IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Modelling And 3D Printing Of 4-Wheeler Exhaust Manifold

Maimuna Siddiqui[1], P. Sai Naga Sudheer Reddy[2*], M. Pravallika[3], M. Pavan Kumar[4], R. Shivamani[5].

[1]Assistant Professor, Department of Mechanical Engineering, GNITC, Hyderabad, Telangana.

[2345]UG Scholars Department of Mechanical Engineering, GNITC, Hyderabad, Telangana.

Abstract: Exhaust noise is one of the main causes of vehicle disturbances, and the exhaust system is designed to reduce the noise level to meet demand levels and lower emission levels. Modern engines must be powerful while also meeting stringent pollution standards. In automobiles, the exhaust system plays an important role in removing exhaust gases from the combustion chamber after the combustion of the air and fuel mixture. The exhaust pipe, or valve, is called the exhaust manifold. Increasing the diameter of the exhaust manifold can increase the airflow rate within the manifold.

A CAD model was built using Solidworks (2022) software in the form of an SLDPRT format, and that file was saved as an STL file. It was then sent to a 3D printer for printing of the part using 3D printing technology, which converts the digital design of the object into a physical part.

Key Words: Exhaust manifold, Solidworks, CAD model, 3d printing.

1. Introduction

Exhaust manifold is the integrated part of the internal combustion engine. It is used to collect the exhaust gasses from the combustion chambers and released to atmosphere through exhaust pipe. It plays a crucial role in performance, efficiency, exhaust gas noise, emissions control etc.

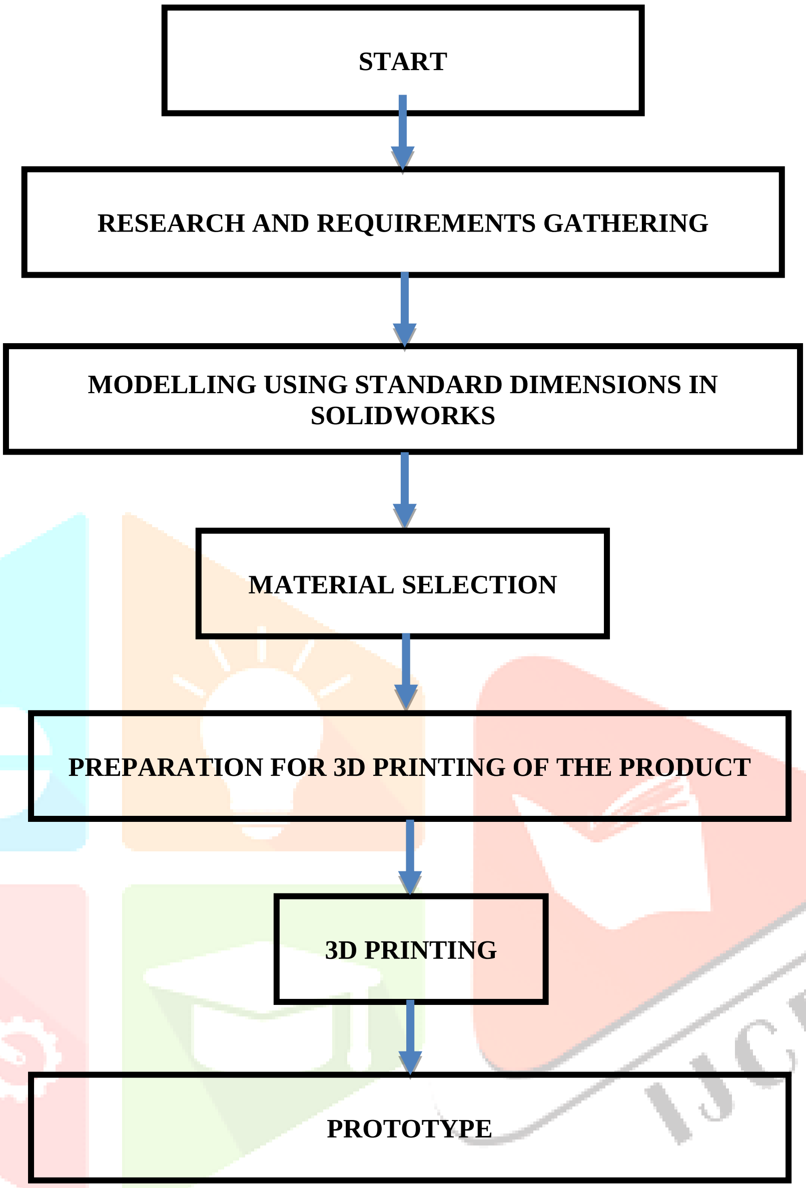
Exhaust gases from the exhaust manifold will be directed to the accessory like turbo-charger for boosting the performance of the internal combustion engine.

Exhaust manifold is used to converge the gases from the different cylinders into one single path. It is also used to decrease the back pressure created by the exhaust gases. This can be achieved by directing the gases to flow without any restrictions caused by exhaust manifold.

Figure 1 Exhaust Manifold

Exhaust manifolds are mostly made of cast iron or stainless steel because, exhaust gases from the internal combustion engine are delivered with high temperatures. These materials can with stand high temperatures and have good resistance to corrosion.

2. Methodology



2.1 Modelling Of Engine Exhaust Manifold

- The Model is created in the Soildworks 2022.
- By using the Solidworks tools (i.e., sketch, extrude, revolve, extrude cut, fillet etc.) the Engine Exhaust Manifold is created.
- The Model is saved as .stl file as to insert in the Flash Forge Creator Pro for 3d printing.

2.2 3D Printing of Engine Exhaust Manifold

- The Model saved in the. stl (stereolithography) format is imported to Flash Forge 3D printing software.
- The model is loaded to the Flash forge creator pro software.
- Adjust the size of the Model according to the prototyping size by using Scale tool.
- The supports are added to the model by using the Auto supports then save the file.
- Print the Engine Exhaust Manifold by using Flash Forge 3D Printing machine.
- Select the material PLA (Poly lactic Acid) used for the model to be printed.
- The Quality of the model is selected as 100% then printed.
- Infill density is selected as 50% and type of infill pattern to hexagonal shape is selected.
- The estimated printing time is shown while printing the model.

3. Introduction To SolidWorks

SolidWorks is a software for 3D solid modelling that is used to create fully solid models in a simulated environment for accurate dimensions. In SolidWorks, users can sketch ideas and explore diverse designs to generate 3D models. It is very useful for students, designers etc which makes their work simple and accurate. The utilization of modelling software like SolidWorks is advantageous as it significantly economizes time, labour, and financial resources that would otherwise be invested in prototyping the design.

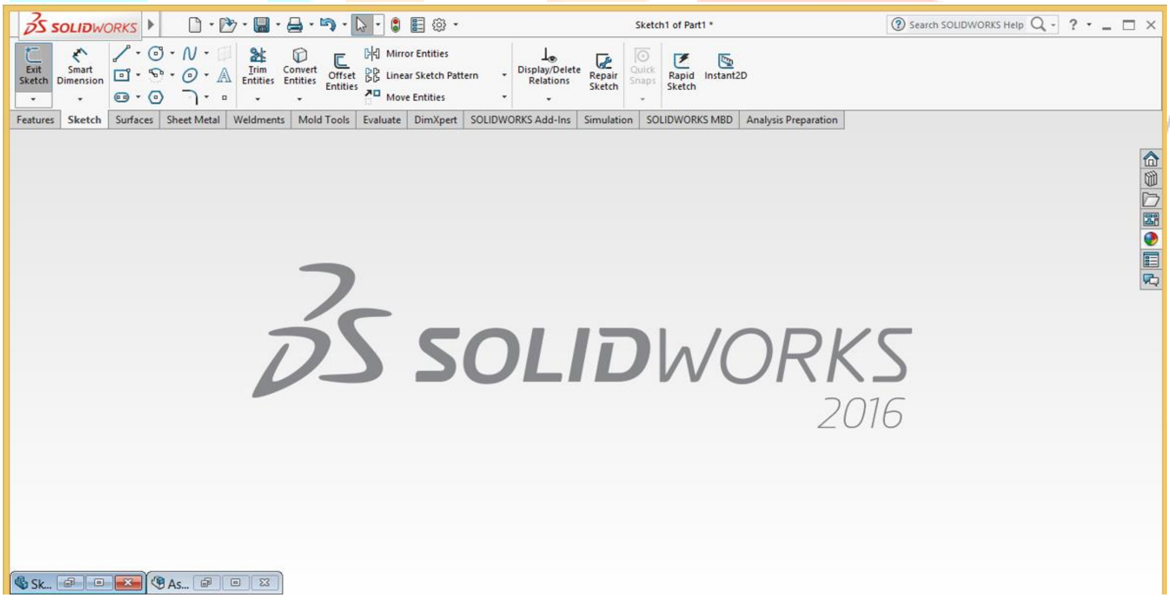


Figure 2 Solidworks Default Page

3.1 SolidWorks Components:

1. Part: The fundamental element of a SolidWorks model, comprising primitive geometry and features like extrudes, revolutions, and sweeps. Parts serve as the foundation for all models.
2. Assembly: Collections of parts assembled using mates (constraints), forming complex models.
3. Drawing: Representations of 3D models enabling engineers or manufacturers to recreate parts, essential for sharing designs uniformly.

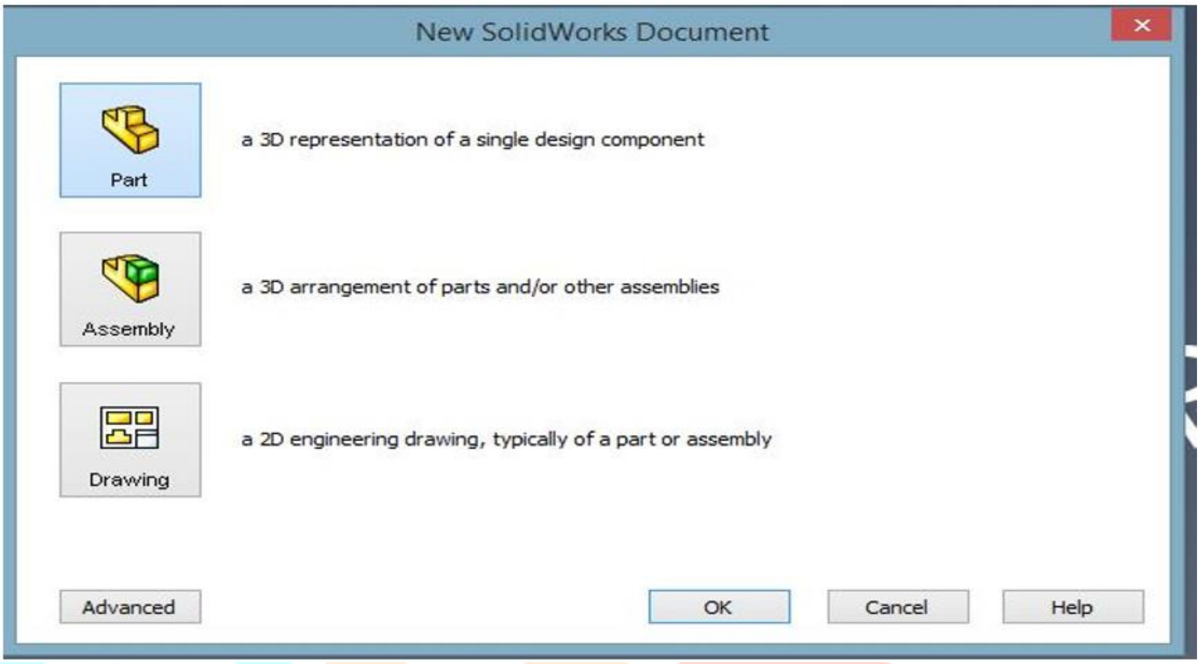


Figure 3 Parts of Solidworks

4. Introduction To 3D Printing

3D printing, a form of additive manufacturing, encompasses various processes to create three-dimensional objects of almost any shape from electronic data sources. This is primarily achieved through successive layers of material laid down under computer control. A 3D printer operates as a type of industrial robot. The early equipment and materials for additive manufacturing emerged in the 1980s. In 1984, Chuck Hull of 3D Systems Corp pioneered stereolithography, utilizing UV lasers to cure photopolymers.

3d printing is used in many streams like automotive, architecture, aero industry, medical industry etc. 3d printing is the most time saving process than the traditional processes. But it has its own drawbacks like space limitation. It is more effective when used for prototyping which saves material and time.

Figure 4 3D Printer

4.1 Methods Of 3D Printing

- Stereolithography (SLA)
- Selective Laser Sintering (SLS)
- Fused Deposition Modelling (FDM)
- Digital Light Process (DLP)
- Multi Jet Fusion (MJF)
- Poly-Jet
- Direct Metal Laser Sintering (DMLS)

4.1.1 Fused Deposition Modeling (FDM)

In this process a CAD model of required dimensions is created on a Solidworks software and saved as .STL format. It is then imported to the Flash Forge software and ensure the dimensions of the prototype to be printed. In this process modeling and support materials will be in the form of spool. The materials in the form of spool are then fed into extrusion head and heated to semi-liquid state. The semi-liquid modeling and support materials are then extruded through the extrusion head and will be deposited in ultra-thin layers. The air present surrounding the head is less than the melting point of material, the material deposited as thin layers will solidify quickly.

Fused deposition modeling is selected due to its advantages like this process is able to fabricate prototypes with material that are usable. In this process the material wastage are minimal. Support structures generated during the process can broken off easily after the product is built.

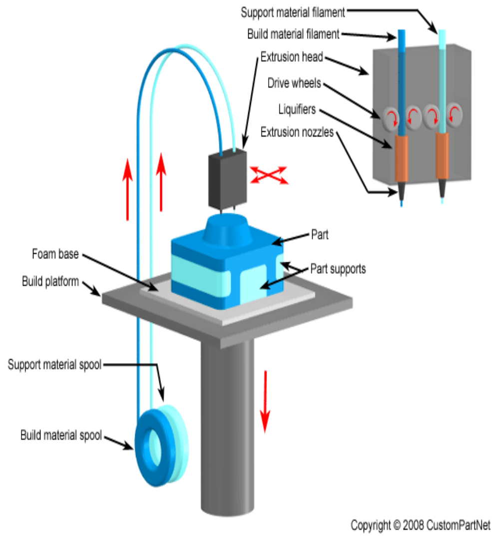


Figure 5 **Fused Deposition Modeling**

5. Modelling Of 4-Wheeler Exhaust Manifold

Modelling of 4-wheeler exhaust manifold is designed using the solidworks software. First wireframe and surface modelling are selected and sketch is drawn using the dimensions selected. After completion of sketch create a 3d curve profile using the intersections. Find the sweep tool and click to activate it and select the profile and path of sketch drawn. After completing the sweep use different tools to modified according the need.

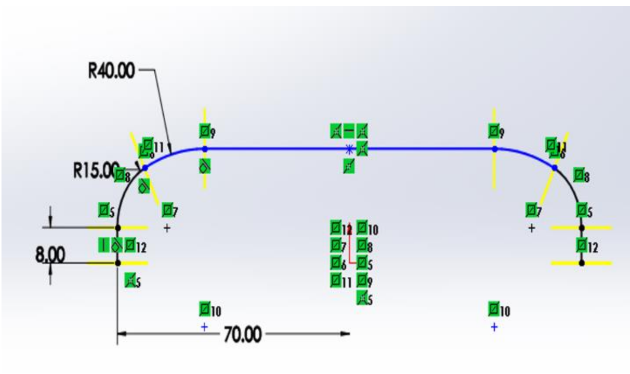


Figure 6 Sketcher

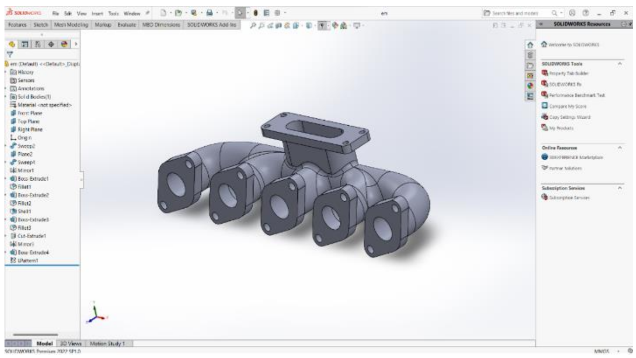


Figure 7 Creating Main Pipe Flange

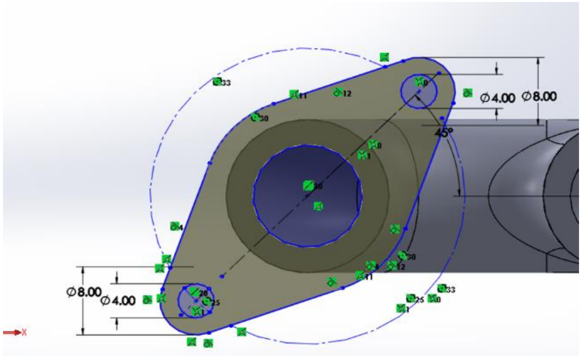


Figure 9 Pad Definition

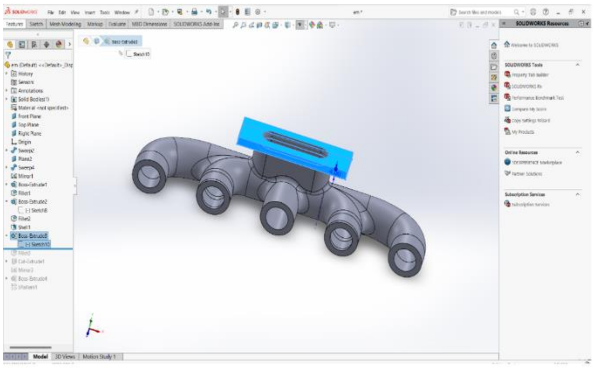


Figure 8 Final Shape Of Manifold

6. Printing Of 4-Wheeler Exhaust Manifold

After creating the exhaust manifold convert or save as .stl file format. Open the Flash Forge software and import the exhaust manifold file. Use the software tools to modify and adjust the printing parameters like orientation, scale and add support structures to the model at the weaker sections and save the file in the Fused Deposition Modeling .fdm format. Now the 3d printer comes into play and starts printing according to our needs. The estimated time will be displayed.

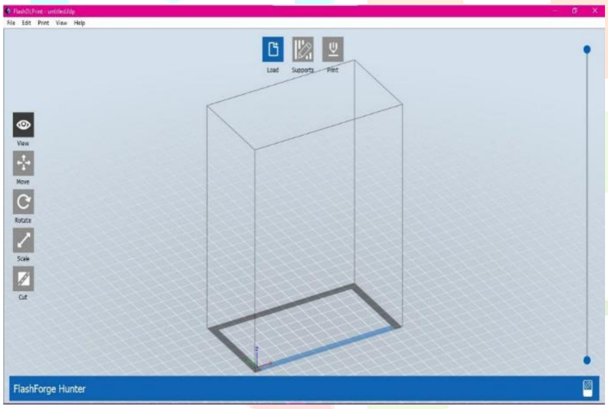


Figure 10 Overview Of 3d Printing Software

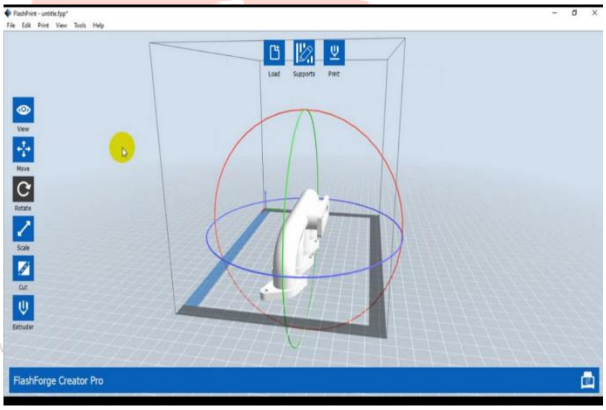


Figure 11 Exhaust Manifold Body Placed on the Platform

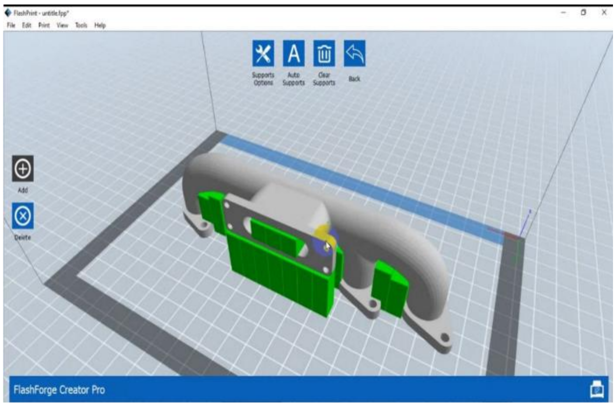


Figure 12 Providing Auto Supports To The Body

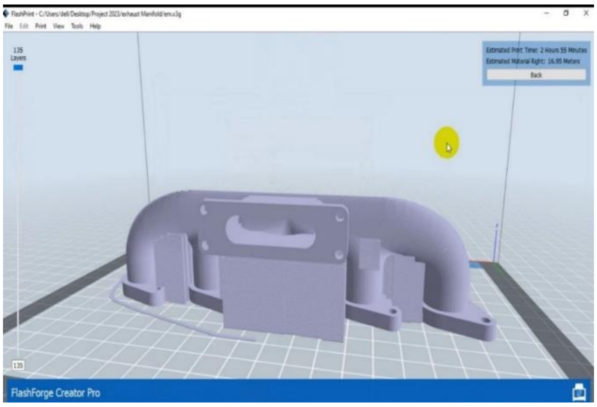


Figure 13 Final Estimated Print Time

7. Results

The result of following these steps is a properly designed and prepared 3D model of the Engine Exhaust manifold, converted to the required file format, configured with suitable support structures, and ready for 3D printing. The model is saved in the appropriate file format (*. svgx or *.fdp) with all the necessary settings adjusted, such as material selection, resolution, layer height, infill density, and fill pattern. The software provides an estimated printing time for the material based on the configured settings. By following these steps, we have successfully prepared the 3D model for printing, ensuring optimal print quality and accuracy.

Figure 14 Final Design

8. Conclusion

In conclusion, a 3D model of the exhaust manifold was designed and properly prepared, successfully created. The application of 3D printing has proven to be a practical and effective method for manufacturing exhaust manifolds, offering advantages such as customization, cost-effectiveness, and efficient production. The utilization of 3D printing technology enables the production of complex geometries and optimized designs, resulting in improved performance and efficiency of the exhaust manifold.

The potential of 3D printing as a manufacturing technique for producing high-quality and tailored components, specifically in the context of exhaust manifolds. This approach holds significant implications for industries reliant on efficient and optimized exhaust systems, such as automotive, aerospace, and marine sectors. By incorporating 3D printing into exhaust manifold production, opportunities for enhanced performance, reduced emissions, and overall improvement in engine efficiency are attainable.

9. Acknowledgment

We wish to express our sincere thanks to **Dr. H.S SAINI, Managing Director**, Guru Nanak Institutions and **Dr. KODUGANTI VENKATA RAO, Director,** Guru Nanak Institutions Technical Campus, School of Engineering and Technology, for providing us with all the necessary facilities and their support.

We place on record, our sincere thanks to **Dr. A. RAJ KUMAR, Professor** and Head of the Department, Mechanical Engineering for their wholehearted co-operation, providing excellent lab facility, constant encouragement and unfailing inspiration.

We would like to say sincere thanks to **Mr. V. SHYAMU, Assistant Professor**, Department of Mechanical Engineering for coordinating Projects.

We would like to say sincere thanks to our guide **Ms. MAIMUNA SIDDIQUI Assistant Professor**, Department of Mechanical Engineering for Coordinating Projects for the suggestions and constant guidance in every stage of the project, we also like to thank all our lecturers helping us in every possible way. On a more personal note, we thank our beloved parents and friends for their moral support during our project.

10. References

[1] J. Galindo, J.M. Luján, J.R. Serrano, V. Dolz, S. Guilain, Design of an exhaust manifold to improve transient performance of a high-speed turbocharged diesel engine, Experimental Thermal and Fluid Science, Volume 28, Issue 8,2004,Pages 863-875https://www.sciencedirect.com/science/article/abs/pii/S0894177704000159.

[2] Sen Qiu, Zhao cheng Yuan, Ruo xun Fan, Jie Liu, Effects of exhaust manifold with different structures on sound order distribution in exhaust system of four-cylinder engine, Applied Acoustics, Volume 145, 2019, Pages 176-183https://www.sciencedirect.com/science/article/abs/pii/S0003682X17309155.

[3] Futakuchi Y, (1984). Engine Intake System, www.google.com/patents/US4469067.

[4] Taylor Jim C, (1953). Intake Manifold. www.google.com/patents/US2636486.

[5] Sullivan D. A. (1939), Intake Manifold, www.google.com/patents/US2160922.

[6]. P. Yagnasri, Dr. N. Seetaramiah, Dr. P. Ushasri, A review on methods of nanoparticle synthesis and nano magnetorheological fluid application. https://ijrar.org/viewfull.php?&p_id=IJRAR19K3589.

[7]. Claywell, M. R., Horkheimer, D. P., and Stockburger, G. R., "Investigation of Intake Concepts for Formula SAE Four-Cylinder Engine Using 1D/3D (Ricardo WAVE-VECTIS) Coupled Modelling Techniques," SAE 2006 Motorsports Conference, 2006.

[8]. Ceviz M. A Akin M. Design of a new SI engine intake manifold with variable length plenum. Energy Convers Manage, 2010.

[9]. Stuart Philip E.A. (2005). Continuously Variable Air Intake Manifold with Adjustable Plenum, www.google.com/patents/US6837204

[10]. Harrison M.F., I. De Soto, P.L. Rubio Unzueta, A Linear Acoustic Model for Multi-Cylinder IC Engine Intake Manifolds Including the Effects of the Intake Throttle, Journal of Sound and Vibration, 2004, pp. 975–1011.

[11]. Dunkley A., Harrison M.F., The Acoustics of Racing Engine Intake Systems, Journal of Sound and Vibration 271 (2004) 959–984.

[12]. Harrison M.F., P.T. Stanev, A Linear Acoustic Model for Intake Wave Dynamics in IC Engines, Journal of Sound and Vibration269 (1+2) (2004) 361–387.

[13]. Davis G. G., Thurm K, (2001). Intake Manifold with Multiple Stage Ram Induction, www.google.com/patents/US6209502

[14]. Sattler Eric R., Myers J. S. Haspel M. J, (1999). Continuously Variable Runner Length Manifold, www.google.com/patents/US5950587.

[15]. Lee C. L, (1997). Variable Air Intake Manifold. www.google.com/patents/US5638785.

[16]. A.K.M. Mohiuddin, et al. in their paper "Optimal design of automobile exhaust system using gt-power", designed exhaust system using GT-Power software and compared its performance with an existing system. The newly designed exhaust manifold shows lower back pressure which ultimately results better performance of the engine.

[17]. GajendraRaghuwanshi, AbhayKakirde and Suman Sharma. Design and Analysis of Exhaust Manifold Comparing Different Specifications, International Journal of Engineering Trends and Technology 62, 2018.

[18]. M.Rajasekhar Reddy and Dr K.Madhava Reddy "Design and Optimization of Exhaust Muffler In Automobiles", International Journal of Engineering Research and Applications, Vol 2, Issue 5, Sept-Oct 2012.

[19]. A.K.M. Mohiuddin, Ataur Rahamn and Mohd. Dzaidin "Optimal design of automobile exhaust system using gt- power", International Journal of Mechanical and Materials Engineering, Vol 2 No. 1, 2007.

[20]. Yuto Otoguroa, Kenji Takizawaa,_, Tayfun E. Tezduyar, Kenichiro Nagaokaa, Sen Mei, "Turbocharger turbine and exhaust manifold flow computation with the Space– Time Variational Multiscale Method and Isogeometric Analysis", An International Journal of Computers & Fluids (2018).

[21]. Masahiro Kanazaki and Masashi Morikawa. "Multiobjective Design Optimization of Merging Configuration for an Exhaust Manifold of a Car Engine", Parallel Computational Fluid Dynamics, International Conference Parallel, Kyoto, Japan, May 2002.

[22]. P Sylvester Selvanathan et al., in 2017, This papers aims to analyze the design of an exhaust manifold to establish the significance of various factors involved in designing an exhaust manifold by comparing various existing designs using Computational Fluid Dynamics.

[23]. Ahmed in 2020 - Title: "Material Selection and Strength Analysis in 3D Printing of Automotive Exhaust Manifolds"
[24]. Lee in 2022 Title: "Integration of Computational Modelling and Additive Manufacturing for Improved Four-Wheeler Exhaust Manifold Performance"
[25]. Chen in 2017 - Title: "Optimization of Exhaust Manifold Design Using Computational Modelling ".
[26]. Suzuki in 2019 - Title: "Advanced Thermal Analysis of 3D Printed Exhaust Manifolds in Automotive Applications ".
[27]. J. E. Shigley, C. R. Mischke and R. G. Budynas, "Mechanical Engineering Design," 7th Edition, McGraw-Hill Press, New York, 2003. https://www.scirp.org/reference/referencespapers?referenceid=106423.
[28]. Alexander H. Slocum is the Walter M. May & A. Hazel May Professor of Mechanical Engineering. Alex has written two books on machine design Precision Machine Design and FUNdaMENTALs of Design https://entrepreneurship.mit.edu/profile/alex-slocum/.
[29] Robert L. Norton is an American engineer, academic and author. He is the President of Norton Associates and the Milton P. Higgins II Distinguished Professor Emeritus in Mechanical Engineering at the Worcester Polytechnic Institute. https://en.m.wikipedia.org/wiki/Robert_L._Norton.
[30]. IanGibson the various aspects of joining materials to form parts. A conceptual overview of rapid prototyping and layered manufacturing. https://books.google.co.in/books/about/Additive_Manufacturing_Technologies.html?id=OPGbBQAAQBAJ&redir_esc=y