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Design, Manufacture and Analysis of Muffler Flange Using Structural Steel and Polylactic Acid

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ABSTRACT

World is for the most part relied upon different mechanical segments to survive, one of the fundamental segments is flange. A flange coupling has two separate solid metal flanges. Flanges are basically utilized where an associating joint is required. Another application of flange is that it can be used for joining two different pipes. In vehicle, flange is utilized to associate the muffler and the exhaust system. The component investigation module is made in ANSYS Workbench by utilizing ANSYS Static Structural module which has a predefined procedure to get ideal outcomes. In this paper, analysis of flange is done using structural steel and polylactic acid material.

Keywords: analysis, exhaust system, flange coupling, mechanical component, polylactic acid

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INTRODUCTION

Flange coupling is largely utilized for substantial load application. It comprises two distinct flanges mounted on each other. One flange has broadened, and another flange has a relating break. It permits bringing the shaft consummately co-pivotal. The tube-shaped flange coupling is utilized to join exhaust arrangement of auto and muffler. The shaft that is related by coupling should be adequately simple to assemble and disassemble with the reason for repair and changes (Figure 1).

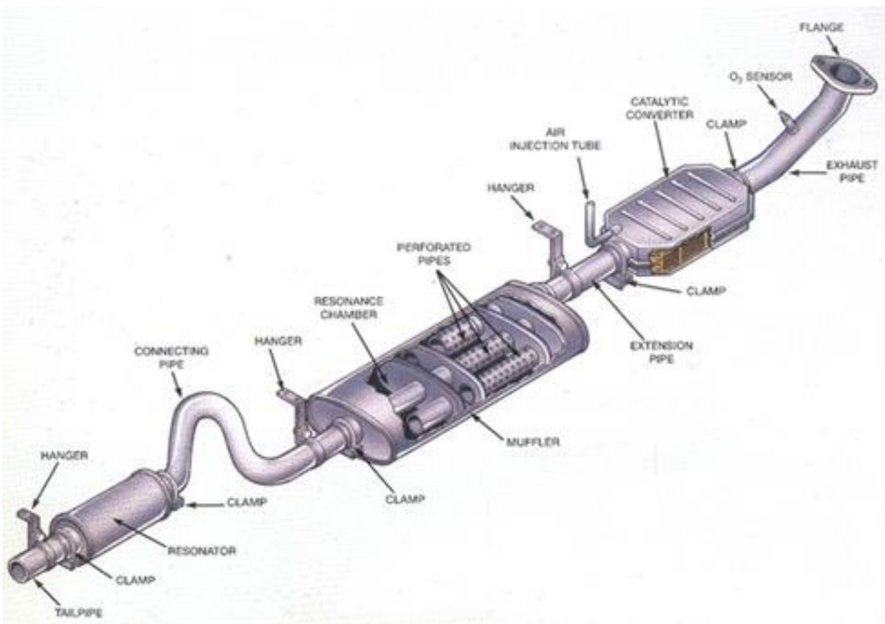

Fig. 1. *Exhaust system of automobile.*

LITERATURE REVIEW

Katta and Rao [1] demonstrate that the basic investigation of flange coupling subjected to static load. A review of flange coupling and usage of various composite materials can be procured from the paper. Result correlation demonstrates that grey cast iron is superior to composite material for flange material. SolidWorks and ANSYS programming are utilized for demonstration and examination work separately. Desai [2] examined on outline, investigation and enhancement of the flange body and using FEM approach for cover flange and its approval by validation according to ASME Code. Sonwane et al. [3] illustrate the calculation of the stress at various positions of the flange using ANSYS software. They reasoned that the stress incited in various parts of the flange coupling are not as much as the hypothetical value, and the design of the flange coupling is in protected mode [4].

Fig. 2. *Process flow chart.*

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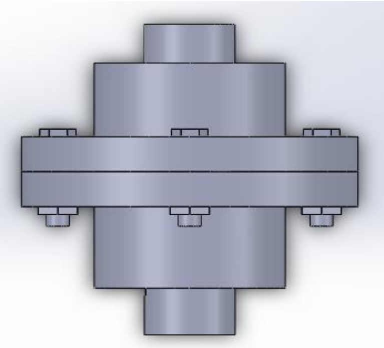


Fig. 3. *Top view.*

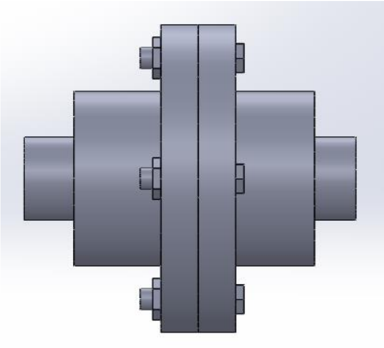


Fig. 4. *Front view.*

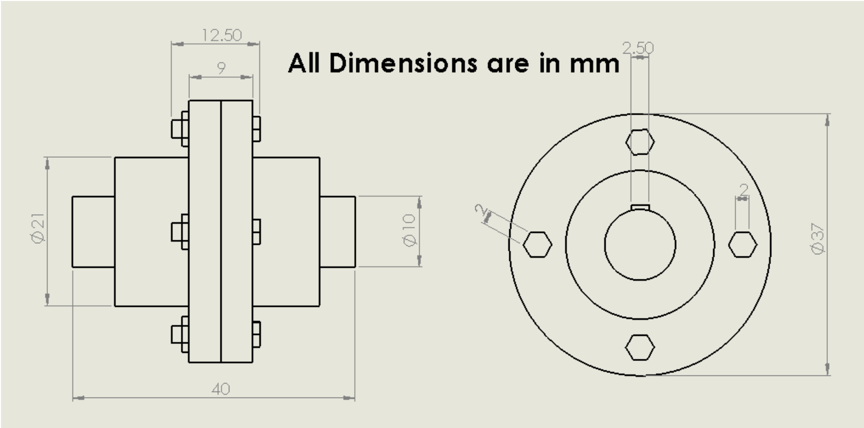


Fig. 5. *Dimensioning of the flange.*

METHODOLOGY

All the parts of the flange coupling are designed in SolidWorks. In this study, the mechanical properties of the flange are assumed to be isotropic, homogenous and linear elastic. The structural steel material is selected which is being compared with polylactic acid, which is nowadays used for 3D printing. Methodology steps are shown in Figure 2 [1, 5, 6,7].

Modelling (Figures 3–7)

The mechanical properties of the material are shown in Table 1.

Analysis

ANSYS Workbench 16.0 is used for doing the analysis. For importing the model to the workbench, go to Static Structure option. After importing the model to workbench, meshing of the muffler flange is done using tetrahedral element and the relevance centre is changed to fine. Figure 8.

Table 1. *Mechanical properties of the material.*

S. no.	Properties	Structural steel	Polylactic acid
1	Density	7.85E−06 kg/mm^3	1.25 g/cm^3
2	Ultimate compressive strength	0 MPa	17.9 MPa
3	Poisson ratio	0.3	0.36
4	Tensile yield strength	250 MPa	59 MPa
5	Young modulus	2E+05 MPa	30.1−46.5 MPa
6	Ultimate tensile strength	460 MPa	37 MPa
7	Compressive yield strength	250 Mega Pascal	59 MPa

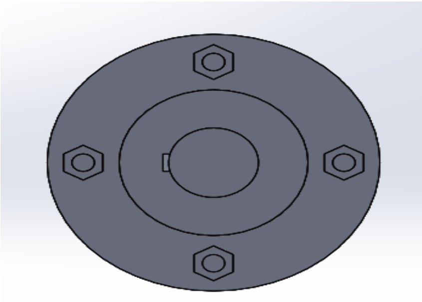
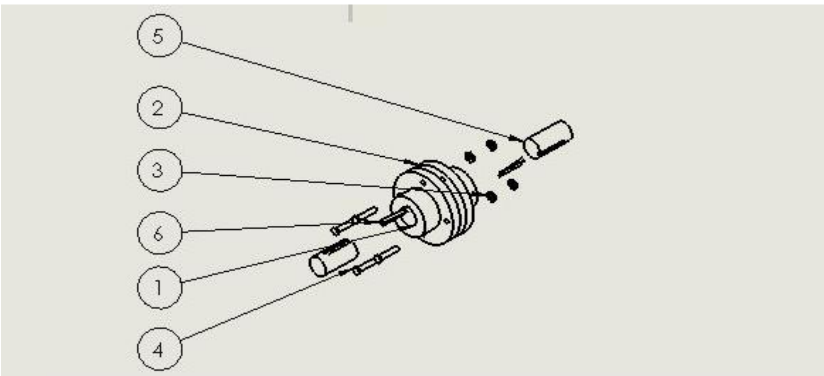


Fig. 6. *Side view.*

Boundary Conditions

1) One end of the shaft is fixed. Figure 9.
2) Another end of the shaft is having a moment of 1500 N-m. Figure 10



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Flange-1	Stainless Steel	1
2	Flange-2	Stainless Steel	1
3	NUT	Stainless Steel	4
4	BOLT	Alloy Steel	4
5	Shaft	Mild Steel	2
6	Taper key	Mild Steel	2

Fig. 7. *Exploded view and bill of material.*

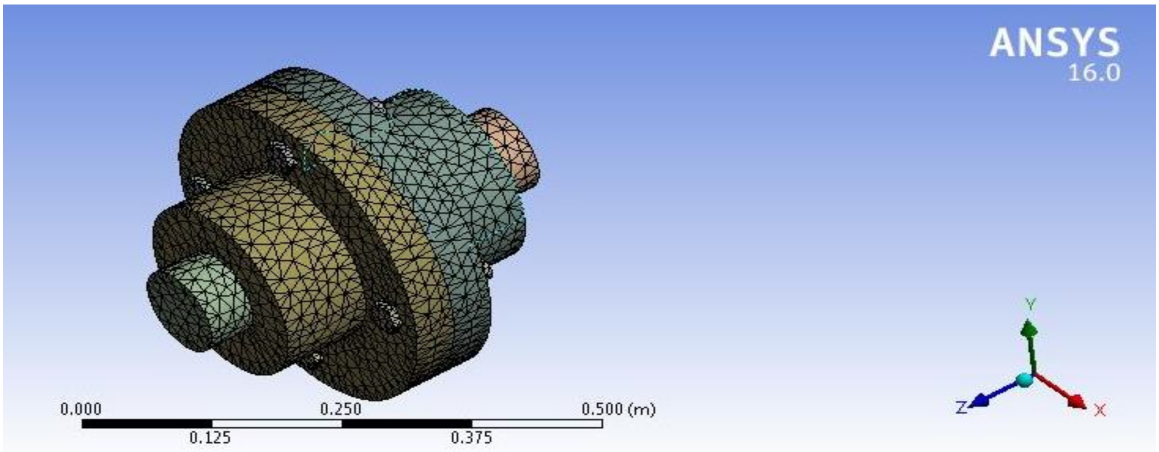


Fig. 8. *Mesh model of the flange coupling.*

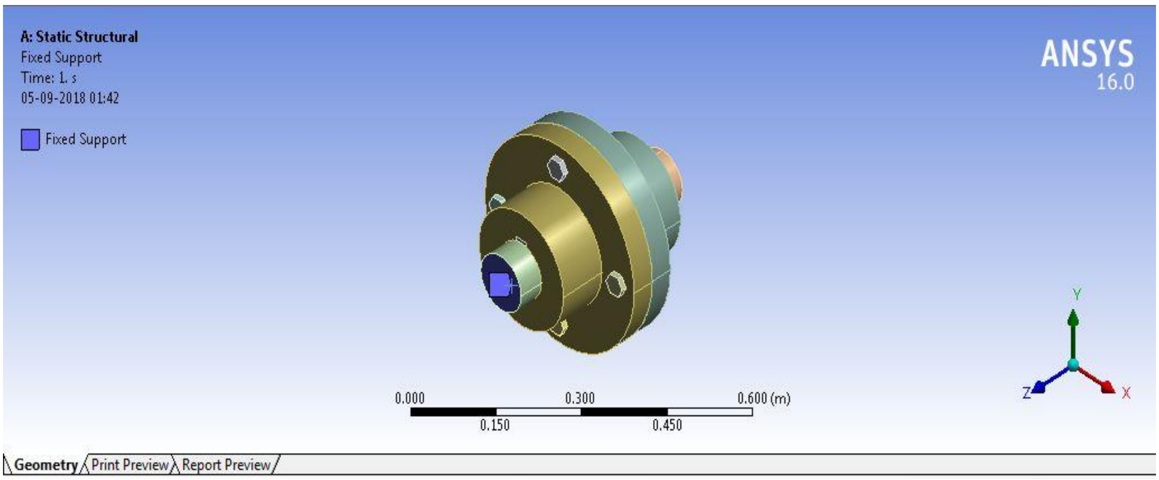


Fig. 9. *Fixed support.*

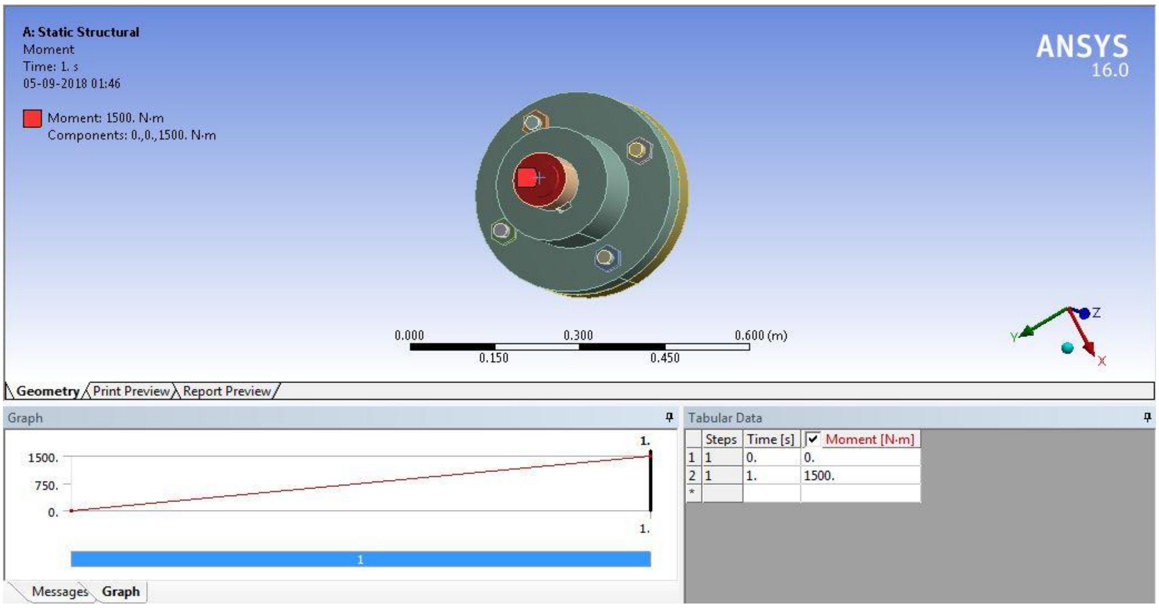


Fig. 10. *Moment.*

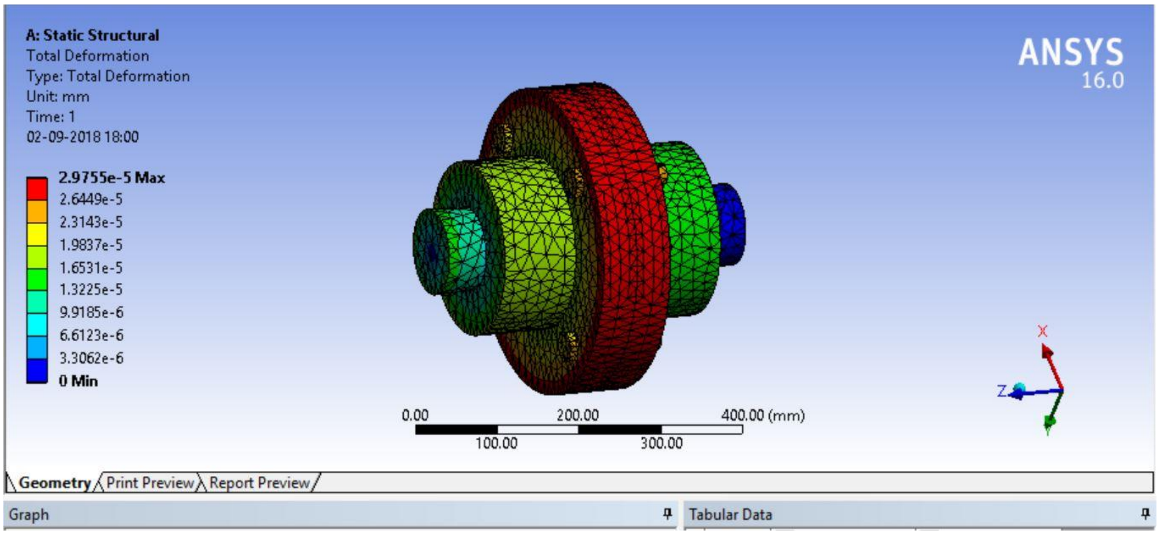


Fig. 11. *Total deformation (structural steel).*

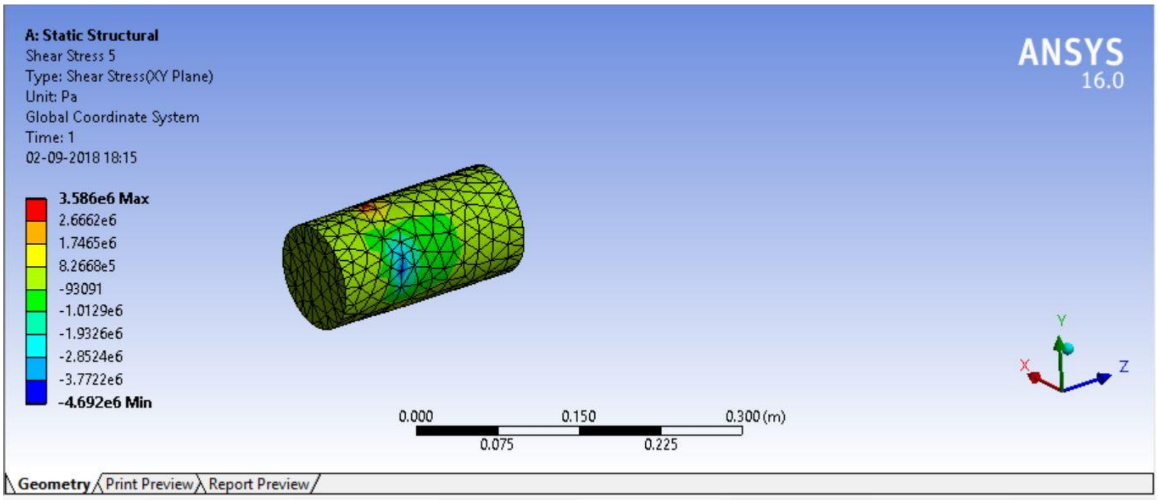


Fig. 12. *Maximum shear stress for shaft (structural steel).*

RESULT AND DISCUSSION

In the present study, the total deformation and equivalent stress are considered for evaluating the results. The total deformation of the flange is shown in Figure 11.

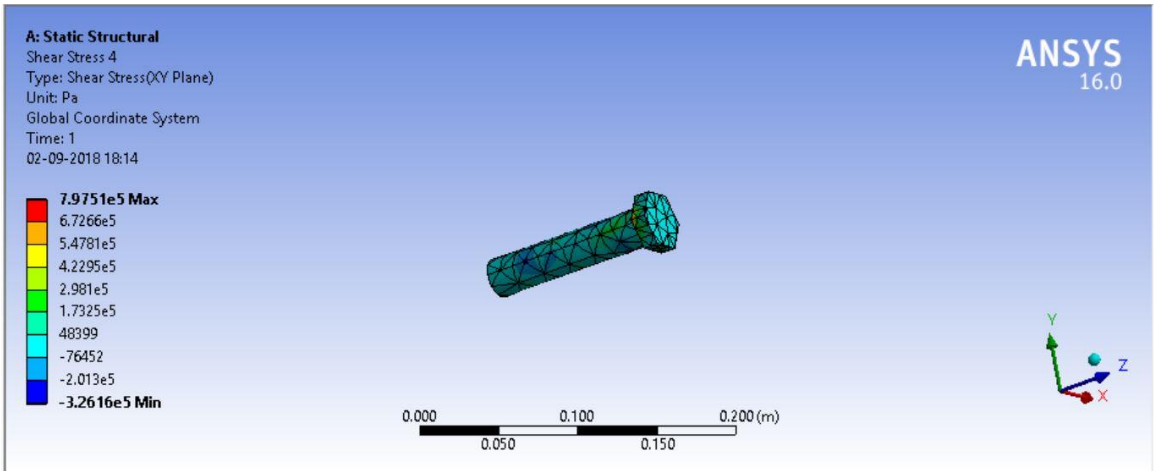


Fig. 13. *Maximum shear stress for bolt (structural steel).*

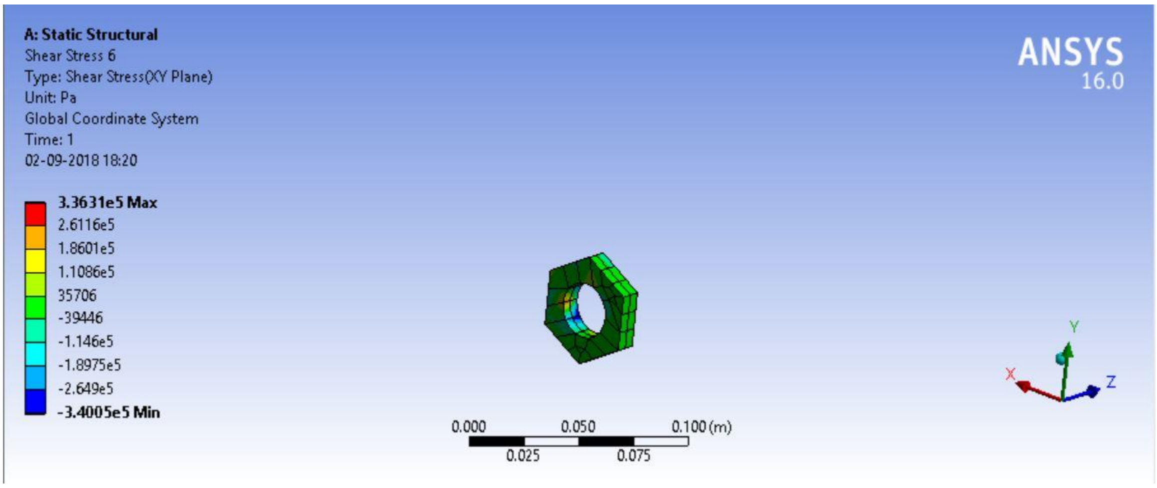


Fig. 14. *Maximum shear stress for nut (structural steel).*

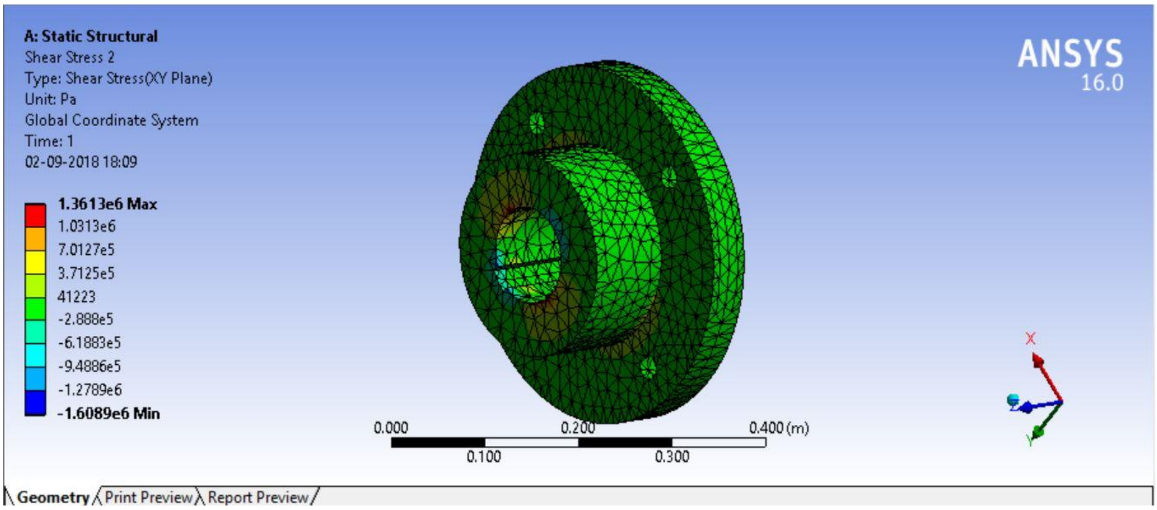


Fig. 15. *Maximum shear stress for flange (structural steel).*

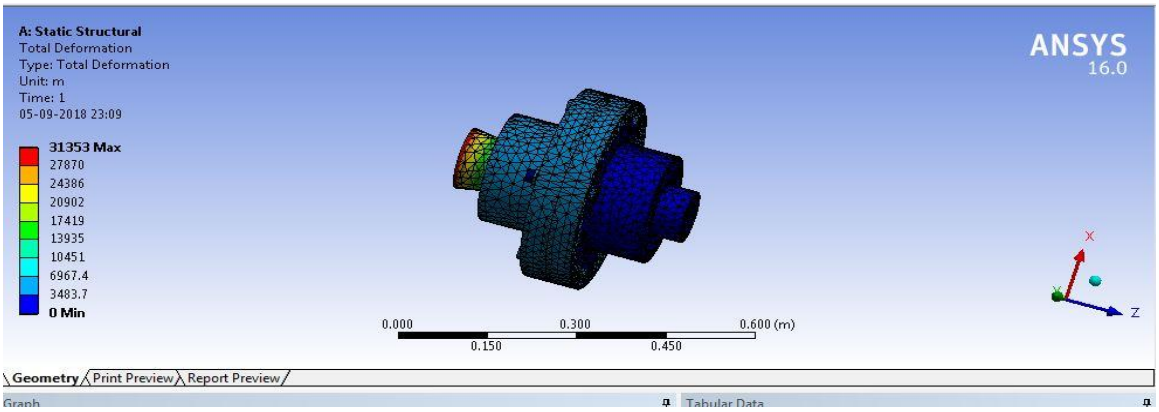


Fig. 16. *Total deformation (PLA).*

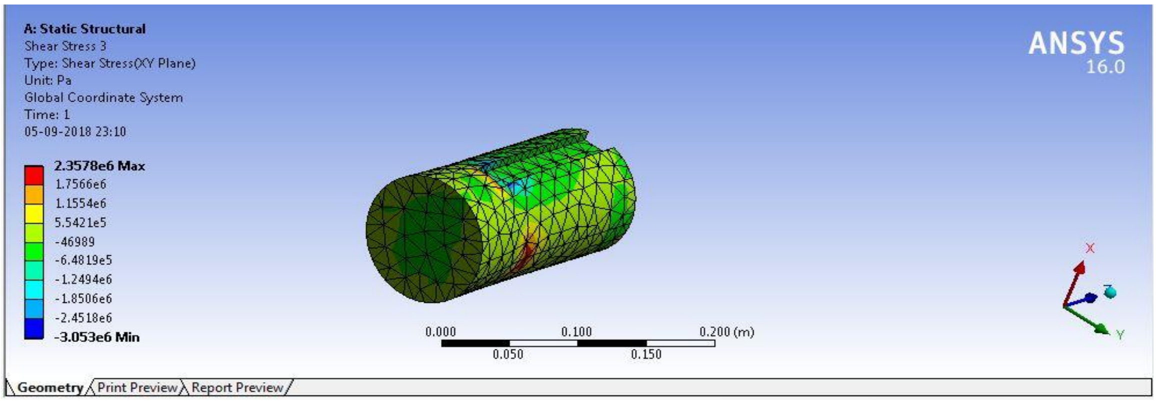


Fig. 17. *Maximum shear stress for shaft (PLA).*

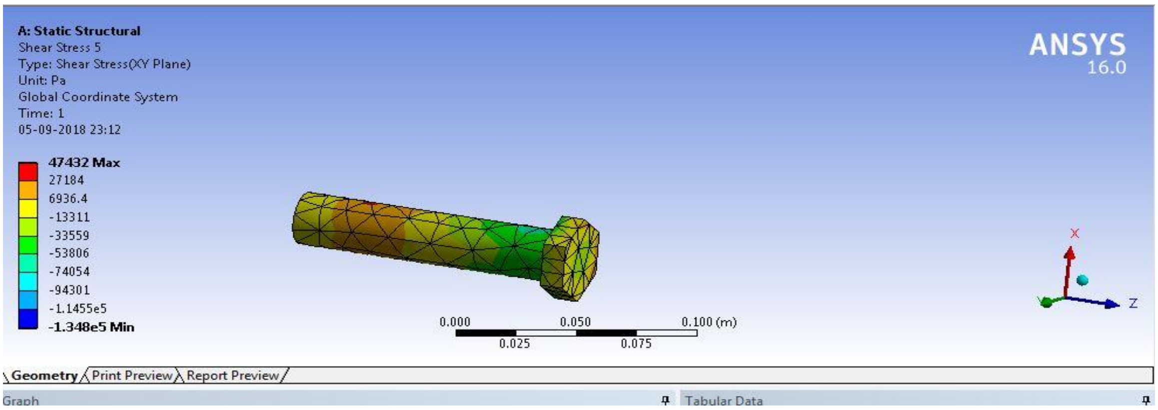


Fig. 18. *Maximum shear stress for bolt (PLA).*

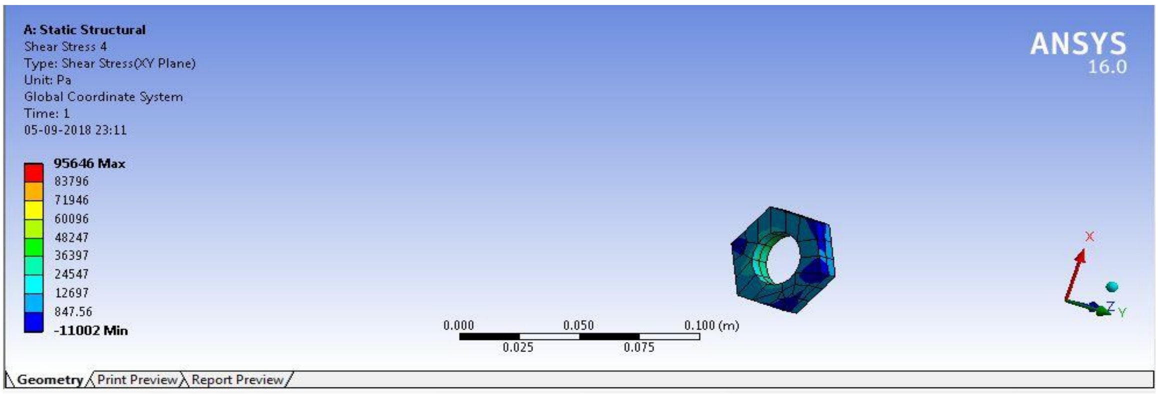


Fig. 19. *Maximum shear stress for nut (PLA).*

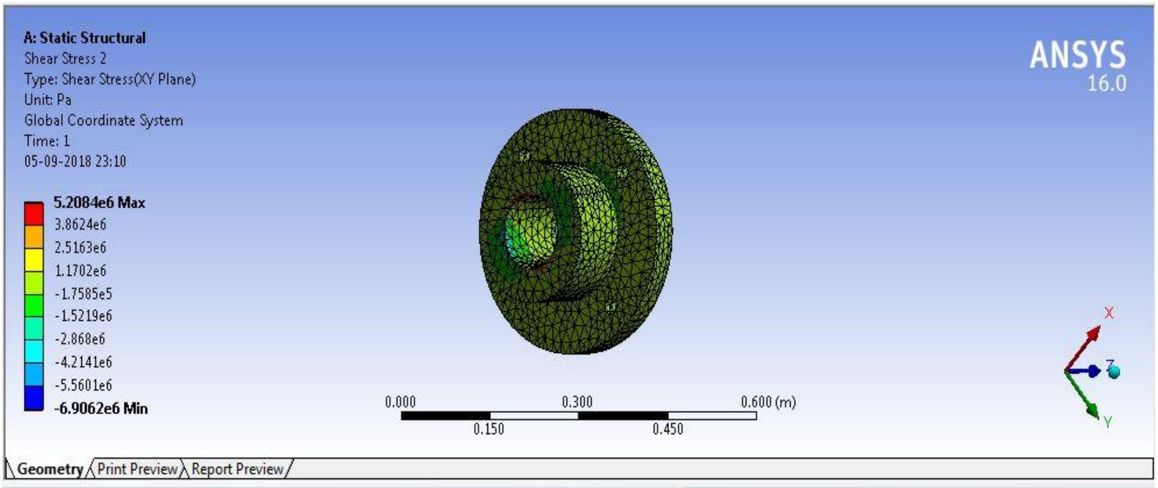


Fig. 20. *Maximum shear stress for flange (PLA).*

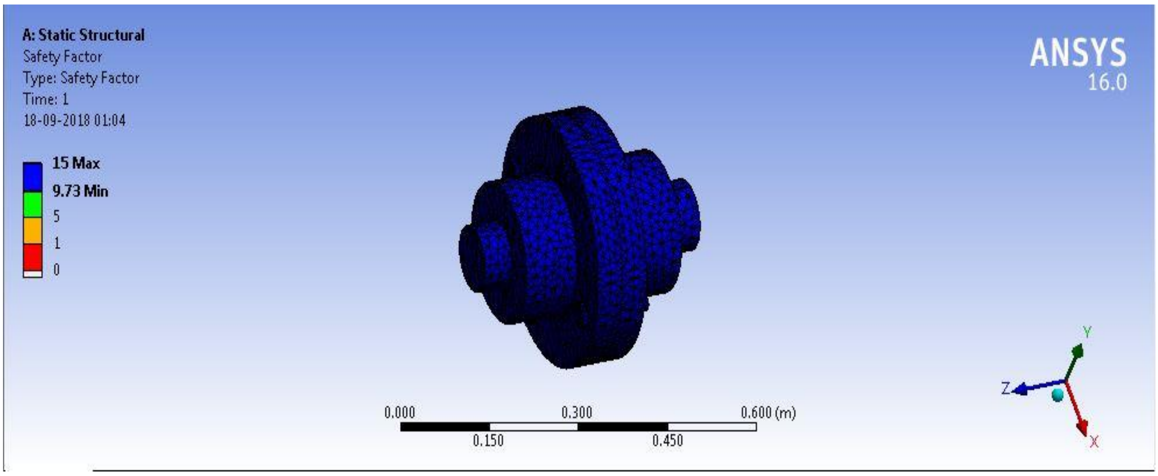


Fig. 21. *Factor of safety of the given component.*

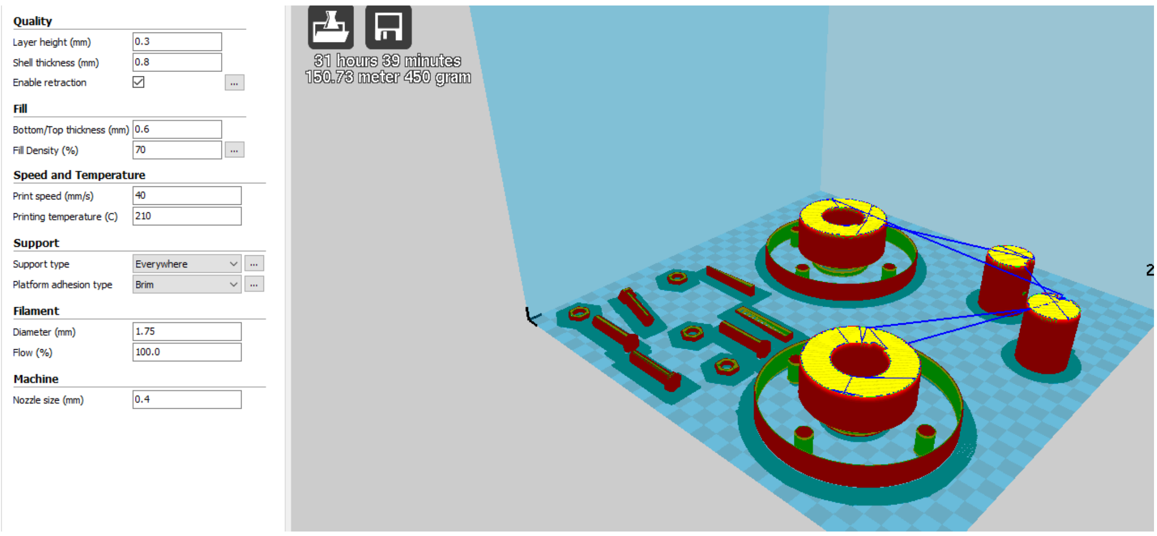


Fig. 22. *Cura analysis.*

Figures 12–15 show the maximum stress developed at various positions for different flange (made up of structural steel) parts.

Figures 16–25 show the maximum stress developed at various positions for different flange (made up of polylactic acid) parts.

Tables 2 and 3 show the ANSYS analyses for structural steel and polylactic acid.

Fig. 23. *Front view.*

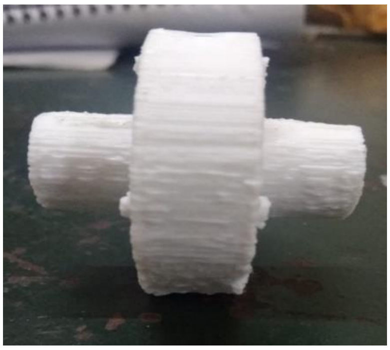


Fig. 24. *Side view.*

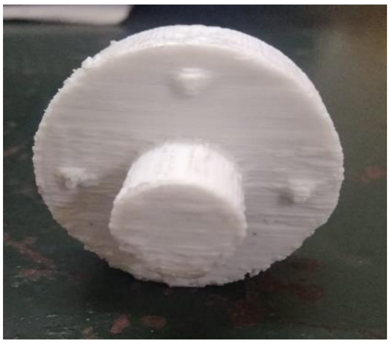


Fig. 25. *Back view.*

Table 2. *ANSYS analysis for structural steel.*

Structural steel	Minimum	Maximum
Total deformation	0 m	2.9755E−005 m
Maximum principal stress	−2.8572E+006 Pa	1.7967E+007 Pa
Shear stress	−1.0114E+007 Pa	8.168E+006 Pa

CONCLUSION

We can conclude the above analysis that PLA cannot be used to design the muffler flange for automobile as it cannot withstand high pressure. The only advantage that PLA gives is that it is lightweight and helps to reduce the weight of the car component. In future, manufacture of flange can take place with the help of ceramic additive manufacturing. Ceramics are lightweight, have good tensile strength and are corrosion-resistant.

Table 3. *ANSYS analysis for polylactic acid.*

Polylactic acid	Minimum	Maximum
Total deformation	0 m	31,353 m
Maximum principal stress	−1.2797E+006 Pa	1.2108E+007 Pa
Shear stress	−6.9062E+006 Pa	5.2084E+006 Pa

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