# Design and analysis of V6 engine on solid works & ANSYS

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***Abstract— This paper explores the design and finite element analysis (FEA) of a V6 engine using ANSYS, with a focus on material optimization to enhance performance and efficiency. The study investigates three distinct materials: aluminum alloy, iron-chromium-aluminum alloy, and iron-silicon-aluminum alloy, assessing their suitability for engine components such as pistons, connecting rods, and crankshafts. Through a series of simulations, the research evaluates each material's mechanical properties, thermal conductivity, and weight implications. The goal is to identify the material that not only withstands the high-stress environment of an engine but also contributes to overall weight reduction and thermal efficiency. The findings aim to provide valuable insights into material selection for V6 engines, potentially leading to advancements in automotive engineering and design.***

***Index Terms— Piston head, Engine block, Cylinder head, Valve, V6 Engine, design, analysis***

## I. INTRODUCTION

The introduction of V6 engines dates back to the early 20th century, with various manufacturers experimenting with different configurations and designs. However, it wasn't until the mid-20th century that V6 engines became more widespread in automotive applications. Over the years, advancements in engineering and manufacturing techniques have led to the refinement and widespread adoption of V6 engines across various automotive brands and models. V6 engines offer a balance of performance, efficiency, and compactness, making them popular choices for a wide range of vehicles, from economy cars to luxury sedans, SUVs, and even high-performance sports cars. Today, V6 engines continue to be a staple in the automotive industry, although they face competition from other engine configurations such as inline-four, inline-six, and V8 engines. Despite this competition, V6 engines remain a popular choice for manufacturers looking to strike a balance between power, fuel efficiency, and packaging constraints. V6 engines find extensive use across a broad spectrum of vehicles, including mid-sized sedans, compact SUVs, pickup trucks, and performance-oriented sports cars. Their compact design allows for efficient use of space under the hood while delivering respectable power outputs and smooth performance. They are favored for their balance of performance and fuel efficiency, making them a popular choice for everyday driving needs. Many luxury automakers also utilize V6 engines in their premium offerings, providing a blend of refinement and power. Additionally, V6 engines are often employed in hybrid powertrains, where they work in conjunction with electric motors to enhance fuel economy and reduce emissions. Overall, the versatility and reliability of V6 engines make them a cornerstone of modern automotive engineering.

Many researchers have investigated the performance of V6 Engine based on different parameters. Dawson, Steve. [1] provide the paper based on well-to-wheels energy comparison for CGI and aluminum, showing a favorable profile for cast iron cylinder blocks. Benjey, Robert P., at all studied a naturally aspirated 5.0 L V8 is replaced by a 3.7 L V6 gasoline boosted engine. Test results for light duty passenger vehicles indicate significant improvement in vehicle performance and fuel economy. Paulovics, László [3] aimed on to develop a test method for rapid and cost-effective comparison of engine lubricants, timing chain materials or coatings, as well as to assess the wear resistance of the chain to contaminants. Moore, Stephen M. [4] written this paper certain late model vehicles have experienced an audible clattering during cold engine-start that is caused by the piston top striking the cylinder head after combustion chamber deposits build up to a level that exceeds the available clearance between the piston and the head. This clattering is referred to variously as "carbon knock," "carbon rap," "deposit induced noise," and "combustion chamber deposit interference (CCDI)." The audible clattering intensity increases with mileage as deposits continue to accumulate. Sarwar, Azeem, and Xiangxing Lu [5] presented Spark Ignition Direct Injection (SIDI) technology enables better fuel economy and tail pipe emissions in vehicles equipped with gasoline engines. The SIDI technology relies on the system's ability to deliver fuel at high pressures (20-40 MPa). In this report, algorithm development for diagnosis and prognosis of leaks in high pressure fuel delivery system is presented.

In the present work, the performance of v6 engine is evaluated through Solid Works & ANSYS by utilizing different material combination. This study aims to identify the best suitable material for Piston, Engine block, Cylinder head, Valve.

## II. MATERIAL AND METHODS

### 2.1 Materials

In the current work we determine the thermal analysis and total heat flux on the V6 Engine's Piston, Cylinder Head, Engine Block, Valve by using Aluminium alloy, Iron Chromium Aluminium Alloy, Ti-6Al-4V, Iron silicon Aluminium Alloy materials and their properties are given in Table.1.

Table.1. Format for Materials, Thermal Conductivity and Heat Transfer

| Material | Thermal Conductivity k =W/m K |
|---|---|
| Aluminium alloy | 205 |
| Iron Chromium Aluminium Alloy | 15 |
| Ti-6Al-4V | 7 |
| Iron silicon Aluminium Alloy | 60 |

### 2.2 Design and Modelling

In the current work designing of V6 engine Piston, Engine block, Cylinder head, Valve has done by utilizing SolidWorks by following these steps Fig. [1]

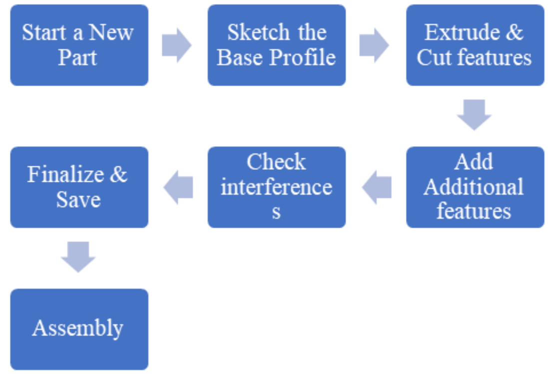



Fig.1.

In the present work analysis has completed by means of ANSYS WORK BENCH for the finished Piston, Cylinder Head, Engine Block, Valve modelled in SOLIDWORKS. Which are given in Fig.2.

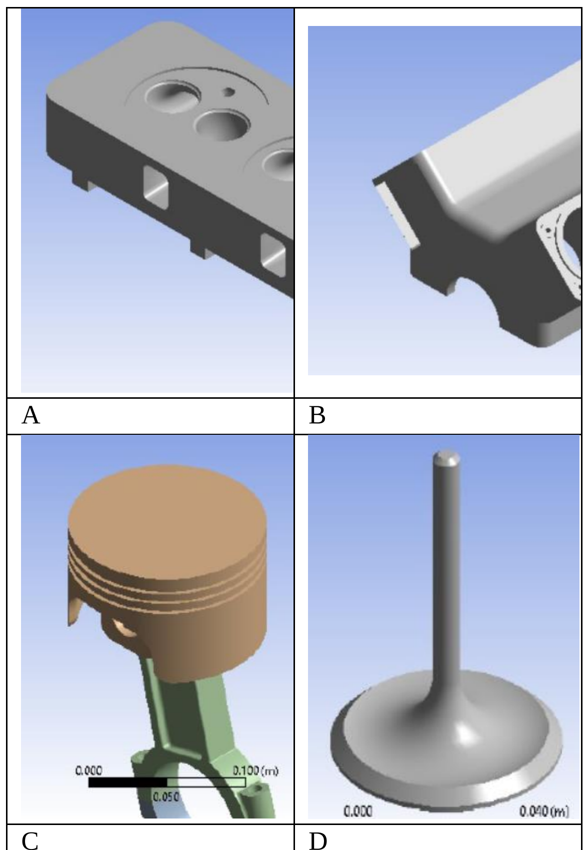
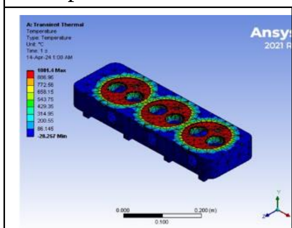
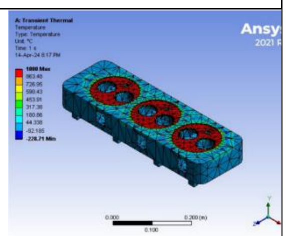
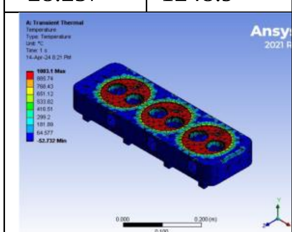
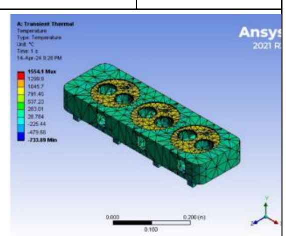
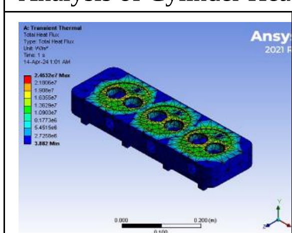
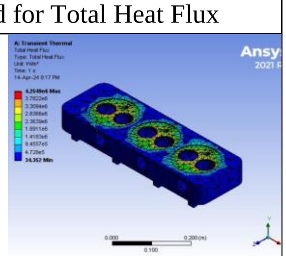
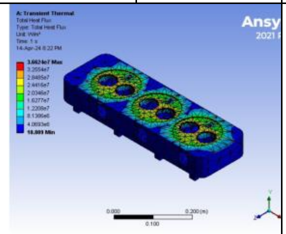
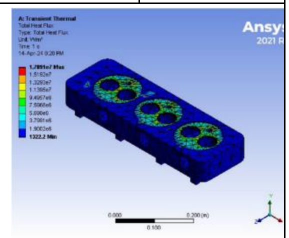



Fig.2. -A. Cylinder Head, B. Engine Block, C. Piston, D. Valve

In this project we are using some boundary constrains – Steady state thermal & Analyse maximum temperature and total heat flux and results are given below.

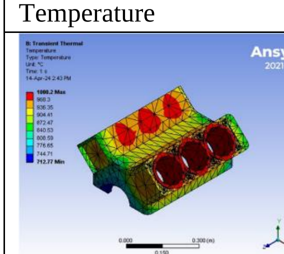
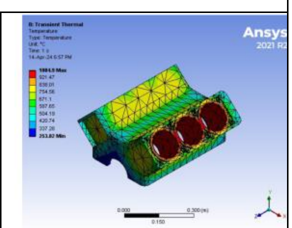
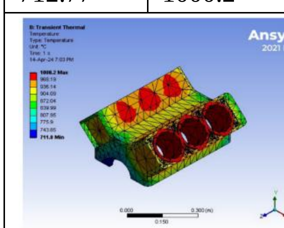
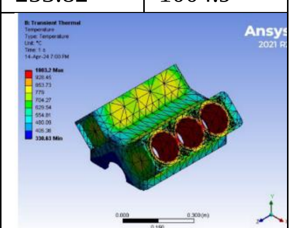
## III. ANALYSIS OF CYLINDER HEAD FOR VARIOUS MATERIALS

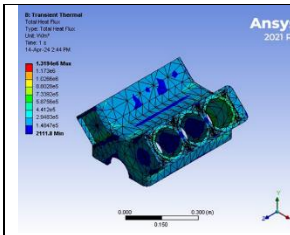
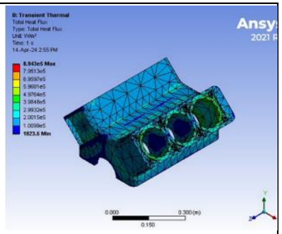
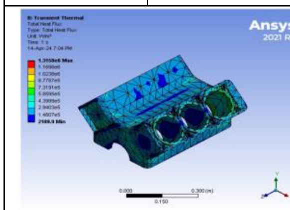
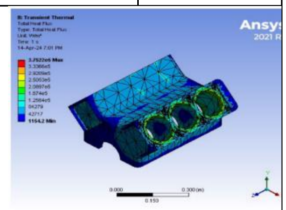
Analysis has completed by means of ANSYS WORK BENCH for the finished cylinder head modelled in SOLIDWORKS and we applying heat in intake ports and the investigative significances of total heat flux and temperature effect are put into a table

| Analysis of Cylinder Head for Maximum Temperature | | | |
|---|---|---|---|
|  Aluminium Alloy | |  Ti-6Al-4V | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum (°C) |
| -28.257 | 1248.9 | -228.71 | 1000 |
|  Iron Silicon Aluminium Alloy | |  Iron Chromium Aluminium Alloy | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum (°C) |
| -52.732 | 1003.1 | -733.89 | 1554.1 |
| Analysis of Cylinder Head for Total Heat Flux | | | |
|  Aluminium Alloy | |  Ti-6Al-4V | |
| Minimum | Maximum | Minimum | Maximum |
| 3.882 | 2.45E+07 | 34.352 | 4.25E+06 |
|  Iron Silicon Aluminium Alloy | |  Iron Chromium Aluminium Alloy | |
| Minimum | Maximum | Minimum | Maximum |
| 10.809 | 3.66E+07 | 1322.2 | 1.71E+07 |

## IV. ANALYSIS OF ENGINE BLOCK FOR VARIOUS MATERIALS

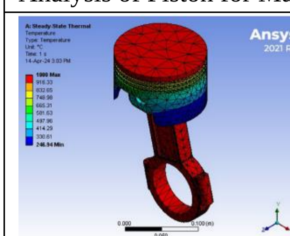
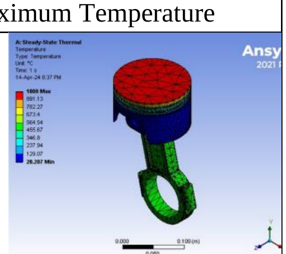
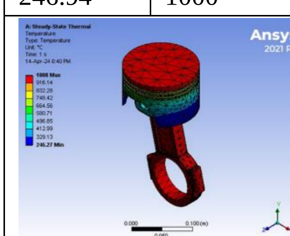
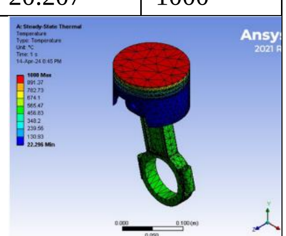
Analysis has completed by means of ANSYS WORK BENCH for the finished engine block modelled in SOLIDWORKS and here we applied heat among the ignition chamber and the combustion chamber wall and the investigative significances of total heat flux and temperature effect are put into a table

| Analysis of Engine Block for Maximum Temperature | | | |
|---|---|---|---|
|  Aluminium Alloy | |  Ti-6Al-4V | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum (°C) |
| 712.77 | 1000.2 | 253.82 | 1004.9 |
|  Iron Silicon Aluminium Alloy | |  Iron Chromium Aluminium Alloy | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum (°C) |
| 711.8 | 1000.2 | 330.63 | 1003.2 |
| Analysis of Engine Block for Total Heat Flux | | | |

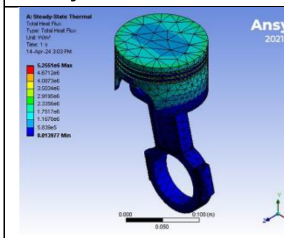
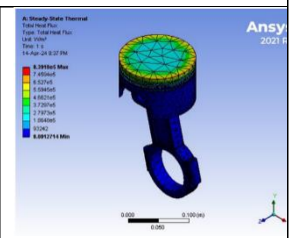
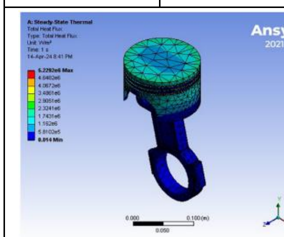
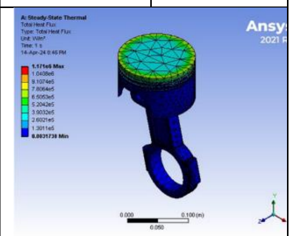
| | | | |
|---|---|---|---|
|  | |  | |
| Aluminium Alloy | | Ti-6Al-4V | |
| Minimum | Maximum | Minimum | Maximum |
| 2111.8 | 1.32E+06 | 1823.5 | 8.94E+05 |
|  | |  | |
| Iron Silicon Aluminium Alloy | | Iron Chromium Aluminium Alloy | |
| Minimum | Maximum | Minimum | Maximum |
| 2109.9 | 1.32E+06 | 1154.2 | 3.75E+05 |

## V. ANALYSIS OF PISTON FOR VARIOUS MATERIALS

Analysis has completed by means of ANSYS WORK BENCH for the finished piston modelled in SOLIDWORKS and heat is applied at piston head and the investigative significances of total heat flux and temperature effect are put into a table

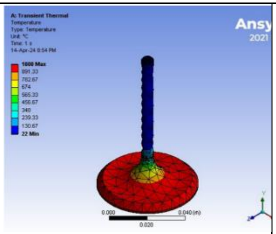
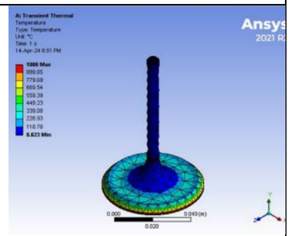
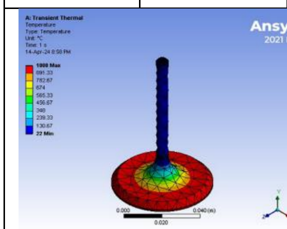
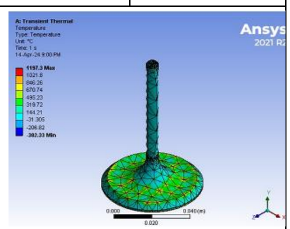
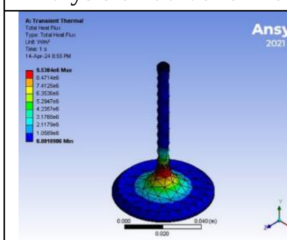
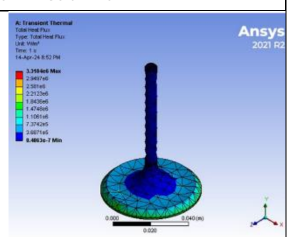
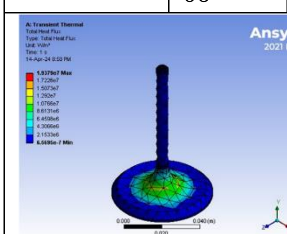
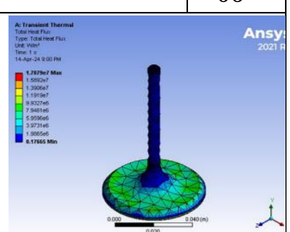
| Analysis of Piston for Maximum Temperature | | | |
|---|---|---|---|
|  | |  | |
| Aluminium Alloy | | Ti-6Al-4V | |
| Minimum(°C) | Maximum (°C) | Minimum(°C) | Maximum (°C) |
| 246.94 | 1000 | 20.207 | 1000 |
|  | |  | |

| Iron Silicon Aluminium Alloy | | Iron Chromium Aluminium Alloy | |
|---|---|---|---|
| Minimum (°C) | Maximum(°C) | Minimum (°C) | Maximum(°C) |
| 245.27 | 1000 | 22.296 | 1000 |

| Analysis of Piston for Total Heat Flux | | | |
|---|---|---|---|
|  | |  | |
| Aluminium Alloy | | Ti-6Al-4V | |
| Minimum | Maximum | Minimum | Maximum |
| 0.013977 | 5.26E+06 | 0.0012714 | 8.39E+05 |
|  | |  | |
| Iron Silicon Aluminium Alloy | | Iron Chromium Aluminium Alloy | |
| Minimum | Maximum | Minimum | Maximum |
| 0.014 | 5.23E+06 | 0.0031738 | 1.17E+07 |

## VI. ANALYSIS OF VALVE FOR VARIOUS MATERIALS

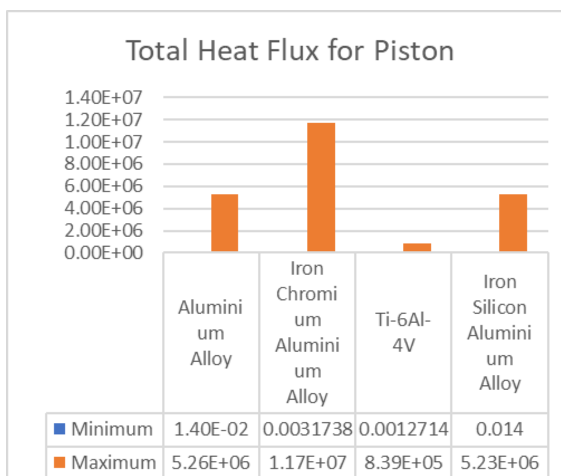
Analysis has completed by means of ANSYS WORK BENCH for the finished valve modelled in SOLIDWORKS and heat is applied at the bottom of valve and the investigative significances of total heat flux and temperature effect are put into a table.

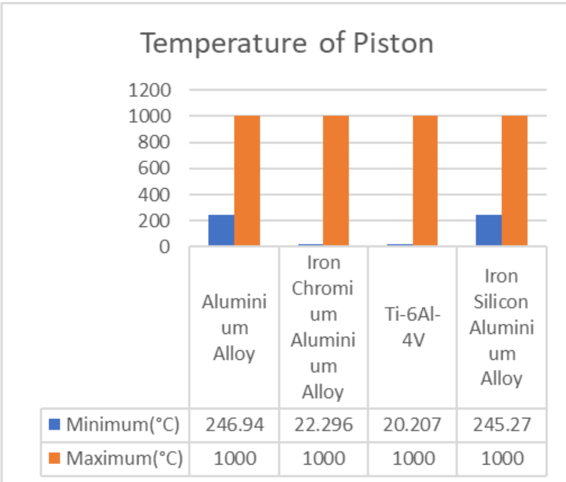
| | | | |
|---|---|---|---|
| Analysis of Valve for Maximum Temperature | | | |
|  Aluminium Alloy | |  Ti-6Al-4V | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum(°C) |
| 22 | 1000 | 8.623 | 1000 |
|  Iron Silicon Aluminium Alloy | |  Iron Chromium Aluminium Alloy | |
| Minimum (°C) | Maximum (°C) | Minimum (°C) | Maximum(°C) |
| 22 | 1000 | -382.33 | 1197.3 |
| Analysis of Valve for Total Heat Flux | | | |
|  Aluminium Alloy | |  Ti-6Al-4V | |
| Minimum | Maximum | Minimum | Maximum |
| 0.0010906 | 9.53E+06 | 8.49E-07 | 3.32E+06 |
|  Iron Silicon Aluminium Alloy | |  Iron Chromium Aluminium Alloy | |
| Minimum | Maximum | Minimum | Maximum |
| 6.57E-07 | 1.94E+07 | 0.17665 | 1.79E+07 |

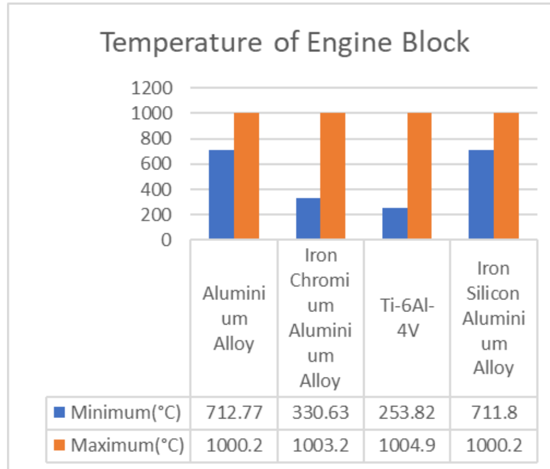
## VII. RESULTS AND DISCUSSION

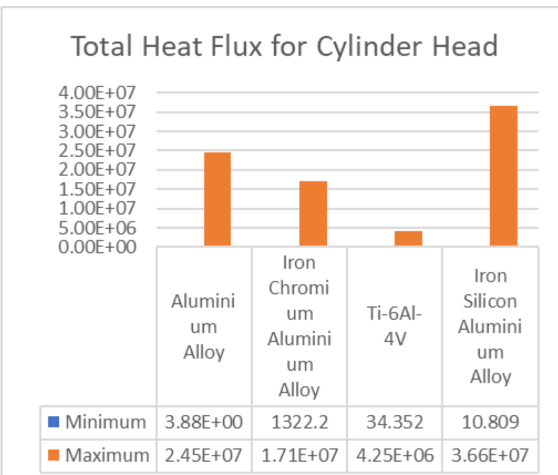
Current research work displaying of V6 engine Cylinder Head, Engine Block, Piston, Valve has designed utilizing SolidWorks. These models were introduced to ANSYS and done the steady condition thermal investigation and determined the thermal analysis, heat flux and disfigurement for the various materials Iron Chromium Aluminium Alloy, Ti-6Al-4V and Iron silicon Aluminium Alloy and contrast the outcomes and existing aluminum alloy and projected the reasonable material. By exploit the consistent state thermal investigation utilizing ANSYS work bench 14.5 V and by computing the convective heat transfer through chamber wall with hypothetical figuring's, and determined the thermal characteristics and the complete misshaping created for the Cylinder Head, Engine Block, Piston, Valve for Aluminum alloy, Iron Chromium Aluminium Alloy, Ti-6Al-4V and Iron silicon Aluminium Alloy alongside their thermal conductivities, and the outcomes are given in Table.

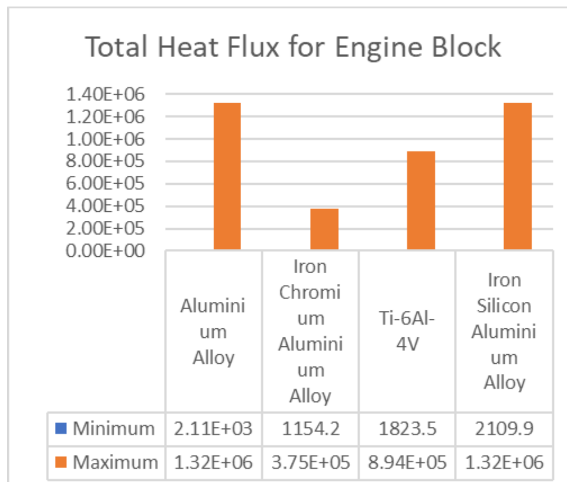
## VIII. ANALYTICAL RESULTS (CYLINDER HEAD, ENGINE BLOCK, PISTON, VALVE) FOR ALUMINUM ALLOY, IRON CHROMIUM ALUMINUM ALLOY, TI-6AL-4V AND IRON SILICON ALUMINUM ALLOY

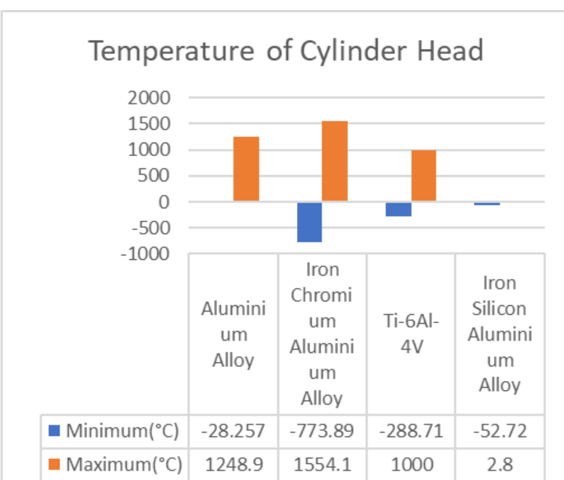


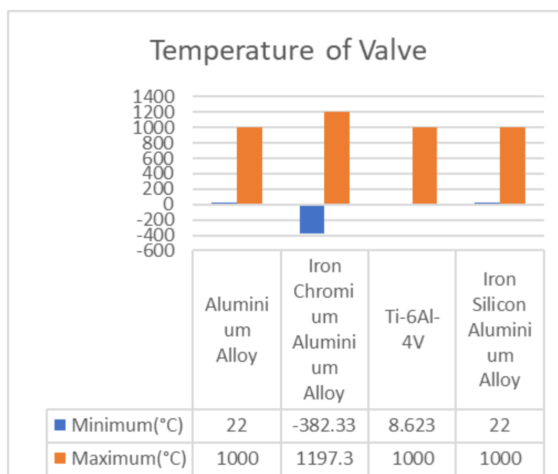

Temperature of Piston
1200
1000
800
600
400
200
0
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum(°C) 246.94 22.296 20.207 245.27
Maximum(°C) 1000 1000 1000 1000

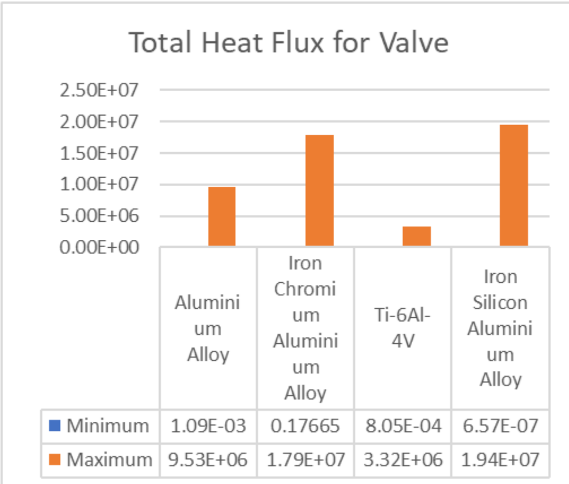

Temperature of Engine Block
1200
1000
800
600
400
200
0
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum(°C) 712.77 330.63 253.82 711.8
Maximum(°C) 1000.2 1003.2 1004.9 1000.2


Total Heat Flux for Cylinder Head
4.00E+07
3.50E+07
3.00E+07
2.50E+07
2.00E+07
1.50E+07
1.00E+07
5.00E+06
0.00E+00
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum 3.88E+00 1322.2 34.352 10.809
Maximum 2.45E+07 1.71E+07 4.25E+06 3.66E+07


Total Heat Flux for Engine Block
1.40E+06
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum 2.11E+03 1154.2 1823.5 2109.9
Maximum 1.32E+06 3.75E+05 8.94E+05 1.32E+06


Temperature of Cylinder Head
2000
1500
1000
500
0
-500
-1000
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum(°C) -28.257 -773.89 -288.71 -52.72
Maximum(°C) 1248.9 1554.1 1000 2.8


Temperature of Valve
1400
1200
1000
800
600
400
200
0
-200
-400
-600
Aluminium Alloy
Iron Chromium Aluminium Alloy
Ti-6Al-4V
Iron Silicon Aluminium Alloy
Minimum(°C) 22 -382.33 8.623 22
Maximum(°C) 1000 1197.3 1000 1000




## CONCLUSION

It is significant transient heat trade among the cylinder head, engine block, piston and valve in V6 engine, transient heat trade relies generally upon the materials. In the current work transient hotness trade among the cylinder head, engine block, piston and valve are looked at for four changed materials. The displaying of V6 engine cylinder head, engine block, piston and valve was finished utilizing SolidWorks, and examination was finished utilizing ANSYS. Hypothetical estimations of the temperature dispersion, total heat flux is determined, and contrasted and ANSYS values. By looking at for the Iron Chromium aluminum Alloy, Ti-6Al-4V and Iron silicon aluminum Alloy materials with conventional material aluminum alloy it is inferred that temperature conveyance are lower for cylinder head, engine block and valve in Iron Chromium aluminum Alloy material, for engine block Ti-6Al-4V material, so these materials are superlative for determine temperature distribution.

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