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CFD Analysis of Exhaust Manifold

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ABSTRACT: Exhaust manifold is one of the components of IC engine for improving the volumetric efficiency. The volumetric efficiency of the engine can be increased by reducing the backpressure in the exhaust manifold. This work analyses the flow through two different models of exhaust manifold using CFD. The analysis results of two models are compared for back pressure and velocity. By comparing the results of two models the decrease in back pressure is found which ensure improvement in volumetric efficiency of the engine.

Keywords: CFD, Exhaust Manifold.

1 Introduction

Depending on the engine type, a vehicle will have either one or two exhaust manifolds attached to it. An inline engine typically has one exhaust manifold. The vast majority of today's car engines are V-shaped, requiring one manifold for each of two cylinder banks. Regardless of whether a vehicle has one or two exhaust manifolds, the basic functioning of it is the same. Understanding exactly what an exhaust manifold is and how it works will help car owners make informed decisions when an exhaust manifold needs to be repaired or replaced. By Knowing the differences in designs and materials will make buying a replacement exhaust manifold easier.

1.1 Definition

An exhaust manifold is a series of connected pipes that bolt directly onto the engine head. It is an integral part of the exhaust system. Hot exhaust gas from the exhaust ports on the engine's cylinder head is funneled through the pipes and into a single collector pipe. From there, it is sent to the exhaust pipe.

1.2 Function

Exhaust manifolds are a necessary component of the exhaust system. Their design is optimized to ensure exhaust gases flow efficiently from the engine combustion chamber without creating any back pressure. A properly functioning exhaust manifold is important to prevent uneven power and engine vibrations.

1.3 Types of Exhaust Manifolds

There are two main design configurations for exhaust manifolds, four-into-one and four-into-two. Each design has the same primary function, with the main differences being performance and cost. The other main difference among exhaust manifolds is their construction. They are generally made from either cast iron or welded tubular steel.

1.4 Four-into-One Exhaust Manifolds

Four into one exhaust manifolds are most often found on high speed engines, as the design is better suited for use at higher RPMs. In this manifold design, all four manifold pipes join at a single point.

1.5 Four-into-Two Exhaust Manifolds

On four-into-two exhaust manifolds, the four pipes coming off the engine head are first paired into twos, and then joined together into a single pipe at the back of the vehicle. This is the preferred design for low- to medium-speed engines, as it is more suited for torque than speed.

2. Literature review

Mr. Sachin G. Chaudhari, Mr. Parag N. Borse, Mr. Raghunath Y. Patil Exhaust manifold collect the exhaust gases from the engine cylinders and discharge to the atmosphere through the exhaust system. The engine efficiency, combustion characteristics would depend upon how the exhaust gases were removed from the cylinder. The design of an exhaust manifold for the internal combustion engine depends on many parameters such as exhaust back pressure, velocity of exhaust gases etc. In this paper, the recent research on design of exhaust manifold, their performance evaluation using experimental methods as well as Numerical methods (CFD), various geometrical types of exhaust manifold and their impact on the performance has been collected and discussed.

Balesh Babali, Aswatha, K. N. Seetharamu, The present scenario, the main objective the engine designer's try to achieve is the best performance with lowest possible emissions. Exhaust Manifold is one of the crucial components that have an influence on this objective. The designing of Exhaust Manifold is one of the complex procedures and relies on many variables like back-pressure, flow velocity, mechanical efficiency, volumetric efficiency, etc. In the present work, three different exhaust manifold models are considered with various pipe diameters. All three models differ from

each other in geometry. Computational fluid dynamics simulation has been carried out with the help of ANSYS Fluent at three different speeds. The pressure contours and velocity streamlines are obtained for all the three models. The work is further extended by modeling two other models and the performed analysis results are validated with journal data. Manifold model 3 considered is yielding the least backpressure and indicates possible design proposals for manifold.

Kanupriya Bajpai, Akash Chandrakar, Akshay Agrawal, Shiena Shekhar Exhaust manifold is one of the most critical components of an IC Engine. The functioning of exhaust manifold is complex and is dependent on many parameters viz. back pressure, exhaust velocity, scavenging etc. In the present work, the performance of a four-stroke four cylinder gasoline engine exhaust manifold have been analyzed using three different fuels - gasoline, alcohol, and LPG for the estimation of flow characteristics, thermal characteristics, and minimum back pressure. The manifold modeling is done in Creo2.0 followed by meshing and analysis in ANSYS. The LPG fuel gives minimum back pressure, temperature and velocity being approximately in the same range for all three fuels viz. gasoline, alcohol and LPG. Thus, LPG can be considered as a suitable alternative for gasoline in terms of minimum back flow in manifold.

Marupilla Akhil Teja, Katari Ayyappa, Sunny Katam and Panga Anusha Overall engine performance of an engine can be obtained from the proper design of engine exhaust systems. With regard to stringent emission legislation in the automotive sector, there is a need design and develop suitable combustion chambers, inlet, and outlet manifold. Exhaust manifold is one of the important components which affect the engine performance. Flow through an exhaust manifold is time dependent with respect to crank angle position. In the present research work, numerical study on four-cylinder petrol engine with two exhaust manifold running at constant speed of 2800 rpm was studied. Flow through an exhaust manifold is dependent on the time since crank angle positions vary with respect to time. Unsteady state simulation can predict how an intake manifold work under real conditions. The boundary conditions are no longer constant but vary with time.

3. Research

The high pressure at the head is due to high pressure difference from exhaust in combustion chamber and atmosphere pressure. The pressure was not uniformly distributed in the existing manifold and the effect of non-uniformly distributed pressure gives an impact on the velocity of the flow of exhaust gases. The pressure flow through the outlet of the exhaust manifold should be uniformly distributed and so the new manifold design is drawn.

3.1 Component Selection

Stainless steel exhaust manifolds are the most expensive, but are rust-resistant and extremely long lasting. Less expensive aluminized steel manifolds offer many of the benefits of stainless ones, but will rust if the outer layer is scratched. Exhaust manifolds are made from cast iron or one of a few types of steel. The majority of exhaust manifolds are made from cast iron, as it is relatively inexpensive and lasts a long time.

The drawbacks to cast iron manifolds are that they are quite heavy and tend to get brittle with age and exposure to the heat cycles of an engine. Tubular steel exhaust manifolds are known for having better exhaust flow and are, therefore, found on many performance vehicles. These are component used in the exhaust manifold system for the exhaust.

Geometrical Specifications	Diameter mm	Center Height mm
70x125	70	125
70x150	70	150
70x175	70	175
70x200	70	200
70x225	70	225

3.2 Geometrical Specification

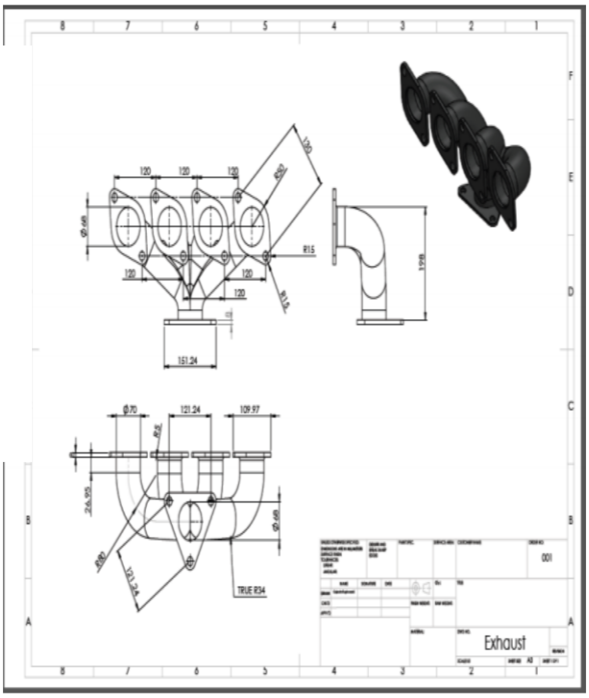


Fig.1 model diagram specifications

4. Problem identification

The major problems encountered in the Exhaust manifold are as follows:

1) In the existing design the heat transfer rate was high.

2) Higher back pressure in the manifold occurs due to the cracks at the curved surface.

3) High corrosion which reduces the life of the manifold.

4) Weight of the manifold is more

.

4.1 Modeling

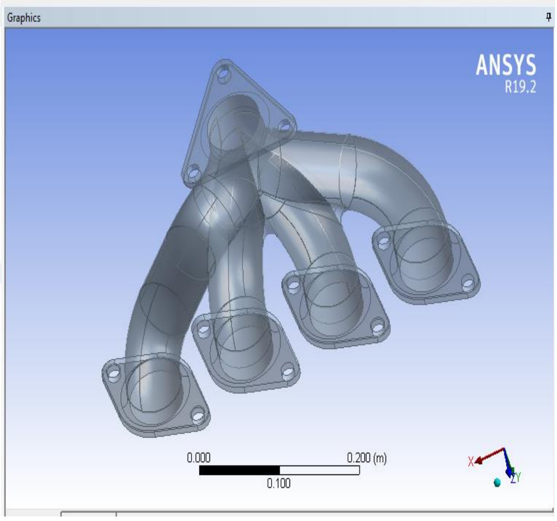
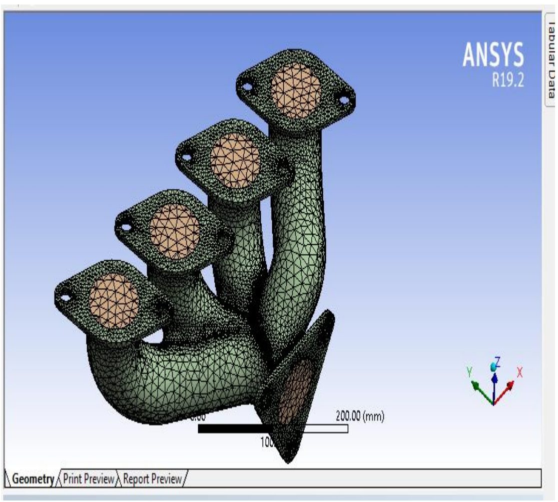


Fig.2 Modeling of Exhaust Manifold

4.2 Meshing

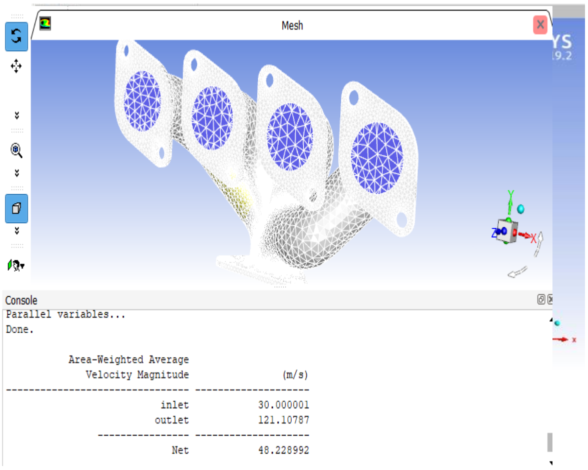
FEM mesh created by an analyst prior to finding a solution to a magnetic problem using FEM software. Colours indicate that the analyst has set material properties for each zone, in this case a conducting wire coil in orange; a ferromagnetic component light blue; and air in grey. Although the geometry may seem simple, it would be very challenging to calculate the magnetic field for this setup without FEM software, using equations alone.



4.3 Pressure Contour

At increased back pressure levels, the engine has to compress the exhaust gases to a higher pressure which involves additional mechanical work and/or less energy extracted by the exhaust turbine which can affect intake manifold boost pressure. This can lead to an increase in fuel consumption, PM and CO emissions and exhaust temperature. The increased exhaust temperature can result in overheating of exhaust valves and the turbine. An increase in NO emissions is also possible due to the increase in engine load. Increased backpressure may affect the performance of the turbocharger, causing changes in the air-to-fuel ratio-usually enrichment which may be a source of emissions and engine performance problems. Increased exhaust pressure may also prevent some exhaust gases from leaving the cylinder especially in naturally aspirated engines), creating an internal exhaust recirculation (EGR) responsible for some NO reduction. Slight NO reductions reported with some DPF system, usually limited to 2-3% percent, are possibly explained by this effect. Excessive exhaust pressures can increase the likelihood of failure of turbocharger seals, resulting in oil leakage into the exhaust system. In systems with catalytic DPFs or other catalysts, such oil leak can also result in the catalyst deactivation by phosphorus and/or other catalyst poisons present in the oil.

Velocity stream



5. Result and analysis

The model is prepared by creo software using parametric dimensions. Flow pattern is studied with velocity and back pressure. Where, the pressure, heat flux, temperature and velocity of the systems are compared.

5.1 Comparison of Exhaust Manifold 1&2

Parameter	Exhaust Manifold 1	Exhaust Manifold2
Pressure (Pa)	6.64×10^5	5.9×10^5
Heat flux (W/m^2)	2.21×10^{-10}	1.828×10^{-9}
Temperature (K)	623.2	623.1
Velocity (m/s)	596	791.4

Table.2 Comparison

6. References

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