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Dimensional Modelling and Analysis of Automotive Master Cylinder

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***Abstract*— In the entire braking system master cylinder is the key role component for a hydraulic braking system which controls the complete braking system. A reservoir is arranged to store the brake oil in the master cylinder.**
As the lubricating oil is in a closed circuit, the pulling force applied by the braking pedal is changes into the hydraulic pressure and it is then distributed to the entire brake unit. The master cylinder had a cylinder formed reservoir and it is made with molded plastics in a single piece. In this thesis, a master cylinder is designed and done the optimization for the stress and heat affected areas using CATIA 3D Modelling and simulated by ANSYS software.

***Keywords*— include at least 5 keywords or phrases**

I. INTRODUCTION

The master cylinders are controlling device in all the automobiles, which converts pulling force developed by a driver's foot into hydraulic pressure. As piston moves inside the cylinder bore by pulling force applied by the driver brake oil is pushed the slave cylinder(s). By reducing the weight of the vehicle, will improve the vehicle’s handling capability as well as performance enhancement. Many of the manufacturers are insisting on decreasing the vehicle’s weight by choosing material with low weight for the body panels. In olden days, the automotive body panels are prepared by using cast iron but it is recently replaced with Aluminium and its alloys and etc. because they need to offer light weight materials compare to cast iron.

A vehicle is passed over the road surface through tires by the produced traction force. This small tire contacting area contacted with the road contact area is generating the acceleration, steering or braking force. Due to the changing traffic conditions and for the safe operation it is required to change the speed of the vehicle. to avoid accidents and controlling on vehicle speed the brakes are the most important safety critical components. The brake system must be operates the most effective in all the conditions such as slippery wet roads and dry roads. The Master cylinder is an important element in the entire hydraulic braking unit, which initiating and controlling the braking action. As we know that the fluid in a closed circuit, the force applied with the brake pedal is transforming into a pressure, which is circulated to the braking unit through the brake lines. Inside a closed system, the pressure is equal in all the areas, the oil is circulated from the cylinder is uniform throughout the braking unit. The Master cylinder basic function is same in all the brake system even it is comes in different shapes and sizes.

II. METHODOLOGY

2.1. Modelling and Design of Master Cylinder

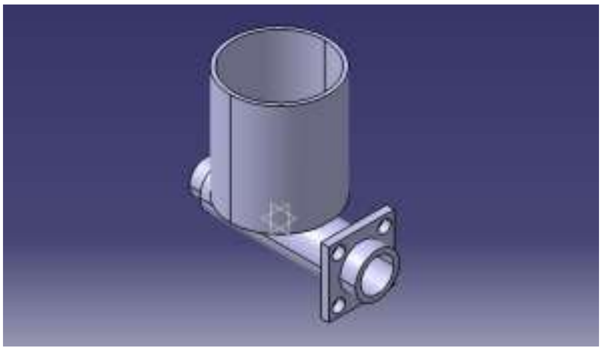


Fig 1.model of master cylinder

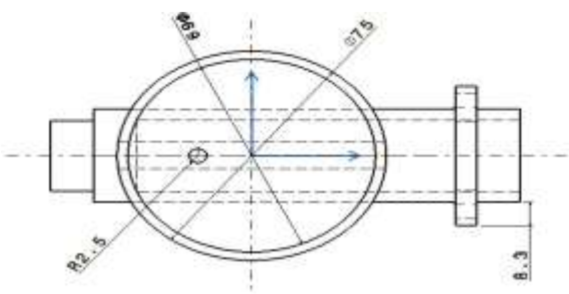


Fig 2. drafted top view of master cylinder

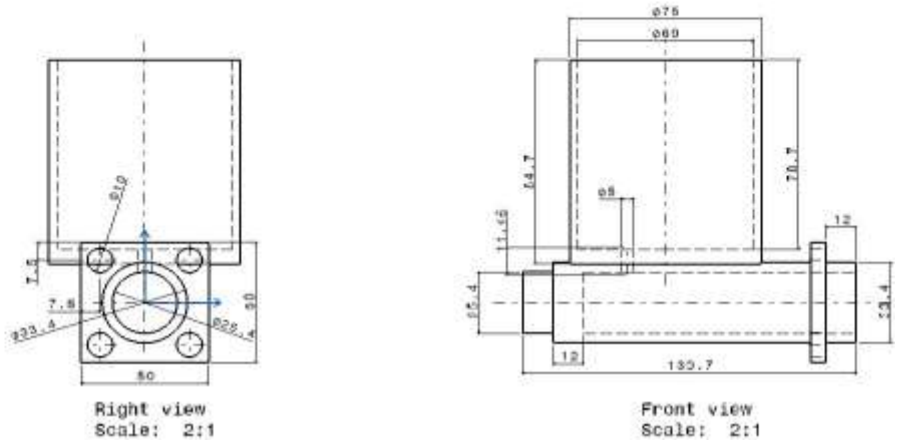
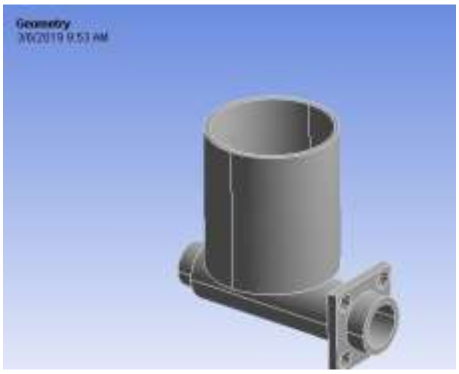


Fig 3. Drafted front and right side view

III. THERMAL ANALYSIS OF MASTER CYLINDER



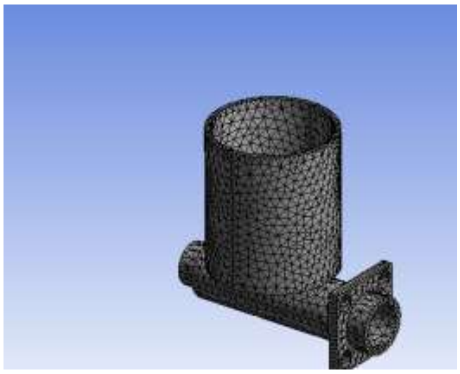


Fig 4. Geometry model imported in to ANSYS

Fig 5. Meshed model of master cylinder

3.1. Boundary conditions

Fig 6. PARAMETER – 1

Fig 7. PARAMETER – 2

Fig 8. PARAMETER – 3

Fig 9. PARAMETER – 4

3.2. Ansys Results for The Acetyl Polymer For Parameter 1

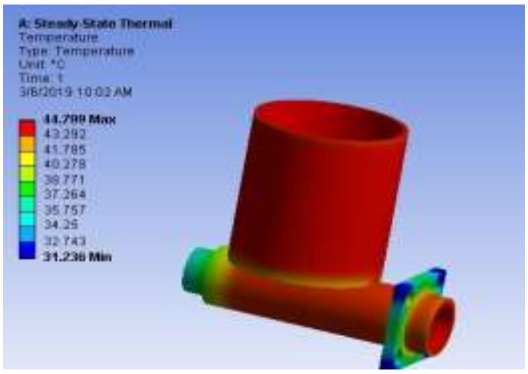


Fig 10 temperature

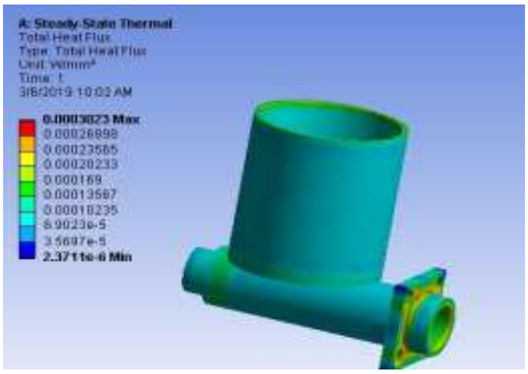


Fig 11 total heat flux

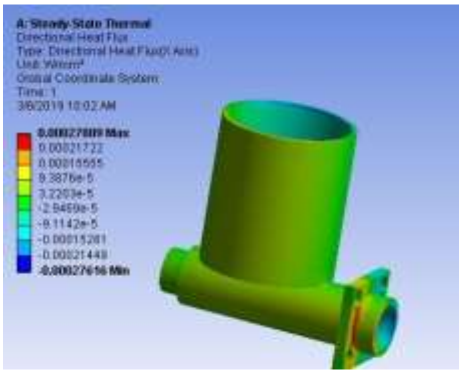


Fig 12 directional heat flux

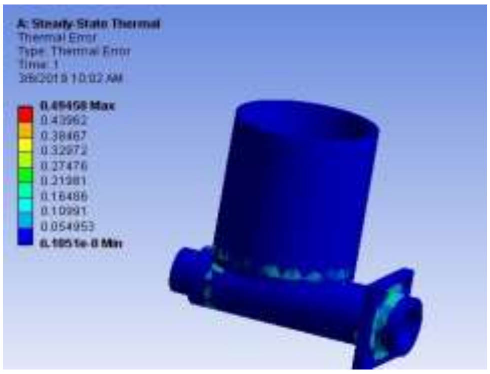


Fig 13 thermal error

3.3. Ansys Results for The Acetyl Polymer For Parameter 2

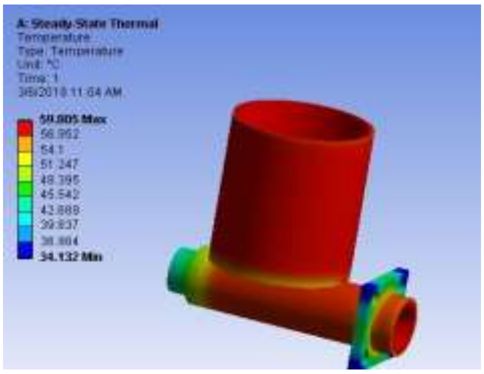


Fig 14 temperature

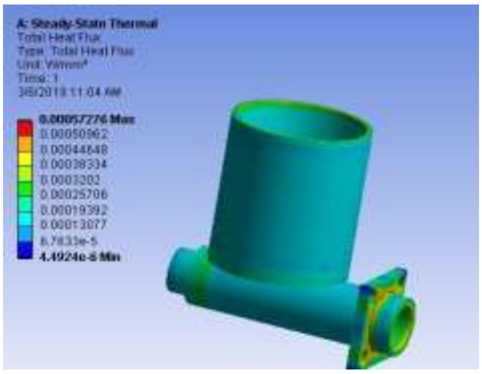


Fig 15 total heat flux

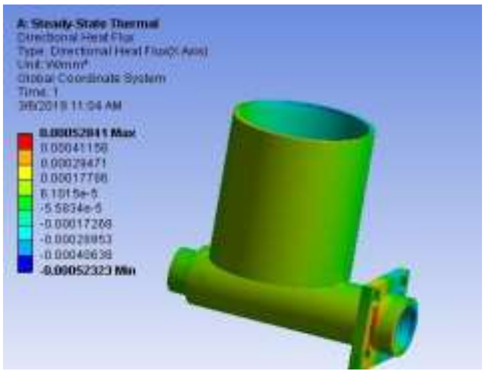


Fig 16 directional heat fiux

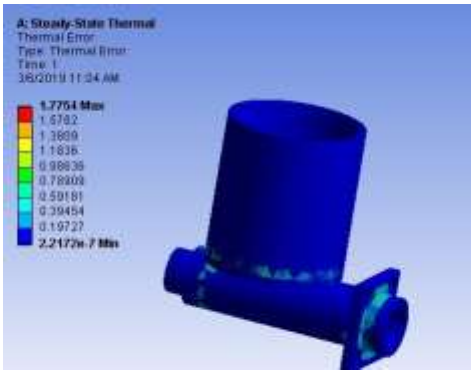


Fig 17 thermal error

3.4. Ansys Results For The Acetyl Polymer For Parameter 3

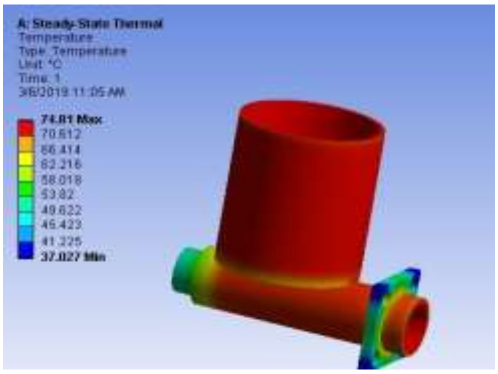


Fig 18 temperature

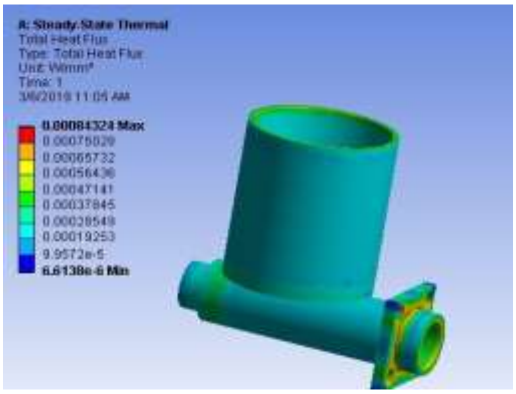


Fig 19 total heat flux

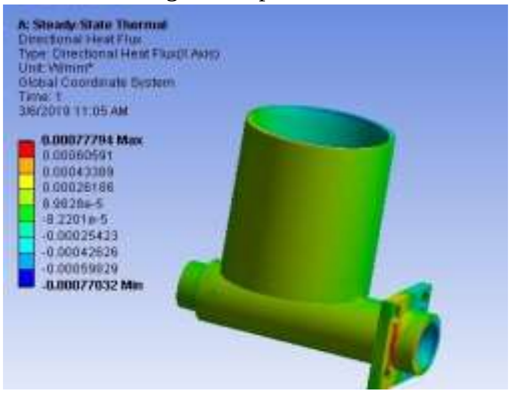


Fig 20 directional heat flux

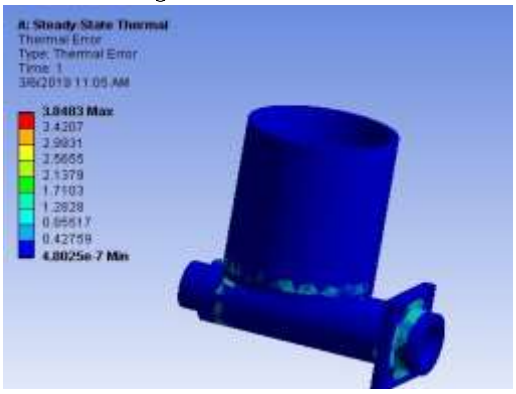


Fig 21 thermal error

3.5. ***Ansys Results for the Al 2024 for Parameter 1***

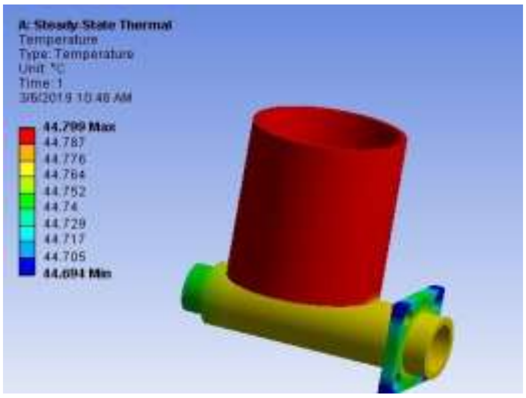


Fig 5.33 temperature

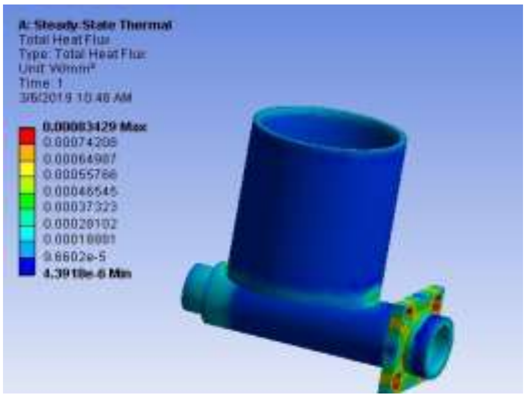


Fig 5.34 total heat flux

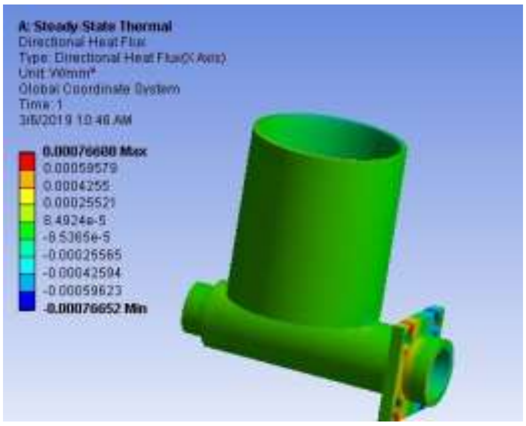


Fig 5.35 directional heat flux

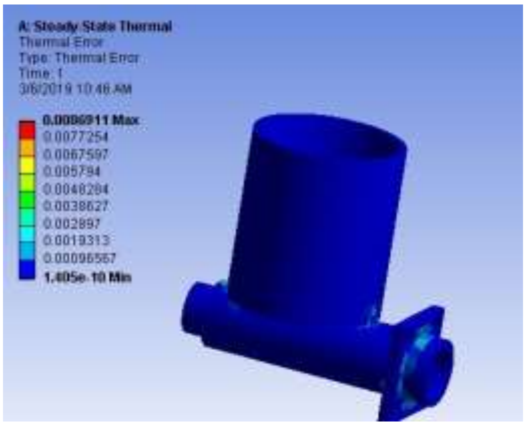


Fig 5.36 thermal error

3.6. Ansys Results for the Al 2024 For Parameter 2

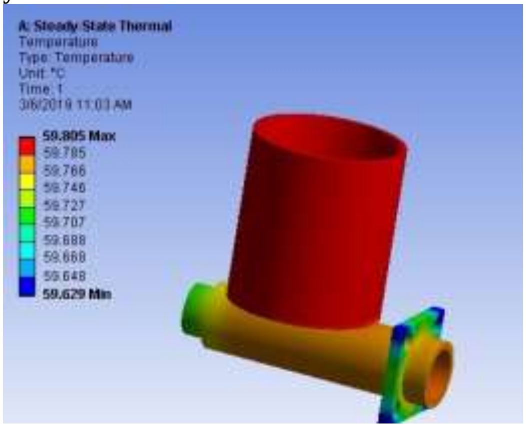


Fig 5.37 temperature

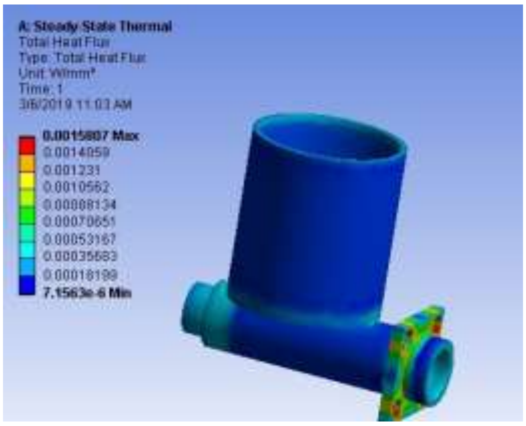


Fig 5.38 total heat flux

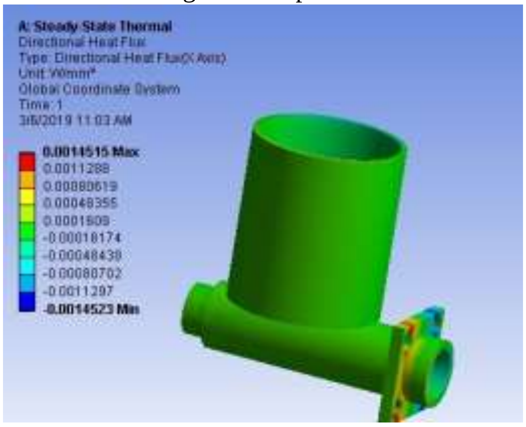


Fig 5.39 directional heat flux

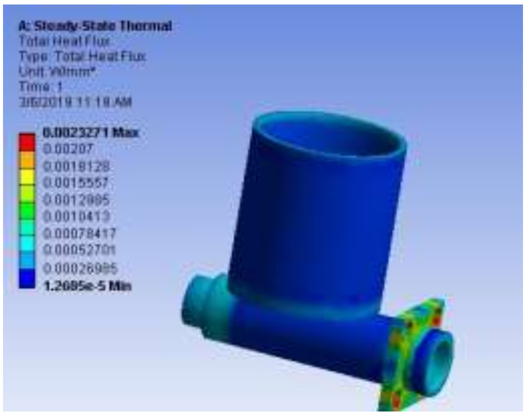


Fig 5.40 thermal error

3.7. Ansys Results for The Al 2024 For Parameter 3

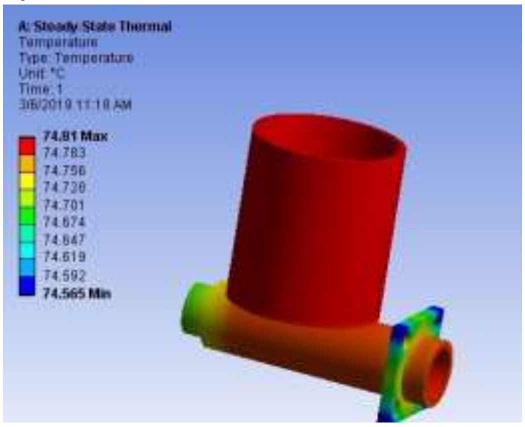


Fig 5.41temperature

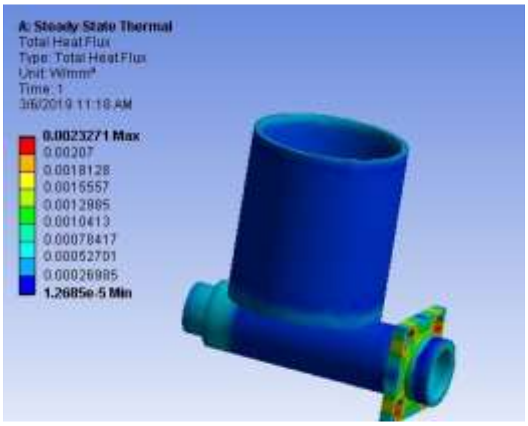


Fig 5.42 total heat flux

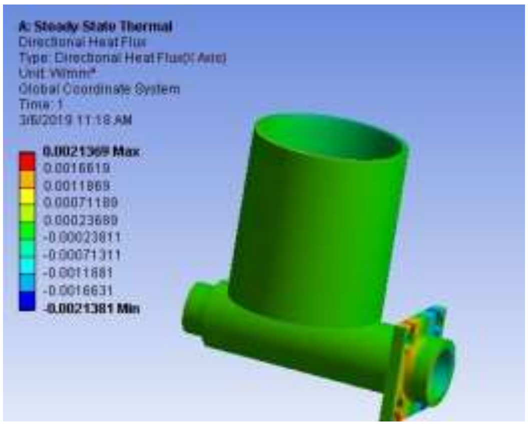


Fig 5.43 directional heat flux

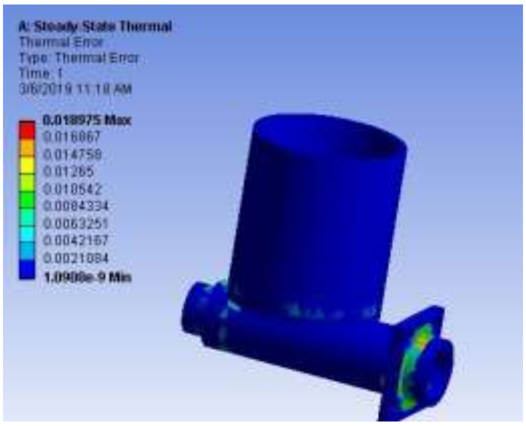


Fig 5.44 thermal error

3.8. Structural Analysis of Master Cylinder Different Input Parameters Considered In Structural Analysis for Ansys

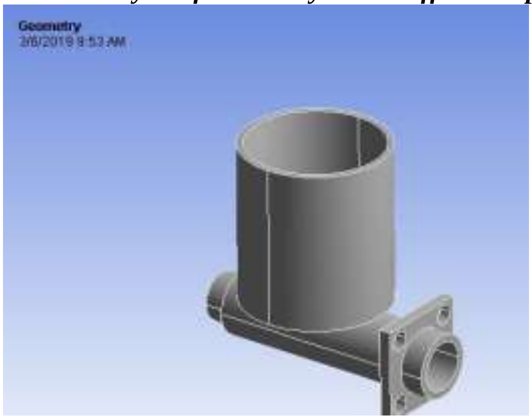


Fig 5.1 geometry model imported in to ANSYS

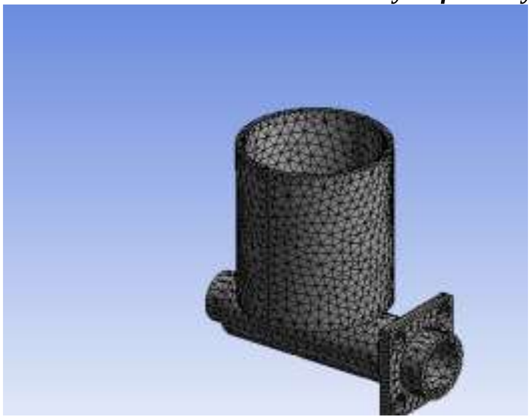


Fig 5.2 Meshed model of master cylinder

Parameter –1

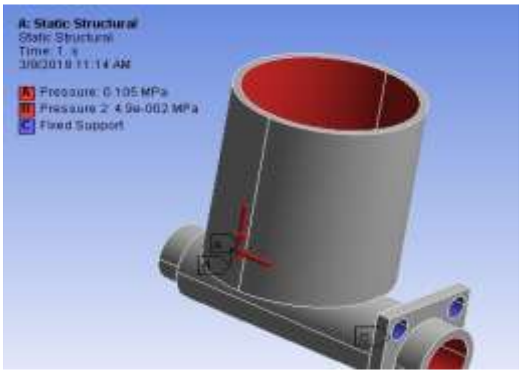


Fig 5.57 structural analysis at pressure 0.105 Mpa

Parameter – 2

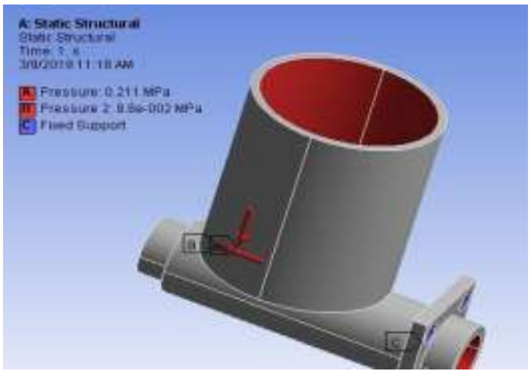


Fig 5.58 structural analysis at a pressure of 0.211 Mpa

Parameter – 3

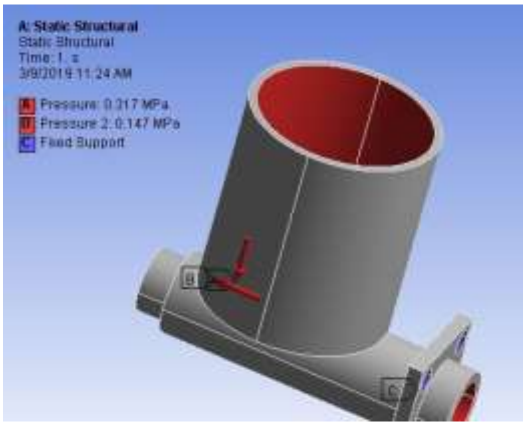


Fig 5.59 structural analysis at a pressure of 0.317 Mpa

Parameter – 4

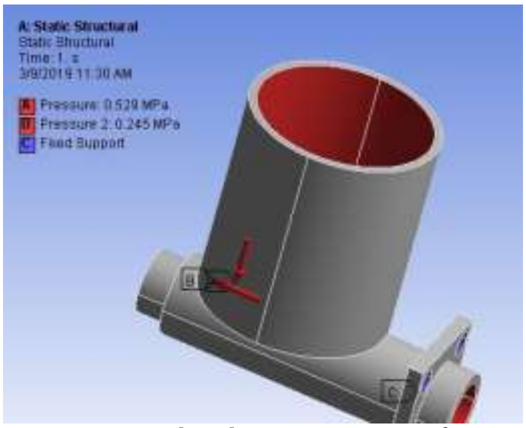


Fig 5.61 structural analysis at a pressure of 0.529 Mpa

3.9. Ansys Results For The Acetyl Polymer For Parameter 1

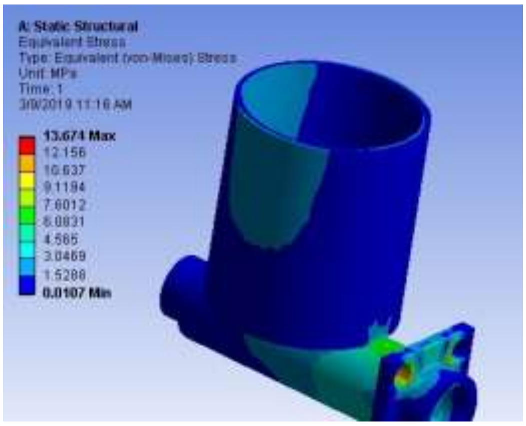


Fig 5.62 equivalent stress

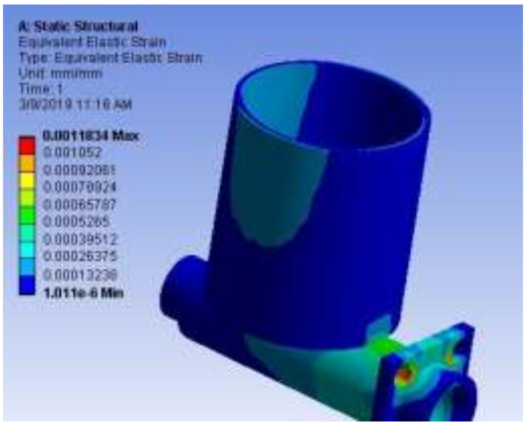


Fig 5.63 equivalent elastic strain

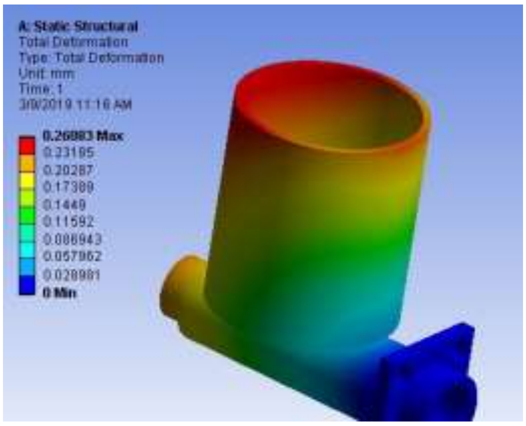


Fig 5.64 total deformation

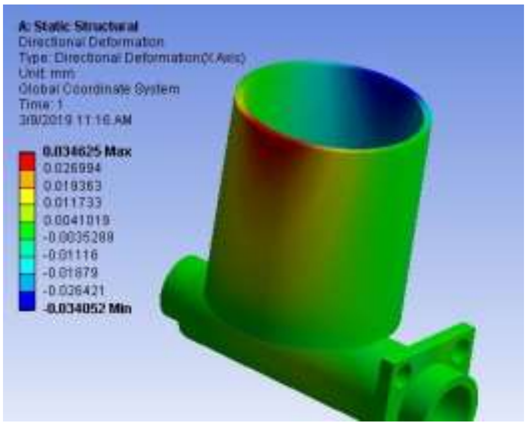


Fig 5.65 directional deformation

3.10. Ansys Results for the Acetyl Polymer for Parameter 2

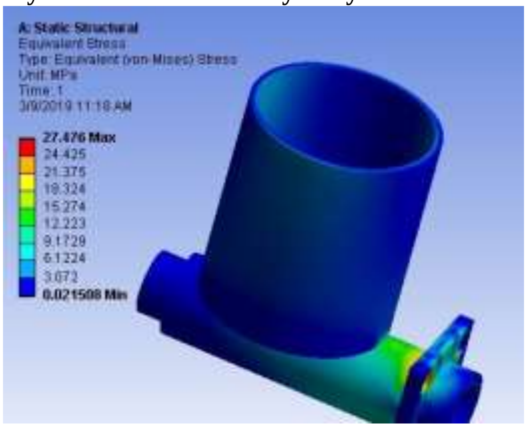


Fig 5.66 equivalent stress

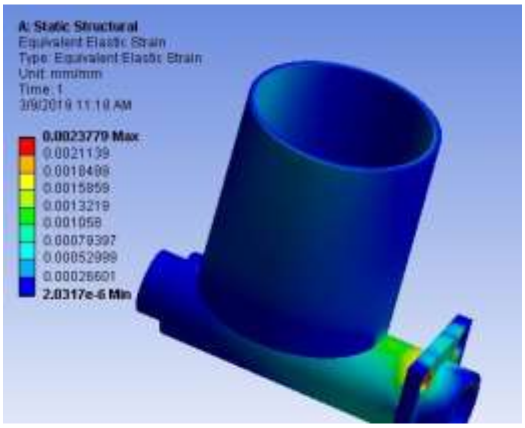


Fig 5.67 equivalent elastic strain

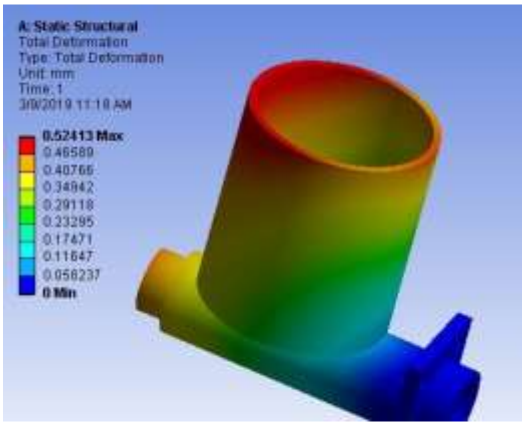


Fig 5.68 total deformation

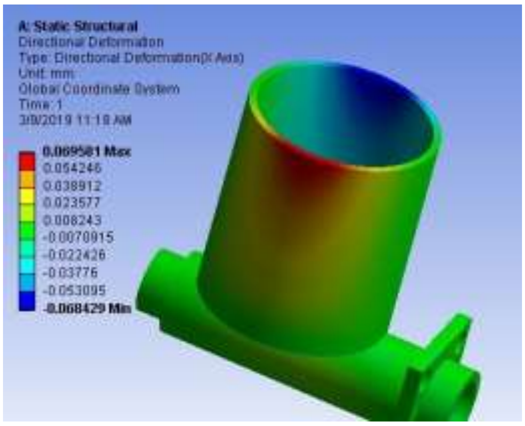


Fig 5.69 directional deformation

3.11. Ansys Results For The Al 2024 For Parameter 1

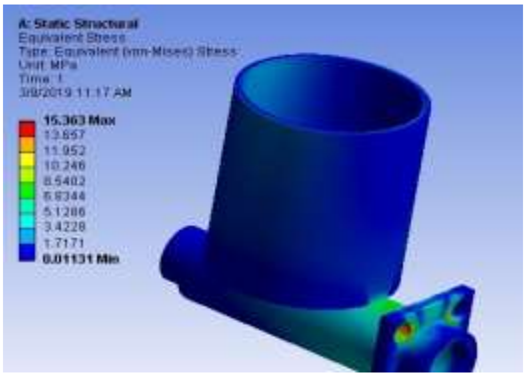


Fig 5.78 equivalent stress

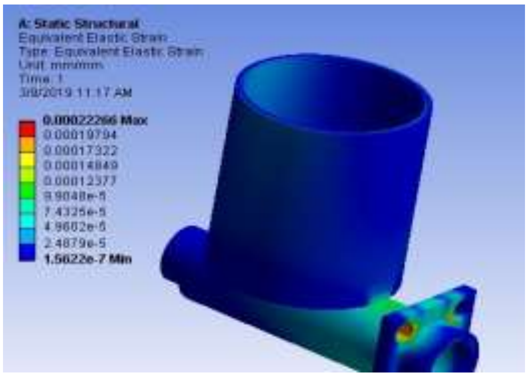


Fig 5.79 equivalent elastic strain

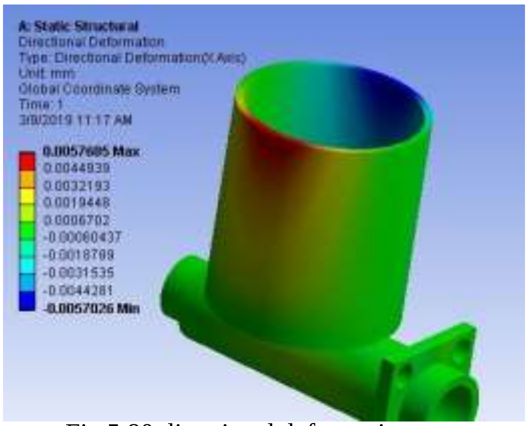


Fig 5.80 directional deformation

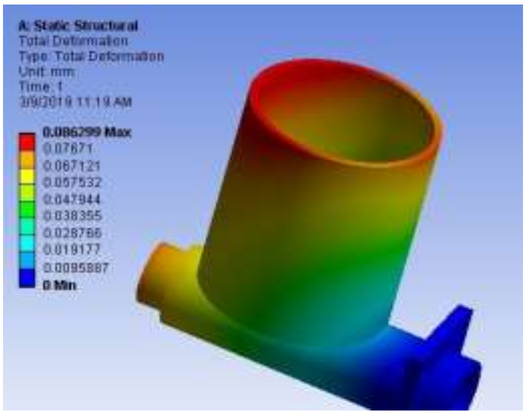


Fig 5.83 total deformation

3.12. Ansys Results For The Acetyl Polymer For Parameter 2

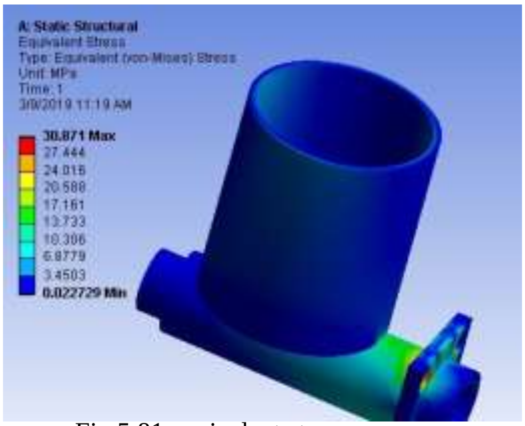


Fig 5.81 equivalent stress

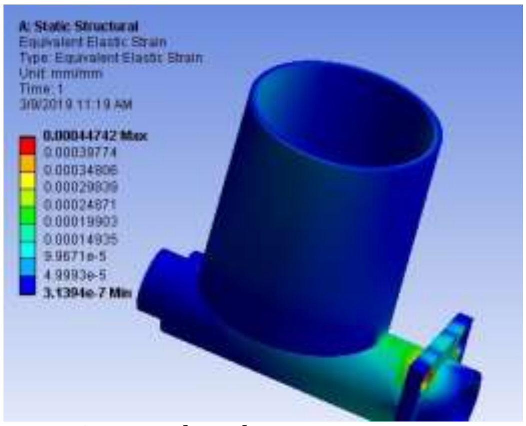


Fig 5.82 equivalent elastic strain

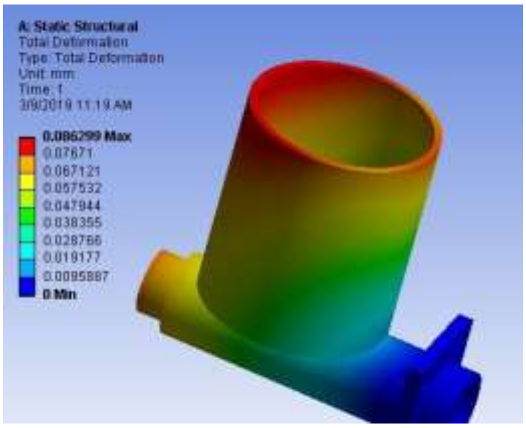


Fig 5.83 total deformation

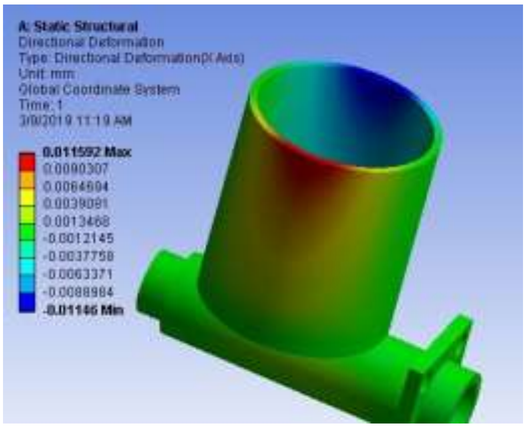


Fig 5.84 directional deformation

IV. RESULTS

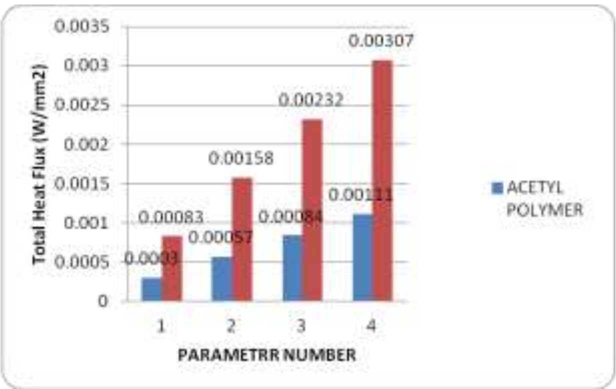
4.1. Thermal Analysis of Master Cylinder in Tabular Form

Parameter Number	1	2	3	4	1	2	3	4
Materials	**Acetyl Polymer**				**Aluminium 2024**			
Temperature(^{o}c)	44.799	59.805	74.81	89.816	89.816	44.799	59.805	74.81
Total Heat Flux (W/mm^2)	0.0003	0.00057	0.00084	0.00111	0.00307	0.00083	0.00158	0.00232
Directional Heat Flux (W/mm^2)	0.00027	0.00052	0.00077	0.00102	0.00282	0.00076	0.00145	0.00213
Thermal Error	0.49458	1.7754	3.8483	6.7127	0.033	0.00869	0.0119	0.01897

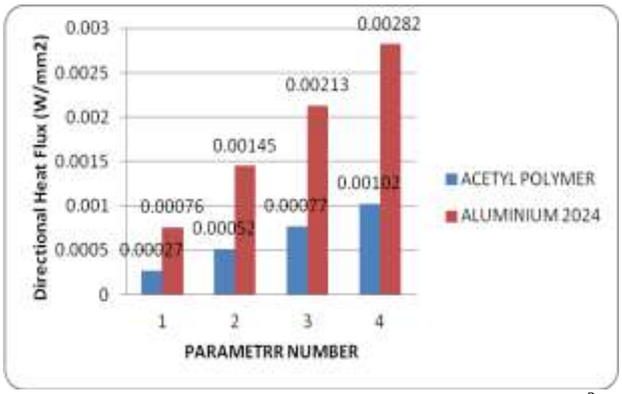
4.2. Results of Structural Analysis of Master Cylinder in Tabular Form

Parameter Number	1	2	3	4	1	2	3	4
Materials	**Acetyl Polymer**				**Aluminium 2024**			
Stress (MPa)	13.674	27.476	41.278	55.079	15.363	30.871	46.379	61.887
Strain (mm/mm)	0.00118	0.00237	0.00357	0.00476	0.00022	0.00044	0.000672	0.000896
Total Deformation (mm)	0.26083	0.52413	0.7874	1.0507	0.0126	0.0862	0.12965	0.173
Directional Deformation(mm)	0.03462	0.069581	0.1045	0.13949	0.00576	0.011592	0.017416	0.023239

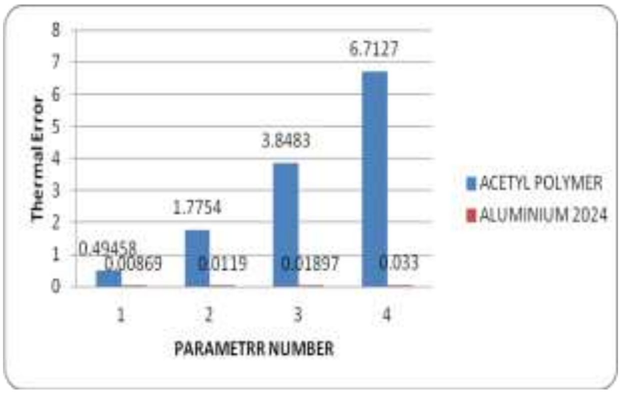
4.3. Graphs

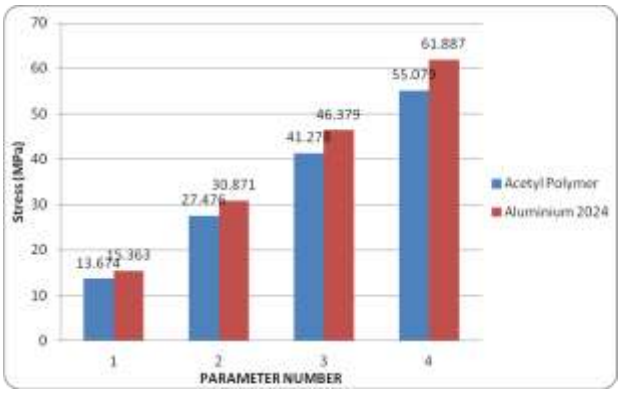


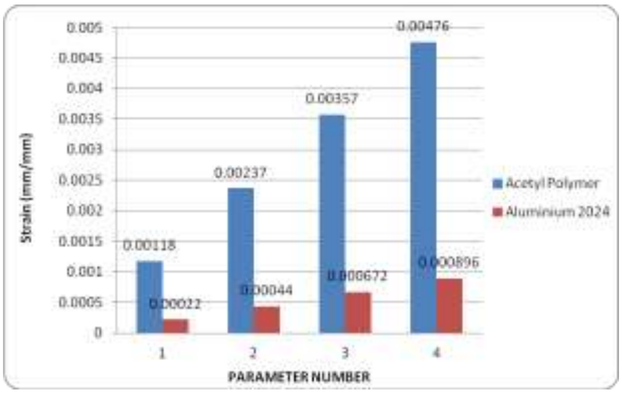
Graph 6.1 Total Heat Flux Comparison (W/mm^2)

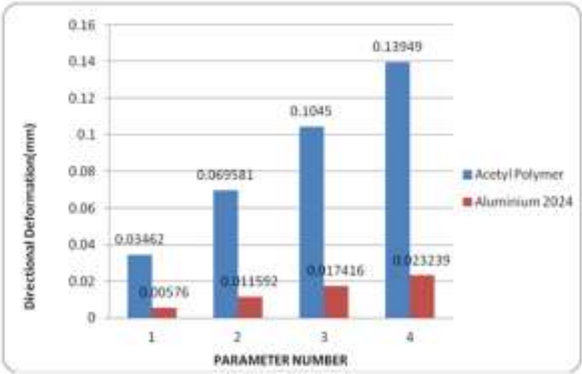


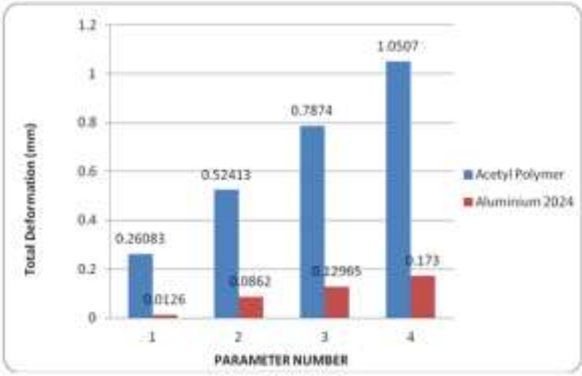
Graph 6.2 Directional Heat Flux Comparison (W/mm^2)











V. CONCLUSIONS

Here in this we are designed a master cylinder and optimization is done at stress affected areas using CATIA and ANSYS software. The thermal analysis is carried out to found the heat flux and thermal stress in master cylinder made with acetyl polymer and al 2024 materials.

In this we analyzed the master cylinder made with two different materials and different parameters using finite element structural analysis and steady state thermal analysis.

If we observe that, the parameters in thermal analysis are considered here the heat flux differences are having the enhanced results made with the aluminum 2024 material than that of the acetyl polymer material.

But if you verify the structural analysis, here the stress is more for the aluminum material but the deformation is very less when compared with the acetyl polymer material. So that, by considering all the aspects I conclude that master cylinder made with aluminium 2024 material gives the best outcomes for the chosen parameters.

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