NUMERICAL INVESTIGATION OF EXHAUST ENGINE MANIFOLD WITH DIFFERENT ALTERNATIVE FUELS

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Abstract – Exhaust manifolds play a crucial role in enhancing the performance of Internal Combustion (IC) engines, and their design is paramount for optimal functionality. This article focuses on conducting a Computational Fluid Dynamics (CFD) analysis to assess the impact of velocity, temperature, and back pressure on the overall (volumetric) efficiency of exhaust manifolds. Specifically, two different designs of exhaust manifolds are compared in this study. Furthermore, the investigation is extended to evaluate the influence of various fuels, including LPG, alcohol, and gasoline, on the overall efficiency. The obtained results are compared to determine the most effective design for the exhaust manifolds. The CFD analysis is carried out using ANSYS software and FUSION 360 software. Gasoline fuel exhibited lower pressure and velocity values, while type A manifold demonstrated higher pressure values, indicating superior performance and efficiency compared to type B manifold.

Key Words**:** *Alternative Fuels, CFD, Combustion, Computational Analysis, Exhaust Manifold, Engine.*

Introduction

The performance of an Internal Combustion Engine (IC Engine) relies heavily on the exhaust manifold [1]. The exhaust manifold plays a crucial role in maintaining optimal temperature, preventing overheating, and enhancing efficiency. It collects the engine emissions and directs them to the atmosphere after combining the exhaust gases from multiple cylinders into a single pipe. During the exhaust stroke, the piston pushes the burnt gases towards the open exhaust valve as the inlet valve remains closed A poorly designed exhaust manifold can result in engine power loss and potential engine failure. Backpressure is a critical factor that affects the performance of the IC Engine. As the exhaust stroke occurs, the gases flow out of the chamber due to the pressure difference, with the pressure inside the chamber being higher than that in the exhaust manifold [2, 3]. The difference between atmospheric pressure and the average back pressure is referred to as back pressure.

Several factors influence the design of an exhaust manifold, including runner length, runner volume, collector, and back pressure [4]. Backpressure can cause the engine to compress gases at higher pressures, resulting in increased mechanical work. Higher exhaust pressure can also lead to oil spillage in the exhaust system . Increased backpressure can result in higher fuel consumption, increased emissions, and decreased engine performance .

In this study, two different exhaust manifold designs are considered, and the impact of alternative fuels such as LPG, gasoline, and alcohol on overall efficiency is investigated. Alternative fuels refer to substances or materials that can be utilized as energy sources, other than conventional fuels.

Methodology

A. Construction

The geometrical dimensions of type A and type B manifold are provided in the Table 3 below.

TABLE 1: Dimensions used for Manifold Type A

Parameter	**Unit**
Diameter(d)	58
Distance between two manifolds (D)	130
End to end distance of manifold	140

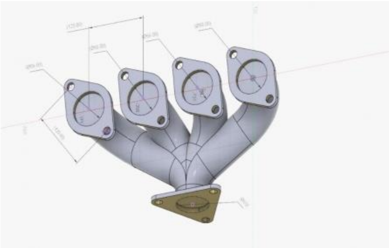


Figure 1. Manifold Type-A

TABLE 2: Dimensions used for Manifold Type B

Parameter	**Unit**
Diameter(d)	55
Distance between two manifolds (D)	130
End to end distance of manifold	492.18

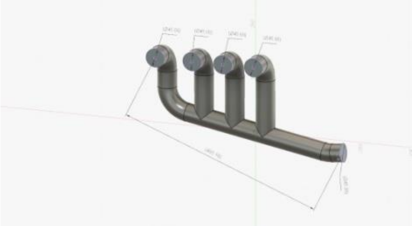


Figure 2. Manifold Type-B

Meshing

The meshing process was carried out using the ANSYS software. The specific meshing parameters are provided in the Table 3 below.

TABLE 3: Parameters used for the meshing

Meshing parameters	**value**
Elements	42001
Nodes	9200

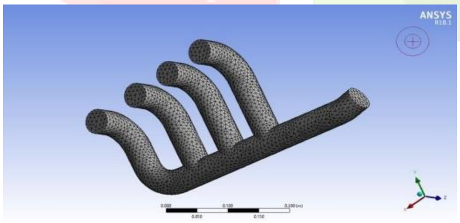


Figure 3. Type A manifold meshing

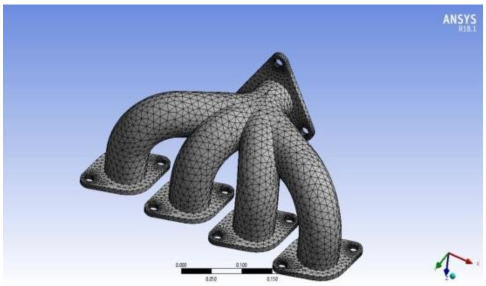


Figure 4. Type B manifold meshing

C. Boundary Conditions

The manifold designs were imported into the ANSYS 18.1 software to conduct numerical analysis. LPG, alcohol, and gasoline were used as the flowing materials for each respective manifold. The analysis focused on determining variations in pressure, velocity, and temperature within the manifold. The material properties for the fuels can be found in Table 4 [5].

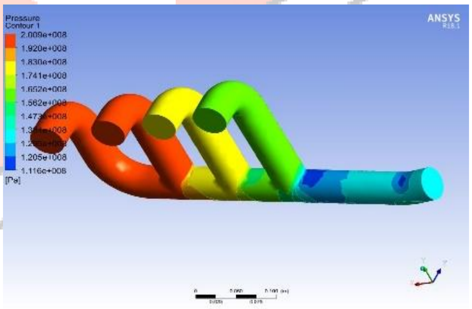
TABLE 4: Properties of Fuels used for the study.

Materials	**Gasoline**	**Alcohol**	**LPG**
Specific Heat (J/Kg-K)	1056.6434	1150.6	1138.40
Viscosity (Pa-s)	3.0927×10^{-5}	2.57×10^{-5}	2.57×10^{-5}
Thermal Conductivity (W/m-K)	0.0250	0.025	0.025
Density (kg/m^3)	1.0685	1.255	1.2631

Results and Discussions

The CFD analysis was performed using the ANSYS software. The inlet velocity for both manifold models was set to 20 m/s. The Type A exhaust manifold was examined in four different regions of the outlet runner, while the Type B exhaust manifold was analyzed in five different regions.

The pressure distribution for LPG, gasoline, and alcohol was investigated within the Type A manifold



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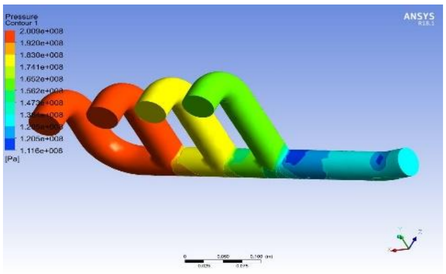

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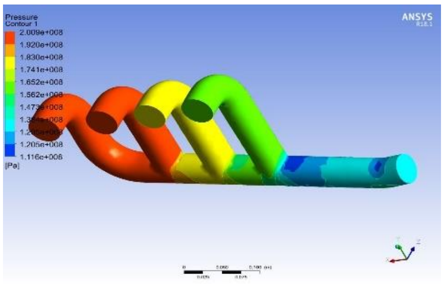

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Figure 5: The pressure distribution for the type A manifold was analyzed for three different fuels: LPG (a), Gasoline (b), and Alcohol (c).

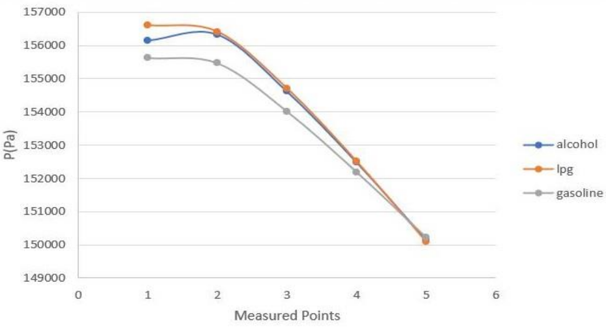
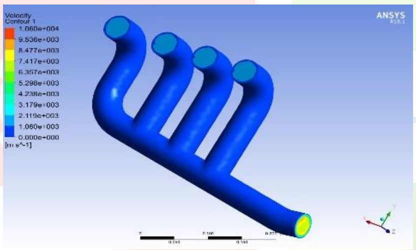


Figure 6. The pressure measurements were conducted across the measured points for different fuels.

The velocity distribution for LPG, gasoline, and alcohol was investigated within the Type A manifold.



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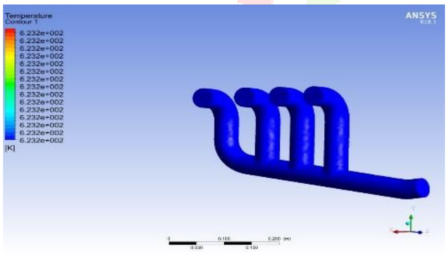

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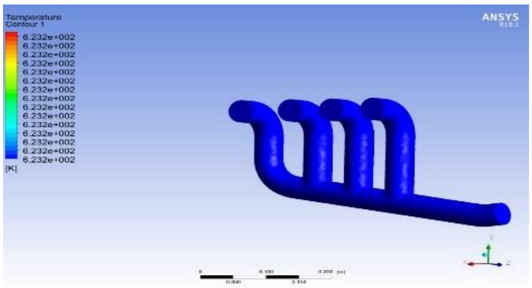

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Figure 7: Distribution of velocity for type A manifold LPG (a), Gasoline (b), Alcohol (c).

The temperature of Gasoline and LPG remained constant at the specified points, while the alcohol fuel decreased between measurement points 1 and 2, and then remained steady, as shown in Figure 10.

Similarly, the pressure for the fuels followed a similar trend, staying consistent up to 3 measurement points. After a slight decrease between the third and fourth points, the parameter increased after the fourth measuring point. It was also observed that the pressure decreased from the inlet to the outlet.

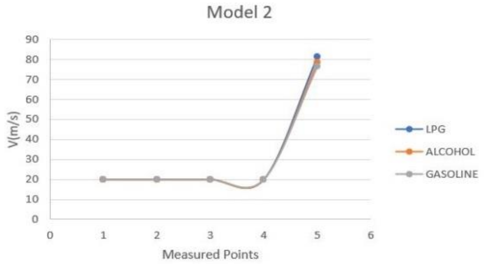
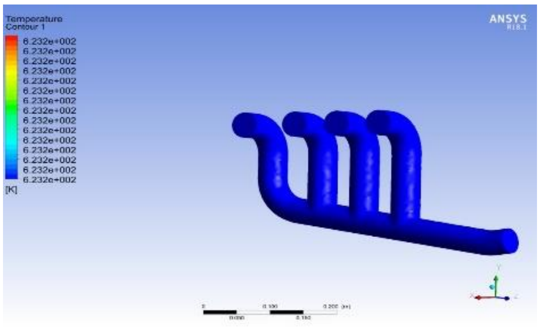


Figure 8. Measurement of velocity for various fuels across the measured points.

Regarding the velocity, it was observed that the speed decreased from measurement point 2 to 3 and then rapidly increased to 5. Measurement points 2 and 3 were closer to the exhaust outlet, and there was a decrease in the flow rate at those points.

The temperature distribution of the type A manifold was studied for three fuel types: LPG, gasoline, and alcohol:



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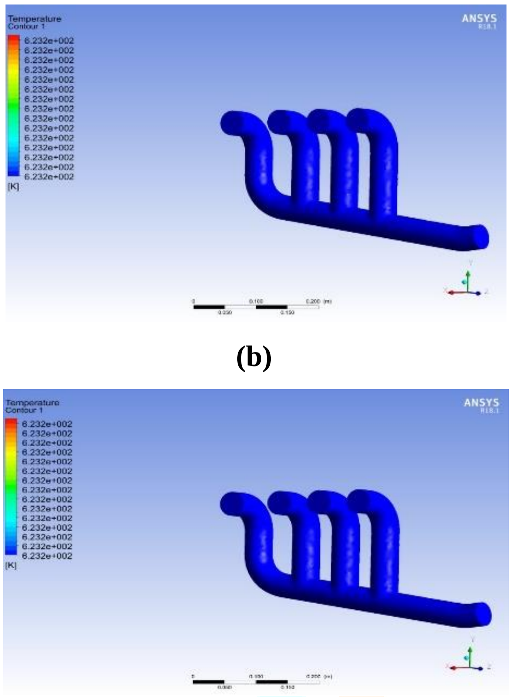

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Figure 9: The temperature distribution for the type A manifold was analyzed for three different fuels: LPG (a), Gasoline (b), and Alcohol (c).

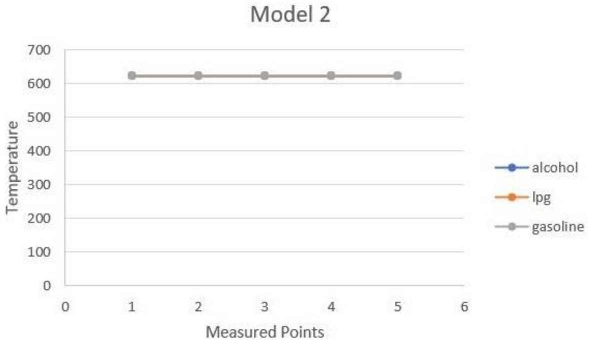
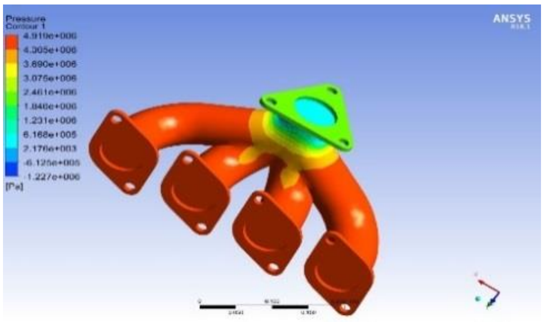


Figure 10. The temperature of different fuels was measured at various points during the experiment.

The effects of different fuels on the pressure, volume, and temperature of design 1 were analyzed, and the simulation results are presented in the table below.

Pressure distribution of the type B manifold was studied for three fuel types: LPG, gasoline, and alcohol



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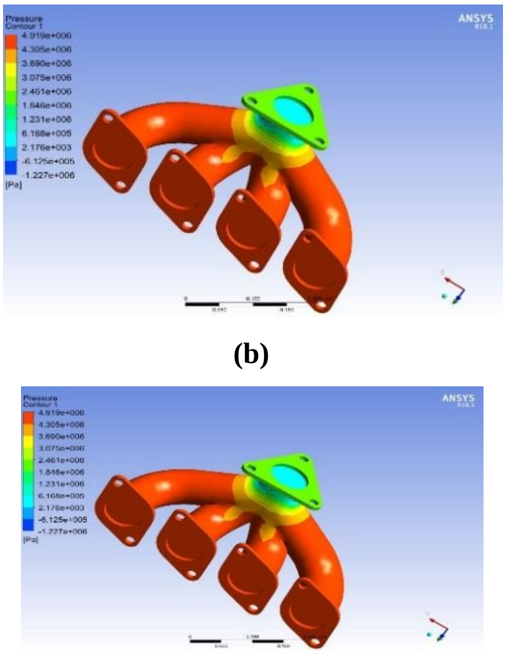

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Figure 11. The pressure distribution was analyzed for the type B manifold with three different fuels: LPG (a), Gasoline (b), and Alcohol (c).

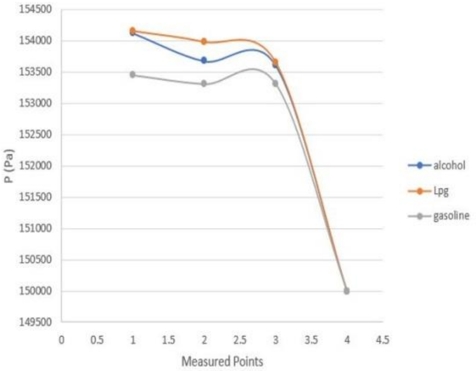
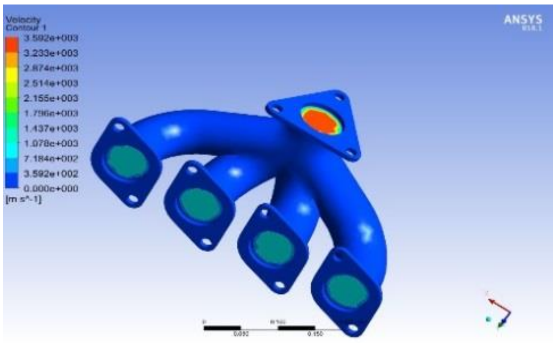


Figure 12. The pressure of different fuels was measured at various points in the experiment.

Velocity distribution of the type B manifold was studied for three fuel types: LPG, gasoline, and alcohol



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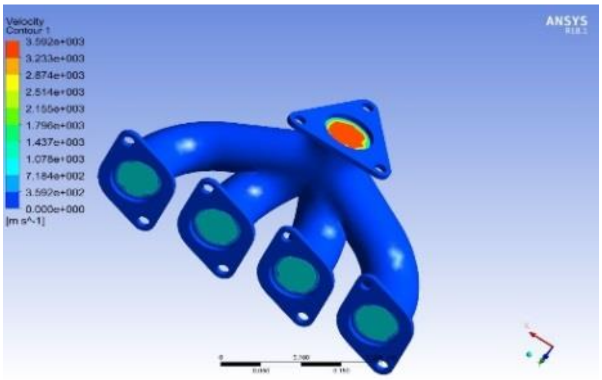

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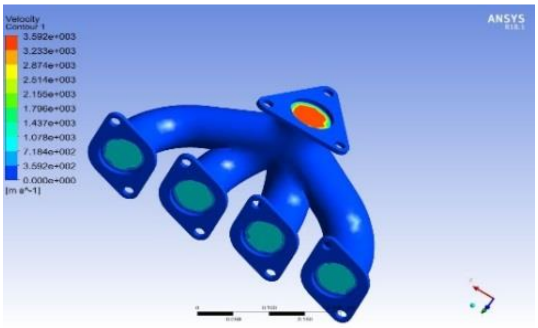

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Figure 13: The velocity distribution was analyzed for the type B manifold with three different fuels: LPG (a), Gasoline (b), and Alcohol (c).

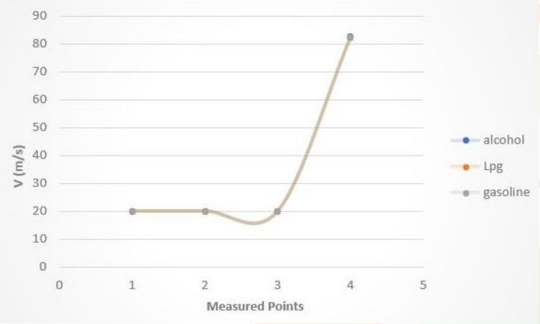
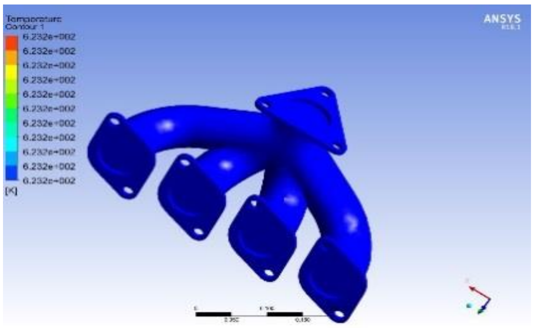


Figure 14. The velocity of different fuels was measured at various points in the experiment.

Temperature distribution of the type B manifold was studied for three fuel types: LPG, gasoline, and alcohol.



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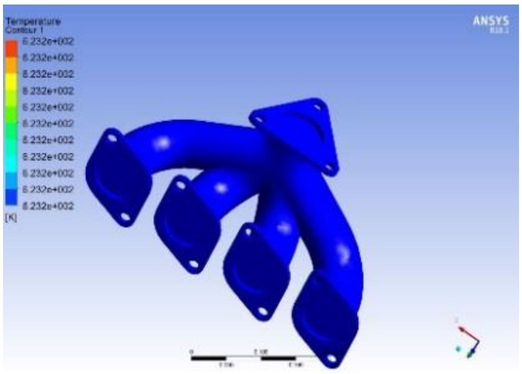

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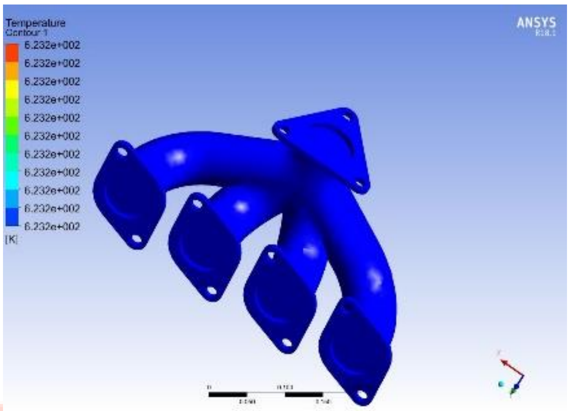

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Figure. 15: The temperature distribution for the type B manifold was analyzed for three different fuels: LPG (a), Gasoline (b), and Alcohol (c).

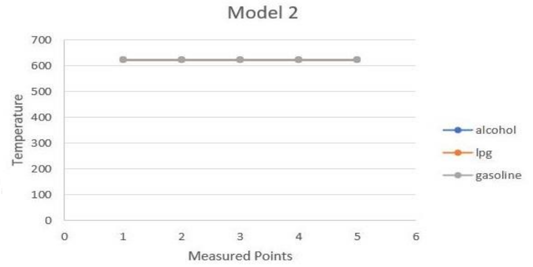

Figure 16. The temperature of different fuels was measured at various points in the experiment.

When comparing the velocities of the different fuels, it was observed that initially, the results were relatively similar at the inlet. However, as depicted in Figure 14, it was discovered that the flow velocities expanded towards the exhaust source for all fuels. Furthermore, due to the consolidation of all fuels into a single channel, the velocity at the outlet increased rapidly.

In terms of pressure, it was determined that the pressure decreased towards the exhaust outlet, and the pressure obtained from gas fuel was lower compared to alcohol and LPG fuels. This can be attributed to the unique fuel flow characteristics of gas, as illustrated in Figure 12.

Examining the effect of temperature, it was found that the temperature remained constant for LPG and gasoline fuels. However, for alcohol, the temperature decreased, as indicated in Figure 16.

Conclusion

In this investigation, we conducted a comparative study on two distinct exhaust manifold models. We evaluated their performance using three fluid materials: alcohol, LPG, and gasoline. As the fluid flowed towards the outlet, the velocity exhibited an increase while the pressure gradually decreased until reaching atmospheric pressure.

Among the different fuel options, the gasoline fuel exhibited lower pressure and velocity values. On the other hand, the type A manifold displayed higher pressure values, indicating superior performance and efficiency compared to the type B manifold.

The current study presents the results of our initial investigation, and we are currently conducting an experimental study on the same topic to further validate and expand upon our findings.

REFERENCES

[1] G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] Selvanathan, P.S., Sudhakaran, R., Venkatesh, K., Tites, C.S. and Rajamanikandan, D., “CFD analysis of IC engine exhaust manifold with respect to the performance of a turbocharger”. Advances in Natural and Applied Sciences, 11(4), pp.242-250, 2017.

[3] Umesh, K.S. and Rajagopal, V.P.K., “Cfd Analysis Of Exhaust Manifold Of Multi-Cylinder Si Engine Todetermine Optimal Geometry For Reducing Emissions”. International Journal of Automobile Engineering Research and Development, pp.45-56, 2013.

[4] Navadagi, V. and Sangamad, S., “CFD analysis of exhaust manifold of multi-cylinder petrol engine for optimal geometry to reduce back pressure”. International Journal of Engineering Research, 3(3)., 2014.

[5] Bajpai, K., Chandrakar, A., Agrawal, A. and Shekhar, S., “CFD analysis of exhaust manifold of SI engine and comparison of back pressure using alternative fuels”. IOSR J. Mech. Civ. Eng, 14(01), pp.23-29, 2017.