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RESEARCH ARTICLE OPEN ACCESS

Modeling and Analysis of V-12 Engine

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Abstract:

The main objective of the project is how to develop the prototype of V 12 engine assembly using CAD tool CATIA V5. These Engine assembly consists major components they are Piston, Connecting Rod Assembly, Crank Shaft, Cylinder head, Cam Shaft, Valves, crank case, oil tank and spark plug with required dimensions. The components which are developed in CATIA V5 are also analysed in it using simulation tool. The structural analysis and thermal analysis of piston is performed for different values of static and thermal loading and the results of stress distribution and temperature distribution of the components are shown. Finally, the structural analysis and thermal analysis results of the different components are compared and the best suited material is selected.

Keywords — **CAD tool CATIA, Piston, Static structural Analysis, Steady State Thermal Analysis, Ansys, Stress distribution, Temperature, Total Heat Flux**

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I. INTRODUCTION

A V-12 engine generally just called a V-12 is an internal combustion engine with 12 cylinders. The V-12 engine has six cylinders on each side called banks. The two banks form a "V" shaped angle. In most V-12 engines, the two banks are at 60° angle to each other. All twelve pistons turn a common crankshaft. It can be powered by varied types of fuels, including gasoline, diesel and natural gas. A V-12 engine does not need balance shafts. An engine angled at 45°, 60°, 120°, or 180° from each other has even firing and is smoother than a straight-6. This provides a smooth-running engine for a luxury car. For a racing car, the engine can be made much lighter. This makes the engine more responsive and smoother. In a large heavy-duty engine, where power is more needed a V12 can run slower and prolonging engine life.

II. LITERATURE REVIEW

A. Bodireddy Hemasundaram and Mr. D. Suresh:

This paper review 3 thing that are modelling, analysis and selection of material. Modelling and analysis has done in solidwoks software. Simulation has carried out on piston, connecting rod and crank shaft with different materials respectively. After getting results they have concluded alloy steel has better load resistance and low deformation.

B. G. S. Cole and A. M. Sherman:

Lightweight metals present a major opportunity for weight reduction and other benefits when used in place of steel and cast irons in provide reliability, manufacturing feasibility, and cost. The ability to design and optimize component weight-reduction opportunities effectively requires a complete understanding of how process, metallurgical structure and properties interact. And future application-specific information for the "newer" materials is still being developed.

C. Eugene Gruenewald:

This paper reviews aluminium alloy as piston materia. The paper gives information about designing part, selection criteria, properties of alloy, advantages and disadvantages of the alloy. And for selection process the key consideration is commercial availability of material. By considering above mention point the discussion is done on different properties of aluminium alloy.

D. Dilip Kumar Sonar and Madhura Chattopadhyay:

This research paper gives information about reasons for failure of piston. The research work is done for piston and different types of stresses are considered for analysis like mechanical and thermal stresses. After the results by performing analysis, the solution proposed for the problems occur (fatigue failure because of thermal and mechanical stresses).

E. Qudong Wang, Changjiang Chen and Yan Gao:

Commercial magnesium alloys have a great potential for structural applications in automotive due to their significant weight saving. So, they have done research for new allot material. Mg-Zn- (Y, Gd), about their properties at different temperature. Mg-2Zn-11Y-5Gd-0.5Zr cast alloy exhibits excellent hight temperature mechanical properties such as tensile strength, creep resistance and fatigue strength, equivalent or even higher in the comparison with the current aluminium alloy for piston. So, it can be concluded that this magnesium alloy is very promising as a candidate material for piston applications. However, there are still manufacturing related issues remained, such as optimization of casting design, heat treatment schedule for the stability of microstructure at elevated temperatures, wear resistant surface treatment strategy, and so on.

F. M. M. Haque and A. Sharif Low:

Expansion aluminium-silicon eutectic alloys are cast to produce most of the automotive pistons. The structure and properties of these alloys are very much dependent on the cooling rate, comparison, modification and heat treatment operations. The overall investigation shows that the heat-treated aluminium-silicon piston alloy has higher strength, hardness and wear resistance properties.

III. MATERIALS/TOOLS REQUIRED

G. Magnesium Alloy

To overcome the limitation of aluminium alloy, the research is going on to use magnesium alloy as an engine material for reducing the weight of engine without affecting its performance. Key reason for selecting magnesium alloy is its lower density, which is very useful. The magnesium allot is 33% lighter than aluminium alloy.

Commercial magnesium alloys have a great potential for structural applications in automotive due to their significant weight saving. However, the have poor creep resistance at temperature over 125 °C, thus making them inadequate for power train applications such as engine pistons, which are operated at temperature up to 300°C. Recently, creep resistant magnesium alloys with rare earth elements and Zn have been developed, hence the applicability of Mg-Zn-(Y,Gd) alloys for engine pistons was investigated.

At room temperature, the fatigue strength of this material is 27% lower than A336, while it is 35% higher at 300°C. It is suggested that Mg-2Zn-11 Y-5Gd-0.5Zr alloy shows attractive high temperature mechanical properties higher than A336, hence it is promising as a candidate material for the engine piston application.

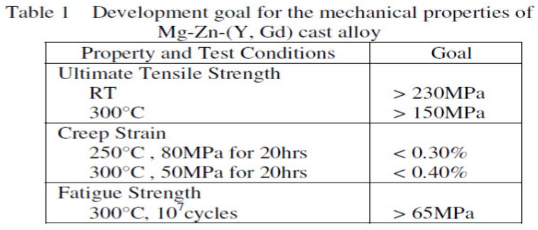


Table 1 Development goal for the mechanical properties of Mg-Zn-(Y, Gd) cast alloy

Property and Test Conditions	Goal
Ultimate Tensile Strength	
RT	> 230MPa
300°C	> 150MPa
Creep Strain	
250°C , 80MPa for 20hrs	< 0.30%
300°C , 50MPa for 20hrs	< 0.40%
Fatigue Strength	
300°C, 10^7cycles	> 65MPa

Fig.1: Development goal for the mechanical properties of Mg-Zn-(Y,Gd) cast alloy

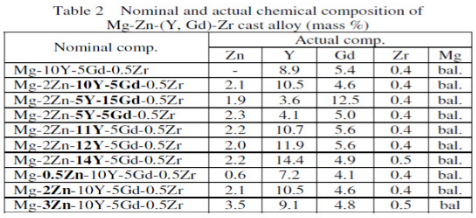


Table 2 Nominal and actual chemical composition of Mg-Zn-(Y, Gd)-Zr cast alloy (mass %)

Nominal comp.	Actual comp.				
	Zn	Y	Gd	Zr	Mg
Mg-10Y-5Gd-0.5Zr	-	8.9	5.4	0.4	bal.
Mg-2Zn-**10Y-5Gd**-0.5Zr	2.1	10.5	4.6	0.4	bal.
Mg-2Zn-**5Y-15Gd**-0.5Zr	1.9	3.6	12.5	0.4	bal.
Mg-2Zn-**5Y-5Gd**-0.5Zr	2.3	4.1	5.0	0.4	bal.
Mg-2Zn-**11Y**-5Gd-0.5Zr	2.2	10.7	5.6	0.4	bal.
Mg-2Zn-**12Y**-5Gd-0.5Zr	2.0	11.9	5.6	0.4	bal.
Mg-2Zn-**14Y**-5Gd-0.5Zr	2.2	14.4	4.9	0.5	bal.
Mg-**0.5Zn**-10Y-5Gd-0.5Zr	0.6	7.2	4.1	0.4	bal.
Mg-**2Zn**-10Y-5Gd-0.5Zr	2.1	10.5	4.6	0.4	bal.
Mg-**3Zn**-10Y-5Gd-0.5Zr	3.5	9.1	4.8	0.5	bal

H. Heat Treatment

DSC was conducted for both Mg-10Y-5Gd-0.5Zr and Mg-2Zn-10Y-5Gd-0.5Zr alloys as shown in figure and the peak temperatures were measured at 567°C and 540°C, respectively. In order to apply a same heat treatment condition to both alloys, temperature for solution heat treatment was set to 535°C, just below the eutectic temperature of Mg-2Zn-10Y-5Gd-0.5Zr alloy.

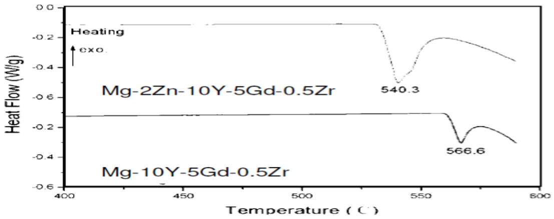


Fig.3 DCS curves for the magnesium alloys

Fig. 2: DSC Curves for the magnesium Alloy

I. Tensile Strength

In order to investigate the effects of the total amount of RE elements, effects of Y and Gd on the tensile properties were evaluated. Table 3 summarizes the tensile properties of Mg-2Zn-(Y-Gd)-0.5Zr alloys.

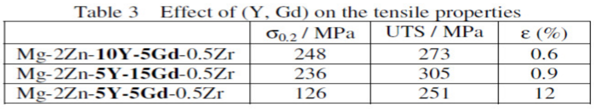


Table 3 Effect of (Y, Gd) on the tensile properties

	$\sigma_{0.2}$ / MPa	UTS / MPa	ε (%)
Mg-2Zn-**10Y-5Gd**-0.5Zr	248	273	0.6
Mg-2Zn-**5Y-15Gd**-0.5Zr	236	305	0.9
Mg-2Zn-**5Y-5Gd**-0.5Zr	126	251	12

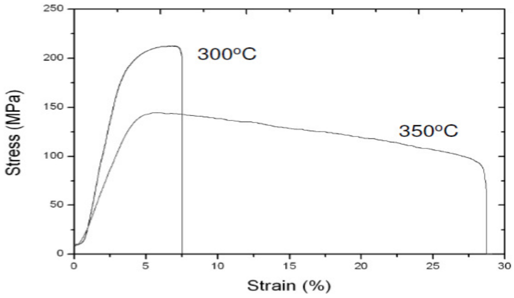


Fig. 6 Stress-strain curves of Mg-2Zn-10Y-5Gd-0.5Zr alloy at elevated temperatures

Fig. 3: Stress-strain curve of Mg-2Zn-10Y-0.5Zr alloy at evaluated temperature

J. Creep Strain

In order to determine the composition range, effects of Zn and Y content on the creep properties were investigated. It was found that the addition of Zn to Mg-10Y-5Gd-0.5Zr alloy remarkably improves the creep resistance, as shown in Table 4, summarizing the creep strain and secondary creep rate at 250°C, 80MPa. Furthermore, Zn content of mass % is most affective for the improvement of creep resistance.

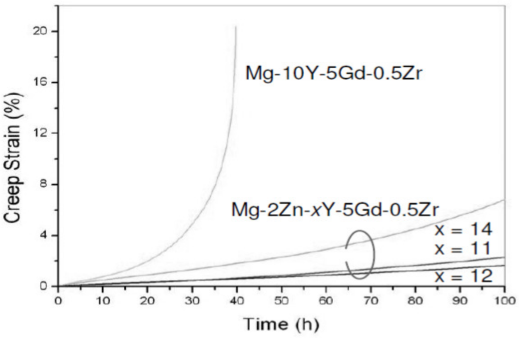


Fig. 7 Creep curves of the magnesium alloys at 300°C, 50MPa

Fig. 4: Creep curves of the Mg alloys at 300°C, 50MPa

K. Fatigue Strength

Based on the mechanical properties of various Mg-Zn-(Y,Gd)-Zr alloys above mentioned, Mg-2Zn-11Y-5Gd-0.5Zr alloy was selected for further investigations. Table 5 summarizers the high cycle tensile-tensile fatigue test at room temperature, 250°C and 300°C, comparing to those of A336-T6.

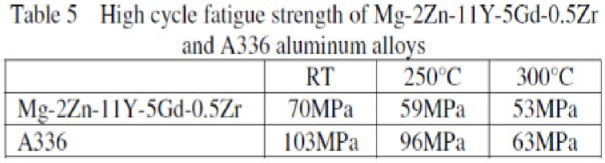


Table 5 High cycle fatigue strength of Mg-2Zn-11Y-5Gd-0.5Zr and A336 aluminum alloys

	RT	250°C	300°C
Mg-2Zn-11Y-5Gd-0.5Zr	70MPa	59MPa	53MPa
A336	103MPa	96MPa	63MPa

IV. MATHEMATICAL CALCULATION

A. Design of Cylinder

$$\mathrm{B.P.} = \frac{\mathrm{p_m L A n}}{60 * 1000} * \eta_m$$

$$L = 1.25\ D$$

$$L_c = L + L_1 + L_p$$

$$t = \frac{p_{max} D}{2\sigma_{all}}$$

$$t_f = 1.3\, t$$

Table IV
Dimensions of Cylinder

Cylinder bore D	90mm
Stroke L	115mm
Length of cylinder L_c	230mm
Thickness of cylinder wall t	10mm
Thickness of cylinder flange t_f	13mm

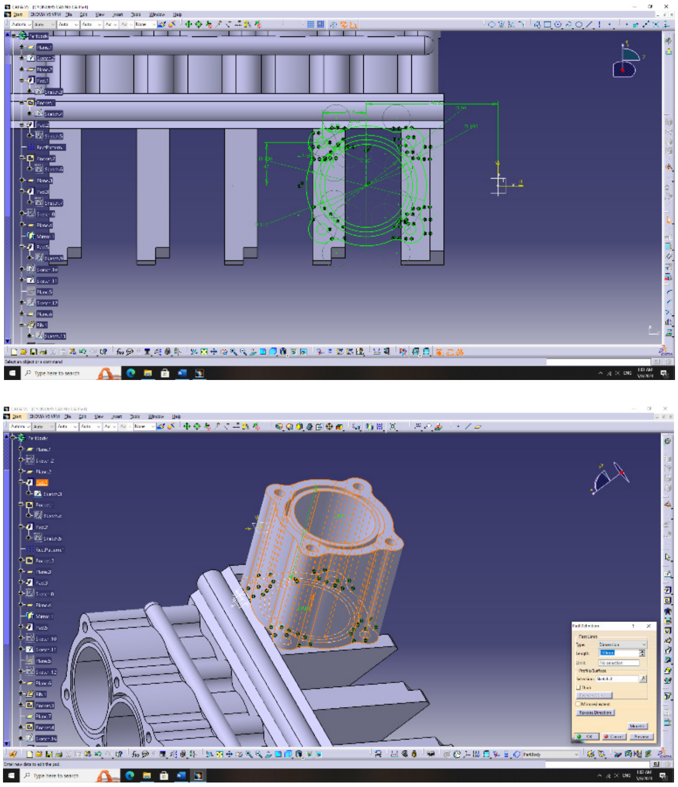


Fig. 5: Catia V-5 Modelling of Cyclinder

B. *DESIGN OF PISTON*

$$t_{ph} = 0.433D\sqrt{\frac{p_{max}}{\sigma_{allp}}}$$

$$t_{pb} = t_{ph}$$

$$t_r = \sqrt{\frac{3\, p_w}{\sigma_{br}}}$$

$$b_r = 0.75\, t_r \text{ to} 1.0\, t_r$$

$$R_n = L_{ps} * D * P_{bc}$$

$$l_1 = 0.45 * D$$

$$F_{gmax} = l_1 * d_p * 20 \qquad d_i = 0.6 * d_p$$

Table IV
Dimensions of Cylinder

Thickness of piston head t_{ph}	10mm
Thickness of piston barrel t_{pb}	10mm
Radial thickness of piston ring t_r	2mm
Axial width of piston ring b_r	2mm
Length of piston skirt L_{ps}	40mm
Length of piston pin in CR bearing l_1	35mm
Diameter of piston pin d_p and d_i	22mm and 17mm

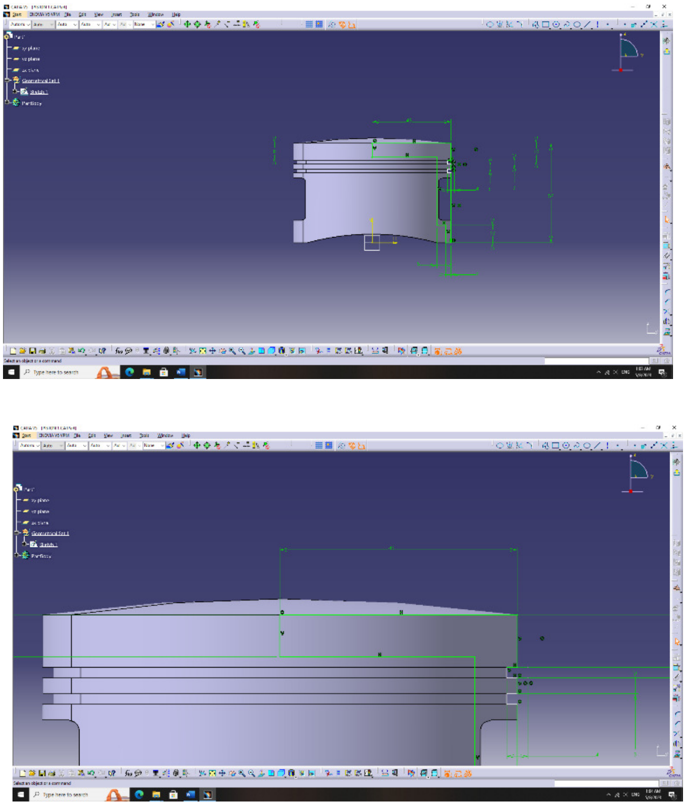


Fig. 6: Catia V-5 Modelling of Piston

C. DESIGN OF CONNECTING ROD

$$d_{pi} = d_p + 2 * \text{thickness of bearing bush}$$

$$d_{po} = 2 * d_p$$

$$F_{max} = l_{bc} * d_{cp} * p_b$$

$$L_{bc} = 1.4\, d_{cp}$$

$$d_{ci} = d_{cp} + 2 * \text{thickness of bearing bush}$$

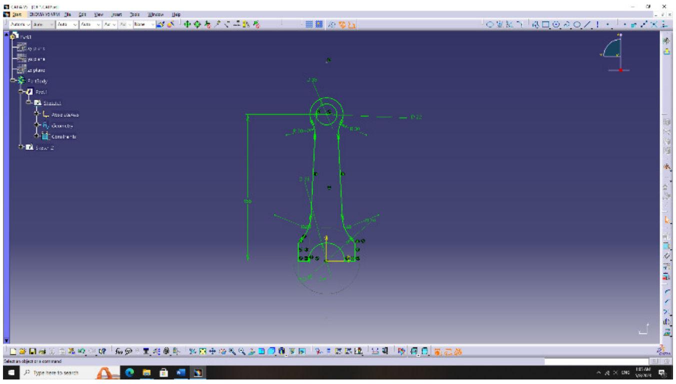
$$Z_{bc} = \frac{1}{6} * 48 * t_{bc}^2$$

$$d_{co} = 1.5 * d_{cp}$$

$$d_b = \frac{d_c}{0.84}$$

Table IV
Dimensions of Connecting Rod

Inner dia of small end d_{pi}	22mm
Outer diameter of small end d_{po}	35mm
Diameter of crank pin d_{cp}	34mm
Length of crank pin l_{bc}	11mm
Inner diameter of big end d_{ci}	38mm
Thickness of bearing cap t_{bc}	18mm
Outer diameter of big end d_{co}	70mm
Nominal diameter of bolts d_b	5mm



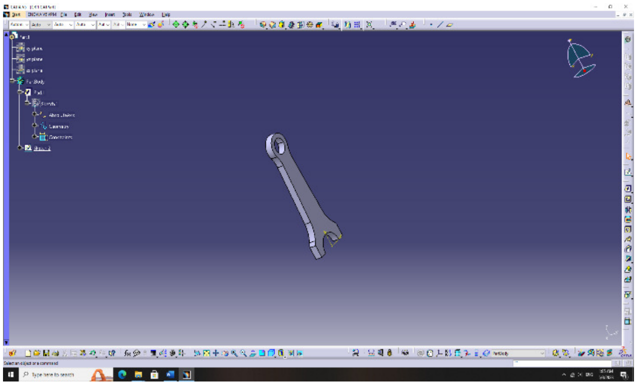


Fig.7: Catia V-5 Modelling of Connecting Rod

D. DESIGN OF CRANK SHAFT

$$a = 1.5\, d_c \qquad b = 1.35\, d$$

$$l_c = 1.25\, d_c$$

$$D_1 = 1.75\, d \qquad D_2 = 2\, d_c$$

$$T_b = 1 \text{ to } 1.25\, d$$

$$t_p = 1.4\, d_c$$

$$t = 0.7\, d$$

$$l_c = 1.1\, d$$

$$w = 1.14\, d$$

Table V
Dimension of Crank Shaft

A	38
B	60
l_c	40
D_1	120
D_2	60
T_b	40
t_p	7.5
T	28
l_c	44
W	45

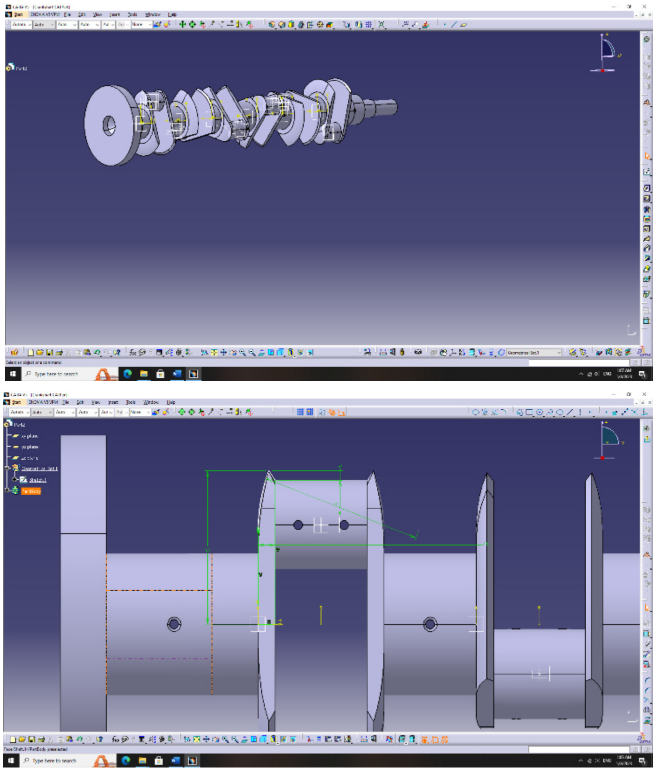


Fig. 8: Catia V-5 Modelling of Crank Shaft

E. DESIGN OF CRATER

For design of crater, we have already dimensions of cylinder total length. So, work of crater is to cover the crank shaft and store the oil. But here the quantity of oil required is also standard so this value is also fixed. By taking this consideration, we have done design accordingly and some dimensions were given below:

Table VI
Dimension of Crater

Length of crater	640mm
Width of crater	246mm
Height of crater	130mm

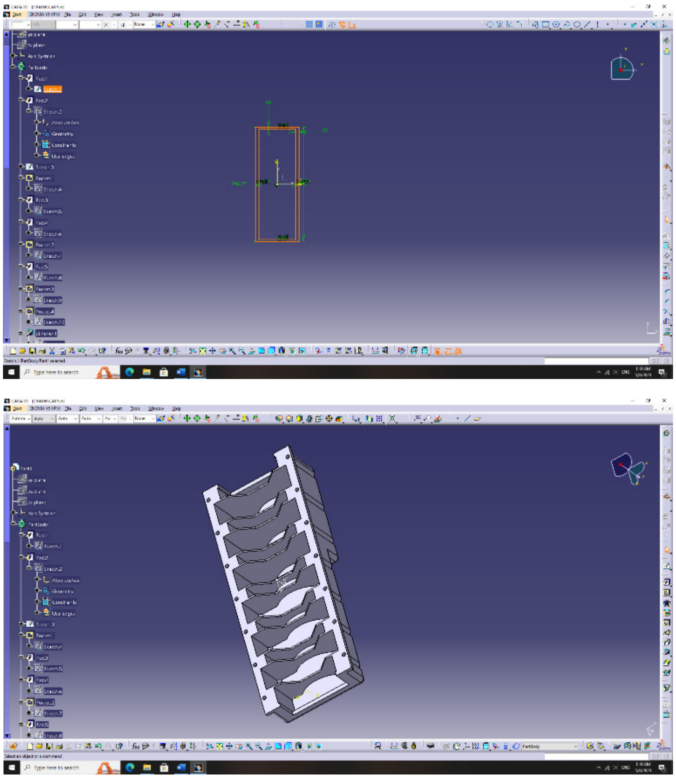


Fig. 9: Catia V-5 Modelling of Crater

F. ASSEMBLY

After the completion of individual parts, we have assembled them using CATIA V-5 assembly option.

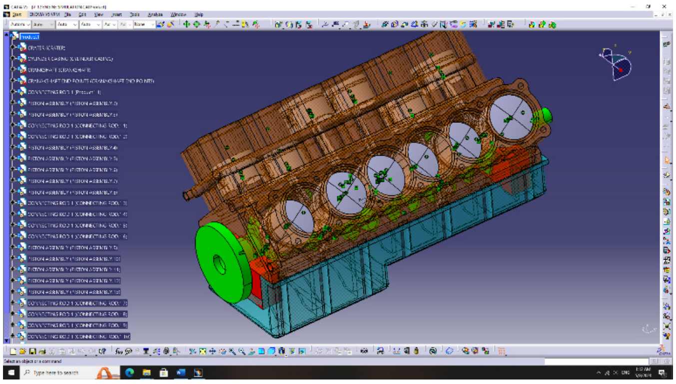


Fig. 10: Catia V-5 Assembly of V-12 Engine

V. ANALYSIS

After completing design and simulation of our project, we need do analysis our design for selected material. We assume that the load which applied on piston surface is static by nature applied on top surface. So, now we have to do static structural analysis. For this we have to first select the analysis software and that is ANSYS. In Ansys from different type of analysis like Rigid dynamic, steady state thermal, transient thermal and fluid flow analysis we select static structural analysis. And that home page is show in below figure.

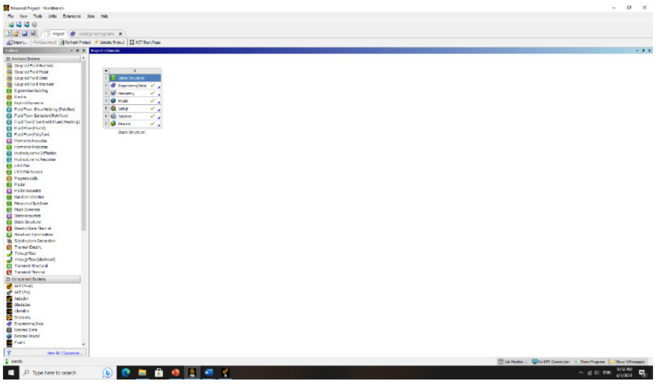


Fig. 11: ANSYS Home Page

A. Engineering Data

a. Magnesium Alloy

We have selected Magnesium Alloy as Research material. We have selected this material for research because our aim is to reduce the weight of engine and Magnesium have density around 1800 kg/m^{3} Hence, 33% it is 33% lighter than Aluminium alloy, which is currently in use and density is around 2700 kg/m^{3}. Some of the property is shown in below figure which is already in the library of ANSYS.

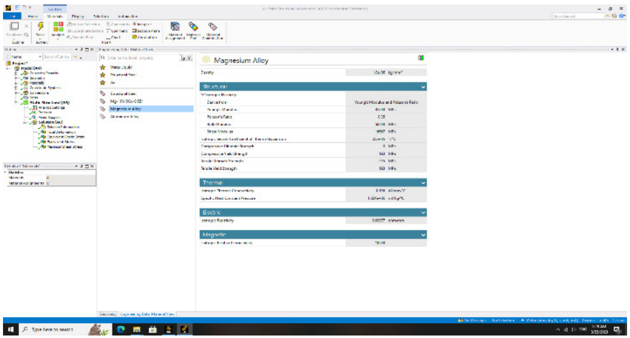


Fig. 12: Engineering Data of Mg Alloy

The properties were,

- Young's Modulus
- Poisson's Ratio
- Tensile ultimate strength
- Compressive ultimate strength
- Specific heat

b. Aluminium Alloy

We have selected Aluminium Alloy as reference material. We have selected this material for reference because currently in manufacturing of V-12 engine, 99% manufacturers use aluminium alloy, because of its advantages over previously used structural steel. Aluminium alloy, which is currently in use and density is around 2700 kg/m^{3}. Some of the property is shown in below figure which is already in the library of ANSYS.

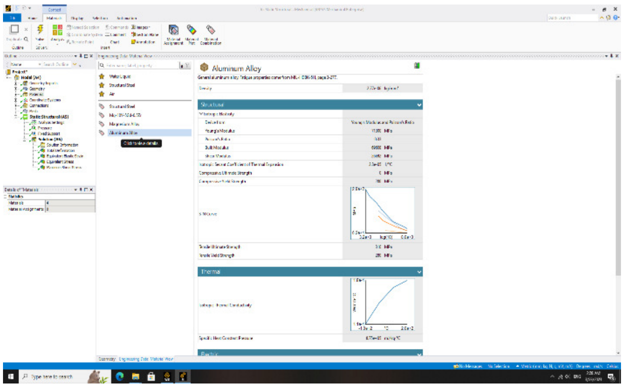


Fig. 13. Engineering Data of Aluminium Alloy

The properties were,

- Young's Modulus
- Poisson's Ratio
- Tensile ultimate strength
- Compressive ultimate strength
- Specific heat

c. Al-GHY-1250 Alloy:

We have selected Aluminium Alloy as reference material. Al-GHY-1250 Alloy, which is currently in use. Some of the property in below figure which is already in the library of ANSYS.

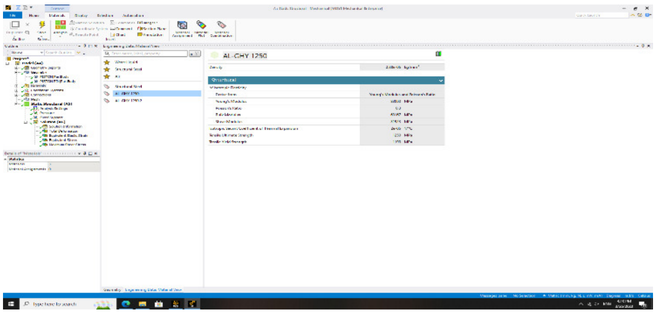


Fig. 14: Engineering Data of Al-GHY-1250 Alloy

The properties were,

- Young's Modulus
- Poisson's Ratio
- Tensile ultimate strength
- Compressive ultimate strength
- Specific heat

d. Mg-2Zn-10Y-5Gd-0.5Zr Alloy

We have selected Mg-2Zn-10Y-5Gd-0.5Zr alloy as reference material. Mg-2Zn-10Y-5Gd-0.5Zr alloy, which is currently in research. Some of the property is show in below figure which is already in the library of ANSYS.

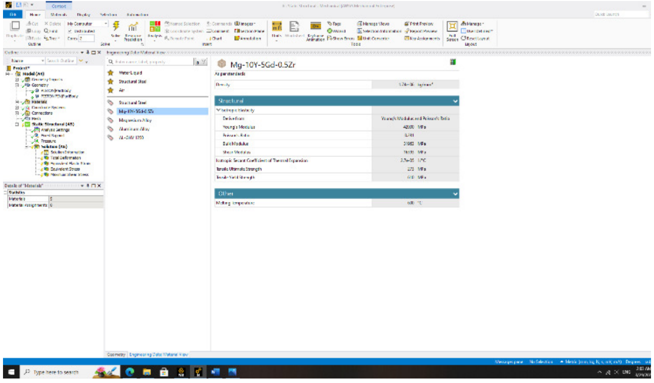


Fig. 15: Engineering Data of Mg-2Zn-10y-5Gd-0.5Zr Alloy

The properties were,

- Young's Modulus
- Poisson's Ratio
- Tensile ultimate strength
- Tensile yield strength
- Shear Modulus
- Bulk Modulus

B. MODEL

After assigning the material in geometric data. The geometry is shown in figure. In the geometry showing piston and piston pin. It also shows the coordinate system; means axis it shows we have done our design on XY Plane. Also, with the help of coordinate system we can shows the view with any reference axis as well as any plane. The below figure shows piston with reference to axis/plane and also the scale which is 0-90 mm in figure.

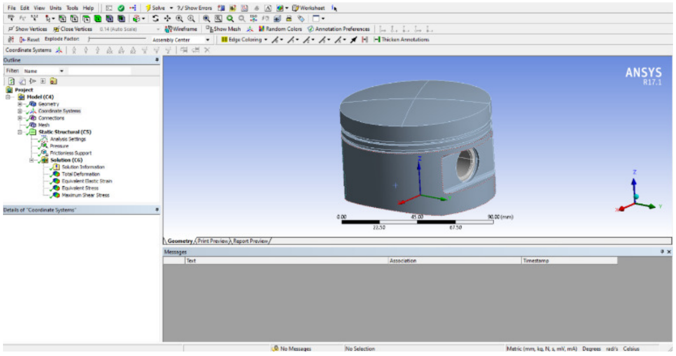


Fig. 16: ANSYS Model

C. SETUP

a. MESH

After assigning the material property and importing geometry, the analysis starts with meshing. The process of dividing the whole component into a number of elements so that whenever the load is applied on the compnent is distributes the load uniformly called as meshing. In this process we select a fine mesh. The reason to choose the fine mesh is the results for coarse, medium and fine were gives huge range. And this decreases after seleting smaller grid size and after fine means very fine didn't give very fluctuating results. And also take a lot of time to get results so we have selected the fine mesh over coarse, medium and very fine.

Statics:

- Nodes 107957
- Elements 63305

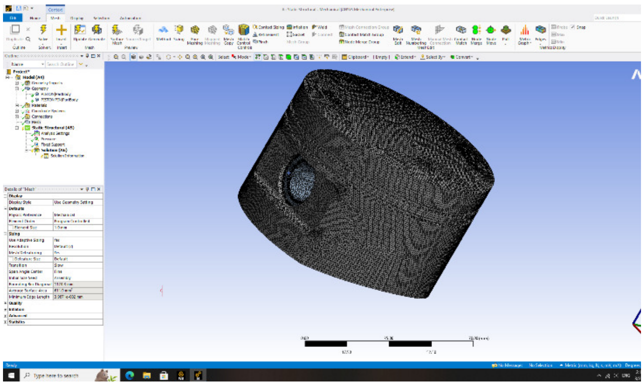
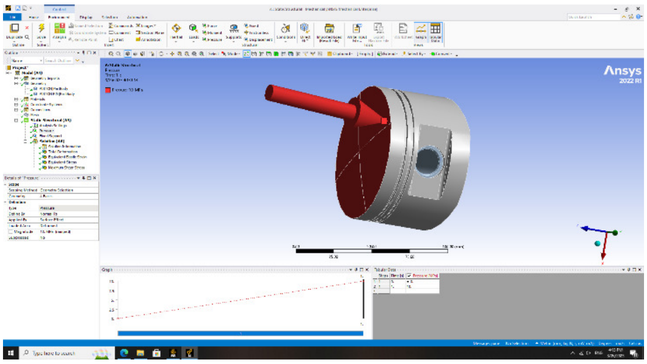
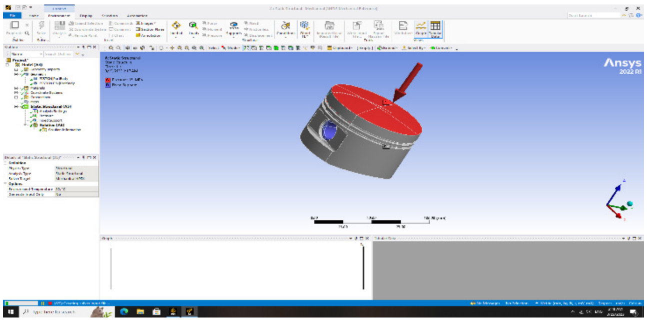


Fig. 17: Meshing

b. PRESSURE

The pressure is applied on top surface of piston because after combustion of fuel the maximum pressure will applied on top surface of piston. The pressure is around 5 MPa, 10 MPa and 15 MPa, which is maximum pressure exerting on piston and for that value the analysis has to be done.





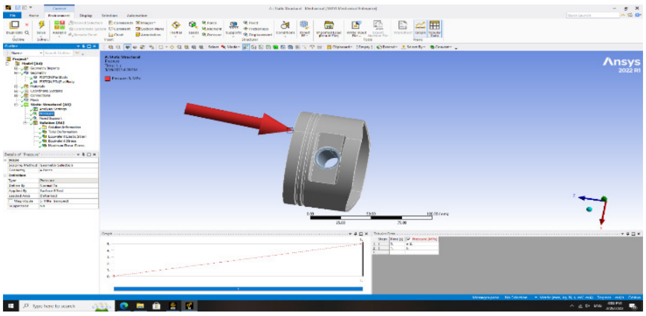


Fig. 17: Pressure on top surface

The figure shows red surface when pressure exert and magnitude is 5 MPa, 10 MPa and 15 MPa.

c. FRICTIONLESS SUPPORT

It is assumed that the contact between cylinder and piston as well as contact between connecting rod and piston pin having friction less contact. And this is shown in below figure. As a figure showing that blue surface suggests that there is frictionless contact. That side were piston surface that have contact with cylinder inner surface, and another surface of piston’s outer surface connecting rod’s inner circular surface at smaller end.

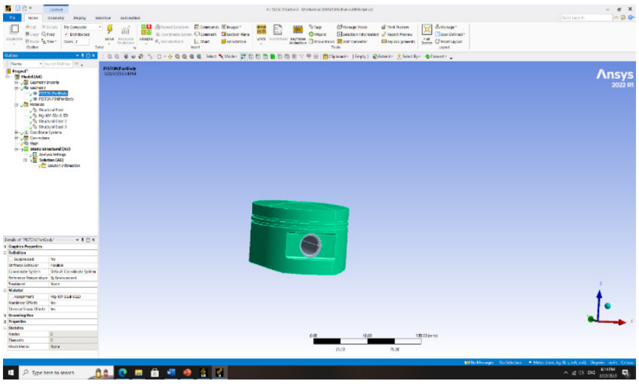


Fig. 18: Frictionless Support

D. SOLUTION/RESULTS

a. Total Deformation

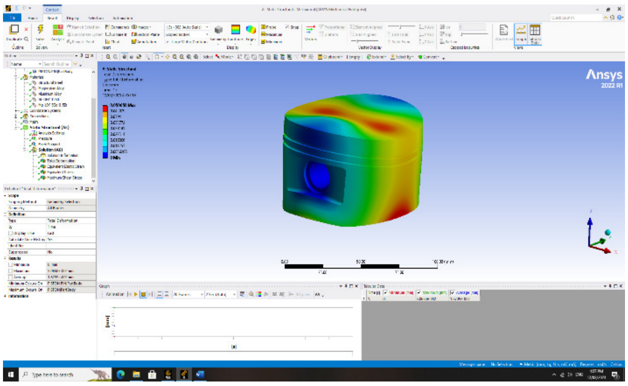


Fig. 19: ANSYS Total Deformation for Mg Alloy

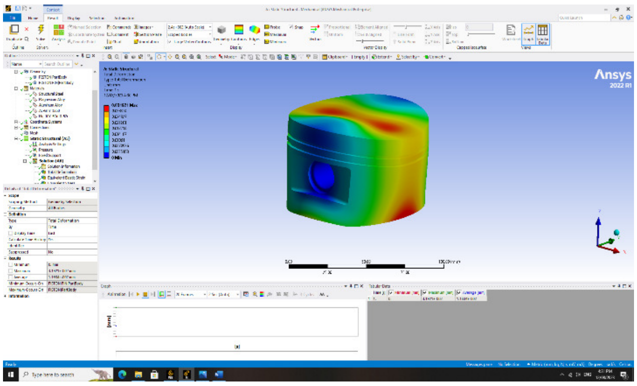


Fig. 20: ANSYS Total Deformation for Al Alloy

b. Equivalent Elastic Strain

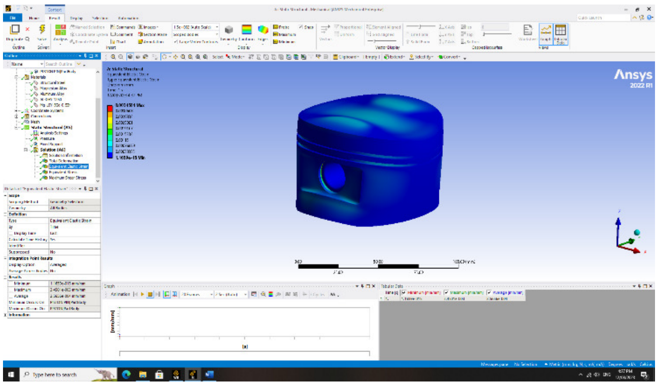


Fig. 21: ANSYS Equivalent Elastic Strain for Mg Alloy

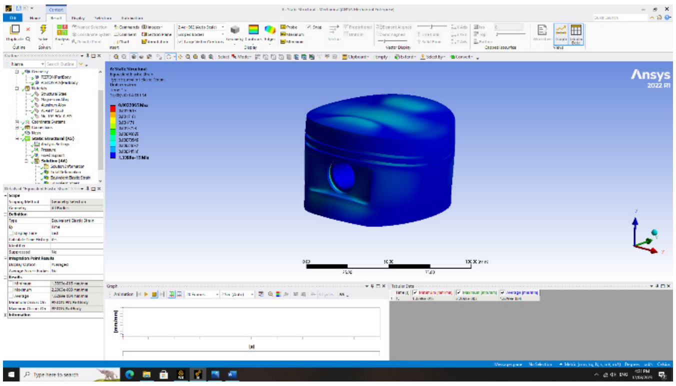


Fig. 22: ANSYS Equivalent Elastic Strain for Al Alloy

c. Equivalent Stress

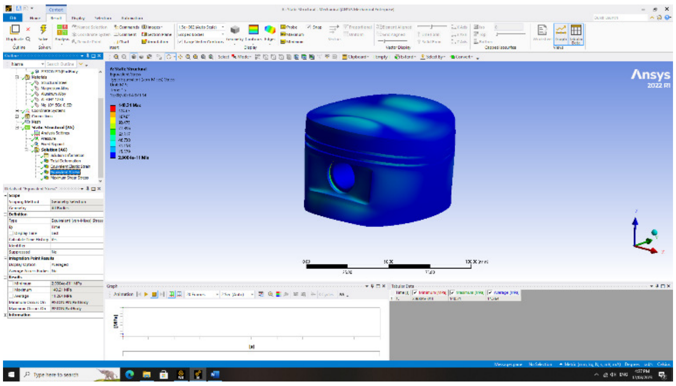


Fig. 23: ANSYS Equivalent stress for Mg Alloy

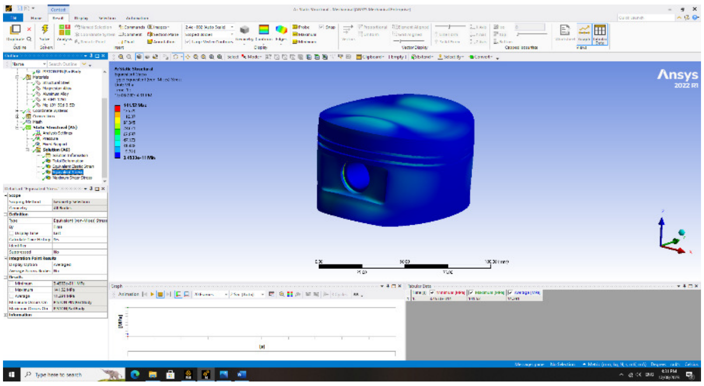


Fig. 24: ANSYS Equivalent stress for Al Alloy

d. Maximum Shear Stress

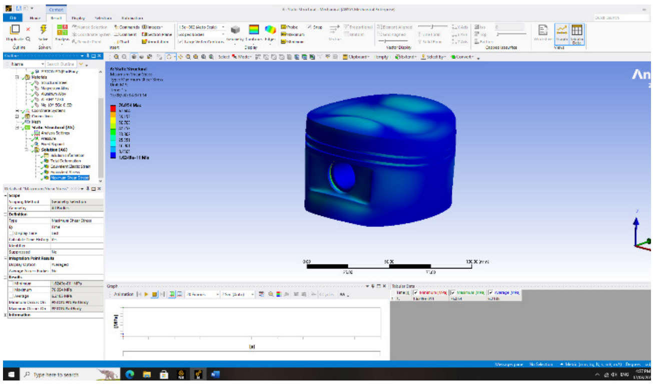


Fig. 25: ANSYS Maximum Shear stress for Mg Alloy

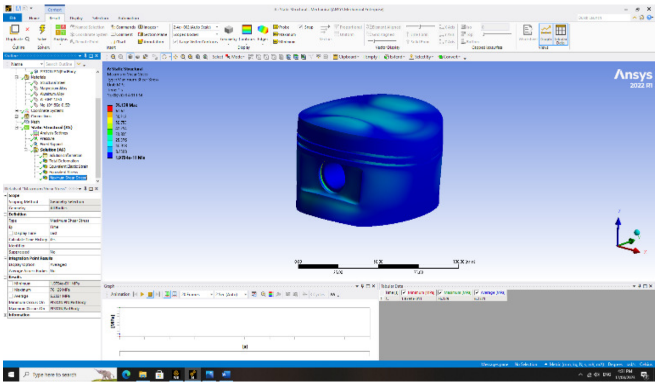


Fig. 26: ANSYS Maximum Shear stress for Al Alloy

e. Temperature

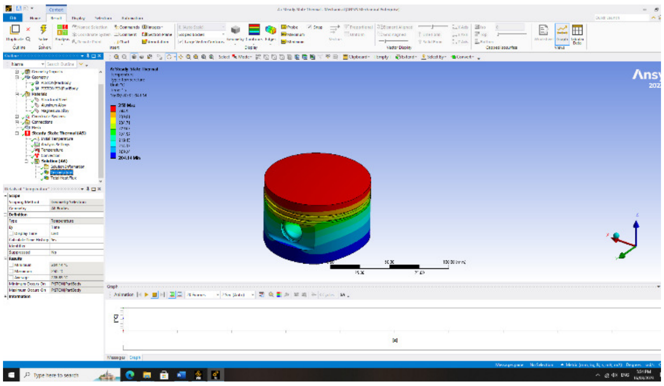


Fig. 27: ANSYS Temperature for Al Alloy

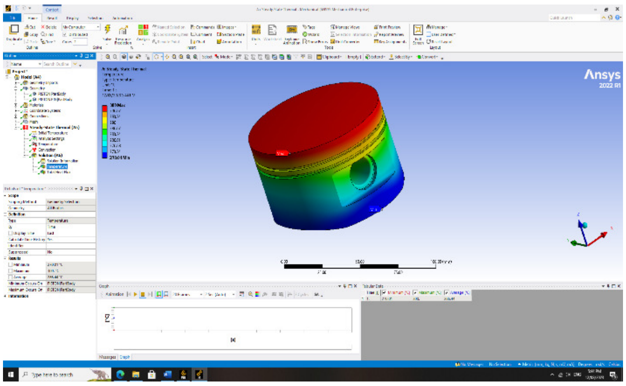


Fig. 28: ANSYS Temperature for Mg Alloy

f. Total Heat Flux

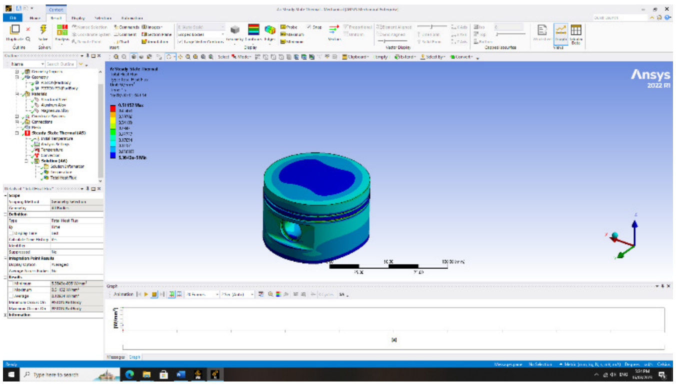


Fig. 29: ANSYS Total Heat Flux for Al Alloy

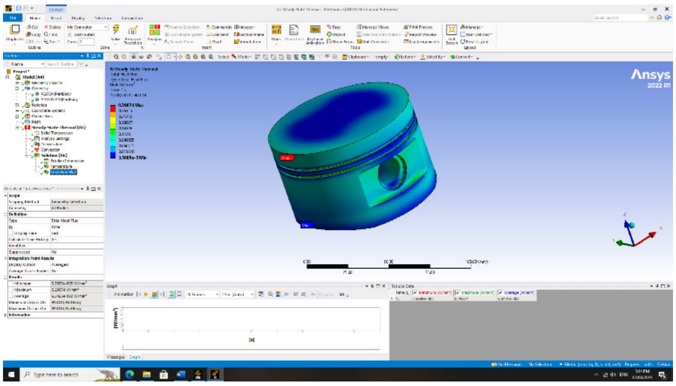


Fig. 30: ANSYS Total Heat Flux for Mg Alloy

VI. COMPARISON

A. Stress Analysis

a. Node: 418085 & Elements: 243902

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (MPa)
1.	5 MPa	Al Alloy	0.031921	141.52
		Mg Alloy	0.050658	140.21
		AL-GHY-1250	0.027052	143.46
		Mg-2Zn-10Y-5Gd-0.5Zr	0.053124	144.69
2.	10MPa	Al Alloy	0.063842	283.04
		Mg Alloy	0.10132	280.43
		AL-GHY-1250	0.054104	286.93
		Mg-2Zn-10Y-5Gd-0.5Zr	0.10625	289.38
3.	15 MPa	Al Alloy	0.095763	424.55
		Mg Alloy	0.15197	420.64
		AL-GHY-1250	0.081156	430.39
		Al Alloy	0.15937	434.07

Table VII

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			MAXIMUM SHEAR STRESS (MPa)	EQUIVALENT ELASTIC STRAIN (mm/mm)
1.	5 MPa	Al Alloy	76.129	0.0022065
		Mg Alloy	76.054	0.0034501
		AL-GHY-1250	76.227	0.0019111
		Mg-2Zn-10Y-5Gd-0.5Zr	76.293	0.00381
2.	10MPa	Al Alloy	152.26	0.0044129
		Mg Alloy	152.11	0.0069002
		AL-GHY-1250	152.45	0.0038222
		Mg-2Zn-10Y-5Gd-0.5Zr	152.59	0.0076226
3.	15 MPa	Al Alloy	228.39	0.0066194
		Mg Alloy	228.16	0.01035
		AL-GHY-1250	228.68	0.0057334
		Al Alloy	228.88	0.011434

Table VIII

b. Node: 86086 & Elements: 24390

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (MPa)
1.	5 MPa	Al Alloy	0.031655	141.96
		Mg Alloy	0.050231	140.85
		AL-GHY-1250	0.026829	143.61
		Mg-2Zn-10Y-5Gd-0.5Zr	0.052689	144.64
2.	10MPa	Al Alloy	0.06331	283.93
		Mg Alloy	0.10046	281.71
		AL-GHY-1250	0.053658	287.21
		Mg-2Zn-10Y-5Gd-0.5Zr	0.10538	289.28
3.	15 MPa	Al Alloy	0.094965	425.89
		Mg Alloy	0.15069	422.56
		AL-GHY-1250	0.080487	430.82
		Al Alloy	0.15807	433.92

Table IX

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			MAXIMUM SHEAR STRESS (MPa)	EQUIVALENT ELASTIC STRAIN (mm/mm)
1.	5 MPa	Al Alloy	74.729	0.0022326
		Mg Alloy	74.937	0.0034858
		AL-GHY-1250	74.727	0.0019388
		Mg-2Zn-10Y-5Gd-0.5Zr	74.768	0.00638668
2.	10MPa	Al Alloy	149.46	0.0044653
		Mg Alloy	149.87	0.0069717
		AL-GHY-1250	149.45	0.0038776
		Mg-2Zn-10Y-5Gd-0.5Zr	149.54	0.0077336
3.	15 MPa	Al Alloy	224.19	0.0066979
		Mg Alloy	224.81	0.010458
		AL-GHY-1250	224.18	0.0058163
		Al Alloy	224.3	0.0116

Table X

c. *Node: 67780 & Elements: 38195*

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (MPa)
1.	5 MPa	Al Alloy	0.031492	140.68
		Mg Alloy	0.049967	139.59
		AL-GHY-1250	0.026694	142.26
		Mg-2Zn-10Y-5Gd-0.5Zr	0.052425	143.24
2.	10MPa	Al Alloy	0.062983	281.36
		Mg Alloy	0.099934	279.18
		AL-GHY-1250	0.053387	284.52
		Mg-2Zn-10Y-5Gd-0.5Zr	0.10485	286.48
3.	15 MPa	Al Alloy	0.094475	422.04
		Mg Alloy	0.1499	418.77
		AL-GHY-1250	0.080081	426.79
		Al Alloy	0.15728	429.71

Table XI

SR. NO.	PRESSURE	MATERIAL	ANSYS RESULT	
			MAXIMUM SHEAR STRESS (MPa)	EQUIVALENT ELASTIC STRAIN (mm/mm)
1.	5 MPa	Al Alloy	75.676	0.0022234
		Mg Alloy	75.883	0.0034798
		AL-GHY-1250	75.297	0.0019237
		Mg-2Zn-10Y-5Gd-0.5Zr	75.071	0.0038278
2.	10MPa	Al Alloy	151.35	0.0044468
		Mg Alloy	151.77	0.0669596
		AL-GHY-1250	150.59	0..0038474
		Mg-2Zn-10Y-5Gd-0.5Zr	150.06	0.0076555
3.	15 MPa	Al Alloy	227.03	0.0066702
		Mg Alloy	227.65	0.010439
		AL-GHY-1250	225.89	0.005771
		Al Alloy	225.09	0.011483

Table XII

B. *Thermal Analysis*

Here, the temperature and convection of Aluminium alloy and Magnesium alloy is 250°C, 0.0007 W/mm^2°C, 350°C and 0.0001 W/mm^2°C.

a. *Node: 418085 & Elements: 243902*

SR. NO.	MATERIAL	ANSYS RESULT	
		TEMPERATURE (°C)	TOTAL HEAT FLUX (W/mm^2)
1.	**Al Alloy**	250	0.51152
	Mg Alloy	300	0.29874

Table XIII

b. *Node: 86086 & Elements: 24390*

SR. NO.	MATERIAL	ANSYS RESULT	
		TEMPERATURE (°C)	TOTAL HEAT FLUX (W/mm^2)
1.	**Al Alloy**	250	0.39109
	Mg Alloy	300	0.20739

Table XIV

c. *Node: 67780 & Elements: 38195*

SR. NO.	MATERIAL	ANSYS RESULT	
		TEMPERATURE (°C)	TOTAL HEAT FLUX (W/mm^2)
1.	**Al Alloy**	250	0.35435
	Mg Alloy	300	0.18807

Table XV

- Total deformation's value for aluminium alloy is 0.03492 mm and for same magnesium alloy is 0.049967 mm. Here, the value for magnesium alloy is good but the life of aluminium alloy will be higher than this magnesium alloy.
- Equivalent Elastic strain is 0.0022234 mm/mm for aluminium alloy and 0.0034798 mm/mm for magnesium alloy. Here, the strain for magnesium alloy is higher but it is in permissible limit. For future progress the design should such that this value can be minimised and better result will get.
- Equivalent stress is 140.68 MPa for aluminium alloy and 139.59 MPa for magnesium alloy. This property should be increased for magnesium alloy for better life of component.

- Maximum Shear stress is 75.676 MPa for aluminium alloy and 75.883 MPa for magnesium alloy. As, from values given above we can see that magnesium alloy is a good choice. Reducing the mesh size can have an impact on the accuracy and converges of simulation results.
- If you reduce the mesh size for the magnesium alloy, you might get more accurate results, particularly in capturing localized stress concentrations and deformation patterns. However, reducing the mesh size can also increase computational time and resource requirements.
- For the magnesium alloy at a temperature of 300 °C, the ANSYS simulation indicates a total heat flux of 0.29874 W/mm^2. The ANSYS simulation shows that when the aluminium alloy is at a temperature of 250 °C, the total heat flux from the surface is 0.51152 W/mm^2. The lower convection coefficient for magnesium compared to aluminium leads to a lower rate of heat transfer in this case.

Future Work:

In advance level, the one can modify the design for getting better results because it can be considered as a primary design. The more complex design can be made and the appropriate result will be there. Also, the same design can be considered for other material and that may be give better results. The one can do more in material selection and the research can be done for better properties of same material by doing such process and improve its property like hardening, increase creep strength, young's modulus, etc.

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