 THERMAL ANALYSIS:

3.4.1 Thermal analysis of cylinder block:

First, we can draw the V8 engine cylinder block and piston in CATIA and then imported into ANSYS workbench software. In the thermal analysis we calculate the total heat flux and temperature distribution of both cylinder block and piston of different materials. The cylinder block is imported into ANSYS and generate a mesh in figures 7 and 8. Calculate temperature distribution of three materials as shown in figures 9, 10, 11, 12, 13 and 14.

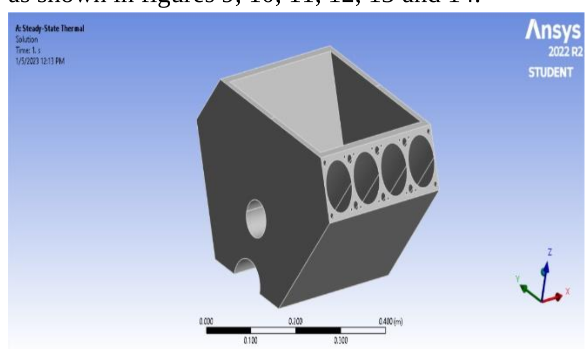

Fig.7: Cylinder block is imported to ANSYS

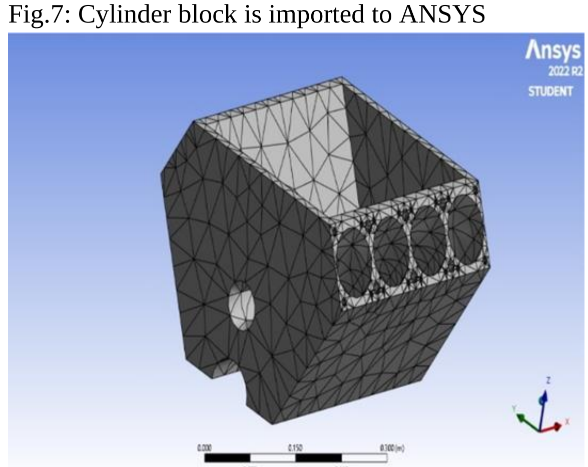

fig.8: Generation of mesh on cylinder block

1. Using Al 2218 material:

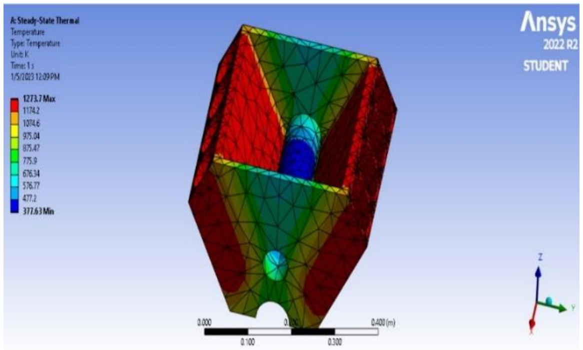

Fig.9: Results of temperature of the cylinder block

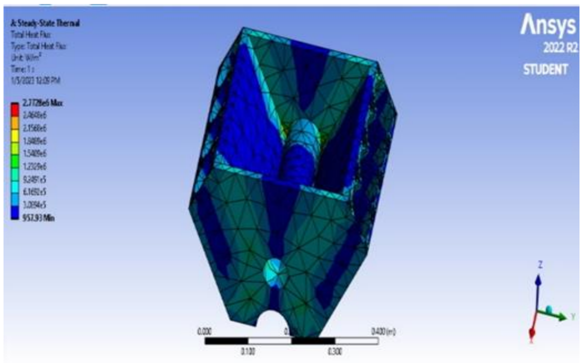

Fig.10: Results of total heat flux of the cylinder block

2. Using Al 6061 material:

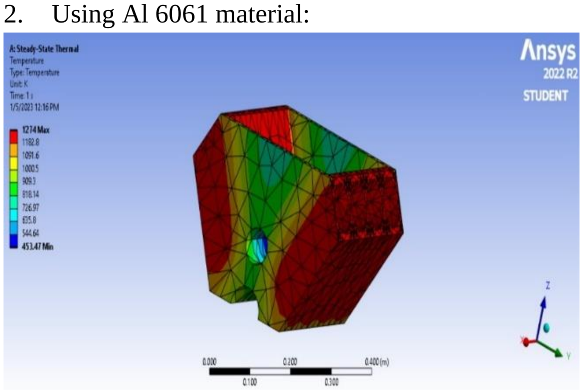

Fig.11: Results of temperature of the cylinder block

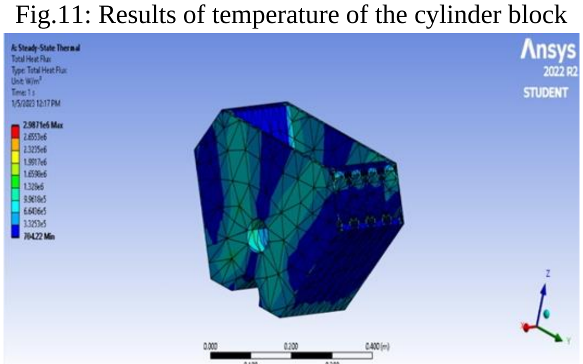

Fig.12: Results of total heat flux of the cylinder block

3. Using Al 5052 material:

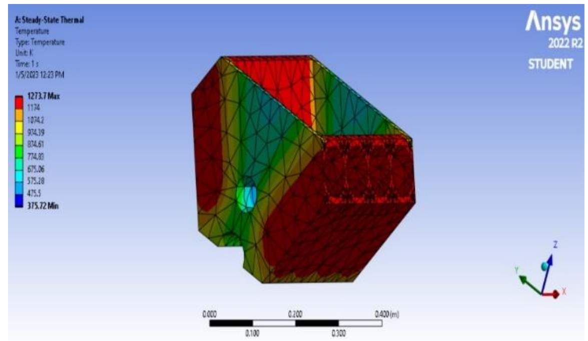

Fig.13: Results of temperature of the cylinder block

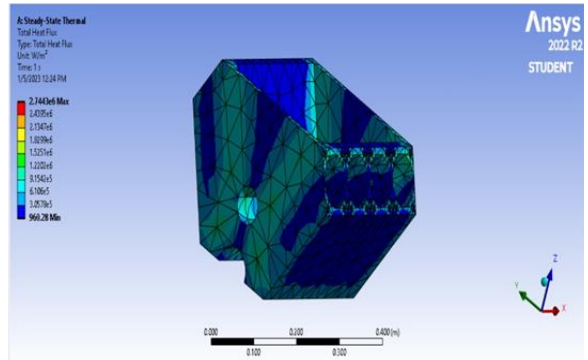

Fig.14: Results of total heat flux of the cylinder block

3.4.2 :Thermal analysis of piston: The cylinder block is imported into ANSYS and generate a mesh in figures 15 and 16. Calculate the temperature distribution of three materials as shown in figures 17, 18, 19, 20, 21 and 22.

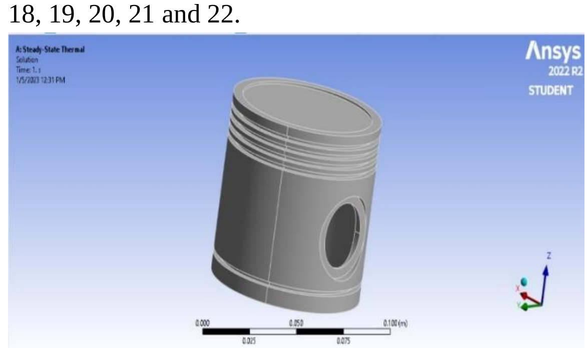

Fig.15: Piston is imported to ANSYS

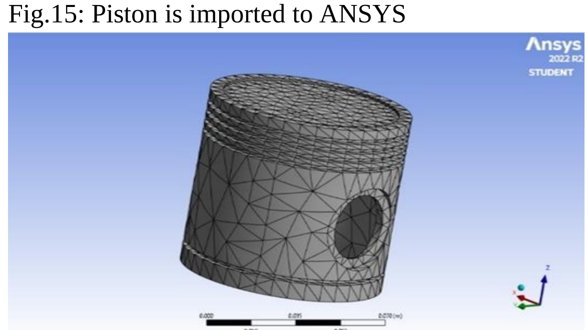

Fig.16: Generation of mesh on the piston

1. Using ALSIC material:

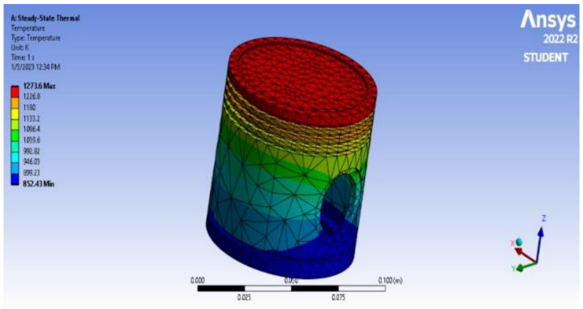

Fig.17: Results of temperature of the cylinder block

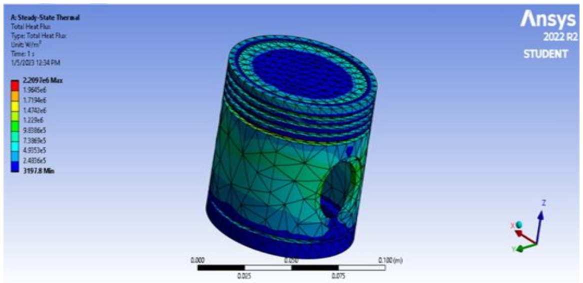

Fig.18: Results of total heat flux of the cylinder block

2. Using Al 6063 material:

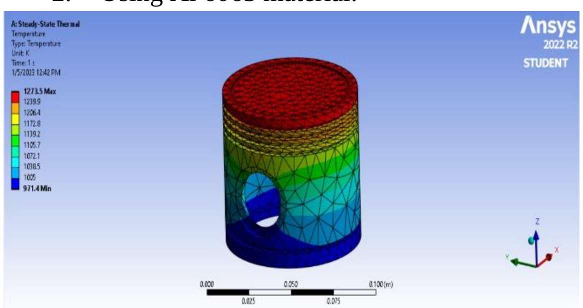

Fig.19: Results of temperature of the cylinder block

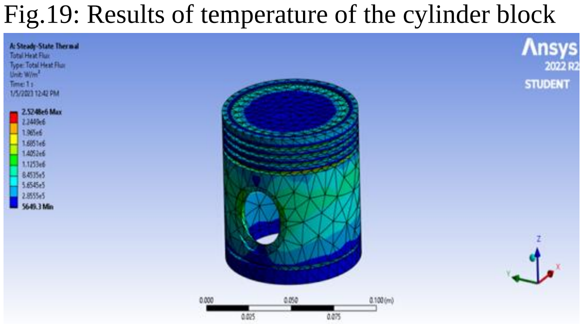

Fig.20: Results of total heat flux of the cylinder block

3. Using Al 2618 material:

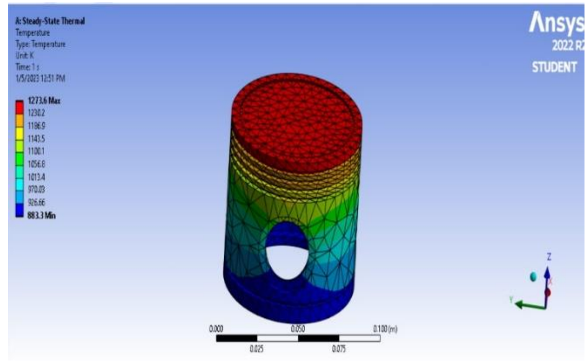

Fig.21: Results of temperature of the cylinder block

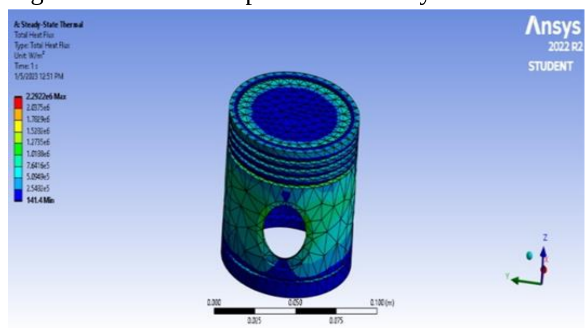

Fig.22: Results of total heat flux of the piston

IV.RESULT AND DISCUSSIONS

Cylinder block: In this work V8 engine block has been designed in CATIA V5. This model was introduced to ANSYS and done the steady condition thermal investigation and determined the thermal analysis like heat flux, temperature distribution for the various materials Al 2218, Al 6061, Al 5052. By exploit the consistent state thermal investigation utilizing ANSYS work bench 2022 R2 and by computing the convective heat transfer through chamber wall with hypothetical figuring's. The completion of analysis for all materials Al 2218, Al 6061, Al 5052 alongside their thermal conductivities, and the outcomes are given in Table 3.

Table3: Analytical Results (FEA) for Al 2218, Al 6061, Al 5052

parameters	Al 2218 K=140		Al 6061K=176.5		Al 5052 K=138	
	Max	Min	Max	Min	Max	Min
Temperature(K)	1273.7	377.63	1274	453.47	1273.7	375.72
Total heat flux(W/m^2)	2.7728	957.93	2.9871	70.422	2.7443	960.28

Piston: V8 engine piston has been designed in CATIA V5. This model was introduced to ANSYS and done the steady condition thermal investigation and determined the thermal analysis like heat flux, temperature distribution for the various materials ALSIC, Al 6063, Al 2618. The completion of analysis for all materials ALSIC, Al 6063, Al 2618 alongside their thermal conductivities, and the outcomes are given in Table 4.

Table4: Analytical Results (FEA) for ALSIC, Al 6063, Al 2618

Parameters	ALSIC		Al 6063		Al 2618	
	Max	Min	Max	Min	Max	Min
Temperature(K)	1273.6	852.43	1273.5	971.4	1273.6	883.3
Total heat flux(W/m^2)	2.2097	3197.8	2.5248	5649.3	2.2922	141.4

V.CONCLUSION

The design of V8 engine cylinder block is generated using CATIA V5 design software. The engine block is made up of three materials, such as Al 2218, Al 6061, and Al 5052 Study of different materials that are suitable for the design of engine blocks made them to work more efficient ways. For a cylinder block, theoretical values of the temperature distribution and heat flux are calculated and compared with ANSYS values. By comparing the Al 2218, Al 6061, and Al 5052, it is clearly understood that the temperature distribution and heat flux are higher in the Al 6061 material. For material Al 2218 has temperature distribution is 1273.7℃ and heat flux is 27728 W/m^2, Al 6061 has temperature distribution is 1274℃ and heat flux is 29871 W/m^2, Al 5052 has temperature distribution is 1273.7℃ and heat flux is 27443 W/m^2. From the above-mentioned results, we can conclude the best material is Al 6061 for quick transient heat exchange between the burning chamber and the cylindrical wall of the cylinder block.

Pistons made of different aluminum alloys, like ALSIC, Al 6063, and Al 2618, were designed and analyzed successfully. The pistons were thermally analyzed to determine heat flux and temperature distribution. For the piston, the values of the temperature distribution and heat flux are calculated in ANSYS and compared with journal papers. by contrasting ALSIC, Al 6063, and Al 2618. The temperature distribution for ALSIC is 1273.6°C and the heat flux is 22097 W/m2, the temperature distribution for Al 6063 is 1273.5°C and the heat flux is 25248 W/m2, and the temperature distribution for Al 2618 is 1273.6°C and the heat flux is 22922 W/m2. It is clearly understood that the temperature distribution and heat flux are higher in the Al 6063 material, so this is the best material for quick transient heat exchange in the piston.

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REFERENCE

[1] R.S. Khurmi J.K. Gupta, “Machine Design Textbook”, Eurasia Publishing House (PVT.) LTD, Fourteenth Edition, page no. 1-1230,

[2] C. P. Kothandaraman, S. Subramayan, “Heat and Mass Transfer Data Book”, ISBN: 81-224-2012-5, New Age Interational(P) Limited, Publishers, sixth edition, 2007.

[3] jalaludeen, “Machine Design Handbook”, ISBN: 978-81-8472-269-7, second edition Anuradha publications, 2018.

[4] Yash Dhamecha, Vaibhav Saptarshi, Shubham Parikh, Tejasve Parnami, “design and analysis of piston using different materials”, International Research Journal of Engineering and Technology (IRJET), ACADEMIA, Volume: 07, Issue: 12, e-ISSN: 2395-0056, page no. 1112-1117, DEC 2020.

[5] Vadde Mallikarjuna, V. Suresh, A. Saiteja, B Charitha, Ayub Aswak, “modeling & analysis of cylinder block for v8 engine”, International Research Journal of Automotive Technology (IRJAT), MAPLE TREE, ISSN 2581-5865, page no. 170-179, NOV 2018.

[6] Pathipati Vasu, Dr. M. Sri Rama Murthy, P. S. Amarnadh, S. V. Gopal Krishna, “Design and Analysis Of IC Engine Piston With Different Materials”, International Journal of Research, ResearchGate, e-ISSN: 2348-6848, Volume 05, Issue 07, page no. 871-878, MARCH 2018.

[7] T. Rohith Goud, Mohd. Naseeruddin, C. Raghavendra, Jyotsna Santhi, “Design and

Thermal Analysis of Cylinder Block", international journal of advance research in science and engineering (IJARSE), ResearchGate, ISSN 2319-8354, volume: 6, Issue: 1, page no. 468-473, JAN 2017.

[8] S. Srikanth Reddy, Dr. B. Sudheer Prem Kumar, "Thermal Analysis and Optimization of I. C. Engine Piston Using Finite Element Method", International Journal of Innovative Research in Science, Engineering and Technology, ResearchGate, ISSN: 2319-8753, Vol. 2, Issue 12, page no. 7834-7843, DEC2013.

[9] Rupa Athimakula, Lakshmi Kanth, Sai Bargav Chowdary B, Ismail Kakarwada, "Modeling and Analysis of Cylinder Block for V8 Engine", International Research Journal on Advanced Science Hub, RSP SCIENCE HUB, e-ISSN: 2582-4376, Volume 02, Issue 12, page no. 30-40, 2020.

[10] Mr. Rushikesh G. Kolhe, Mr. Pratik V. Kokate, Mr. Saurabh D. Kashid , Mr. Akshay Kadu, "Static, Modal & Thermal Analysis of Engine Block", International Journal of Engineering Research & Technology, IJERT, ISSN: 2278-0181, Vol. 9 Issue 08, page no. 185-190, August-2020.

[11] Ikpe Aniekan Essienubong, Owunna Ikechukwu Bismarck, "Design Analysis of Reciprocating Piston for Single Cylinder Internal Combustion Engine", international journal of automotive science and technology, OMD, Doi: 10.30939, VOL. 4, page no. 30-39, 2020.

[12] Dilip Kumar Sonar, Madhura Chattopadhyay, "Theoretical Analysis of Stress And Design of Piston Head Using Catia & Ansys", International Journal of Engineering Science Invention, ijesi, ISSN: 2319 – 6734, Volume 4, Issue 6, page no. 52-61, 2015.

[13] Lokesh Singh, Suneer Singh Rawat, Taufeeque Hasan, Upendra Kumar, "Finite Element Analysis Of Piston In Ansys", International Journal of Modern Trends in Engineering and Research, ResearchGate, ISSN: 2349-9745, Volume 02, Issue 04, page no. 619-626, April – 2015.

[14] Balahari Krishnan S, Aezhisai Vallavi MS, Arunkumar M and Haripraveen A, "Design and Analysis of An Ic Engine Piston Using Composite Material", European Journal of Advances in Engineering and Technology, ResearchGate, ISSN: 2394 - 658X, page no. 209-215, 2017.

[15] Ch.Venkata Rajam, P.V.K.Murthy, M.V.S.Murali Krishna, G.M.Prasada Rao, "Design Analysis and Optimization Of Piston Using Catia And Ansys", International Journal of Innovative Research in Engineering & Science, ResearchGate, ISSN 2319-5665, issue 2 volume 1, page no. 41-51, jan 2013.

[16] Tumpala Uma Santhosh, "Design and Thermal Analysis of Piston", Journal of Mechanical and Civil Engineering, IJRDO, ISSN: 2456-1479, Volume-2, Issue-11, page no. 1-81, November,2016.

[17] K.E.Viany Kumar, T.R.Sydanna, A.Salmon, M.Nagakrian, "Modeling and Analysis of Cylinder Block by Carbon Material (Fu4270) For V8 Engine", International Journal of Engineering Trends and Applications, ACADEMIA, Volume 4 Issue 1, ISSN: 2393-9516, page no. 1-8, Feb 2017.

[18] K. Sathish Kumar, "Design and Analysis of I.C. Engine Piston and Piston-Ring on Composite Material Using Creo And Ansys Software", Journal of Engineering and Science, ResearchGate, Vol. 01, Special Issue 01, page no. 39-51, July 2016.

[19] Preeti Kumari, Anamika, Dr.H.C.Thakur, "Thermal Analysis of Piston of Ic Engine", International Journal of Scientific & Engineering Research, Volume 7, Issue 12, ISSN 2229-5518, page no. 374-381, December-2016.

[20] Sreeraj Nair K., Kiran Robert and Shamnadh M, "Static Stress Analysis of IC Engine Cylinder Head", International Review of Applied Engineering Research, Research India Publications, ISSN 2248-9967, Volume 4, Number 2, page no. 123-128, 2014.