Experimental Investigation on the Emission Level of a Single Cylinder Petrol Engine with Manifolds of Different Geometry

K. Raja, Amala Justus Selvam, and P. L. Rupesh

Abstract Petrol engines have been considered as the most popular engine to be used in automobiles due to their simplicity and easy operations. The main problem of SI engine is to get the homogeneous mixture of fuel and air. Due to the improper mixing of fuel–air mixture, emissions become a great concern for the researchers. This air movement and ensuing in-barrel stream field structure created are extraordinarily impacted by the design of intake manifolds. The study aims at the usage of intake manifolds with different geometries such as convergent, divergent and venture in a single cylinder SI engine. The emission levels of CO, HC and NO_X have been tested for the manifolds with different geometry, and the results have been compared with the existing manifold. The observed emission level for the convergent manifold is less, and it is comparable with the government norms.

Keywords SI engine · Intake manifold · Venture · Convergent · CO and HC

1 Introduction

Internal combustion engines consist of an integral part in which the fuel and an oxidizer undergo combustion. A direct impulsive force is applied to the flywheel and the crankshaft of the engine due to the expansion of the high temperature and high-pressure gases produced by combustion [1, 2].

A spark (SI engines) or compression (CI engines) of air–fuel mixture in the combustion chamber leads to their ignition, and the combustion starts. An enormous amount of heat is produced due to the combustion of air–fuel mixture, and the

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pressure produced by the expansion of combustible gases induces the reciprocating motion of the piston. The crankshaft undergoes rotary motion due to the piston power. A transmission system is used to transmit the rotary motion to the wheels and produce propulsion in the vehicle [3–6]. The air–fuel mixture in correct proportion leads to proper and complete combustion which gives better performance and less emission [7]. The shape of the intake manifold is one of the factors which influence the mixing of air–fuel mixture in correct proportion for efficient combustion. The internal flow structure of the manifold influences the flow of air-fuel mixture.

1.1 Government Emission Norms

Emission norms in India as shown in Table 1 have become strict due to the Environment Protection Act (EPA), Motor Vehicles Rules and Air Act. In 1996, these laws were applicable to the vehicles at the manufacturing stage as well as for vehicles in use [7, 8]. In addition to this, the government took initial steps in reducing the emissions through engine optimization.

Ramalingam et al. [5] have performed research on a bio-diesel operated diesel engine and observed the performance improvement and exhaust emissions reduction. He also concluded that increase of CR with B20 improved the performance and reduction in exhaust emissions except NOx emission. Mahesh et al. [9] have conducted an experimental research on a four-stroke SI engine with different geometry shapes, and a computational analysis of these manifolds has been observed, and an optimized manifold has been selected based on outlet velocity. Yerrennagoudarua et al. [10] have modified an exhaust system of a two-wheeler for emission control, and the experimental results show that a usage of a flexible exhaust pipe in a EGR setup reduces various inclination emissions. An experimental research has been conducted by Gowthaman et al. [7] on improved intake manifold design for IC engine emission control, and the emission test on engine whose intake manifold has various inner sections has shown decreased emissions. The present study deals with the

Table 1 Government norms regarding vehicular emissions

S. No.	Vehicle type	CO %	HC (n-hexane equivalent, ppm)
1	Two- and three-wheelers (mfd. Before March 2000)	4.5	9000
2	Two- and three-wheelers (mfd. after march 2000)—two stroke	3.5	6000
3	Two- and three-wheelers (mfd. after March 2000)—four stroke	3.5	4500
4	BS-II compliant four-wheelers	0.5	750
5	Four-wheelers other than BS-II compliant ones	3.0	1500

fabrication of intake manifold of different shapes such as convergent, venture and divergent and to use them in an experimental setup for performance and emission test.

2 Experimental Setup

The experimental setup consists of a **Bajaj CT100** as shown in Fig. 1a mounted on an engine testing platform, coupled with a rope brake dynamometer. This acts as a perfect setup for performing both the performance test as well as the emission test.

The experimental setup is started and throttled to a rate such that the shaft speed goes to as high as 500 rpm. The test is carried under constant rpm and varying loads condition. Figure 1b shows a AVL 5-gas analyzer in which the purge and O_2 test are carried out. An O_2 level of 21% indicates that the analyzer is functioning properly and the test may be conducted. The one end of the probe is attached to the analyzer and the other end into the silencer of the vehicle.

2.1 Fabrication of Modified Manifolds

The manifolds designed whose dimensions given in Table 2 were set for fabrication

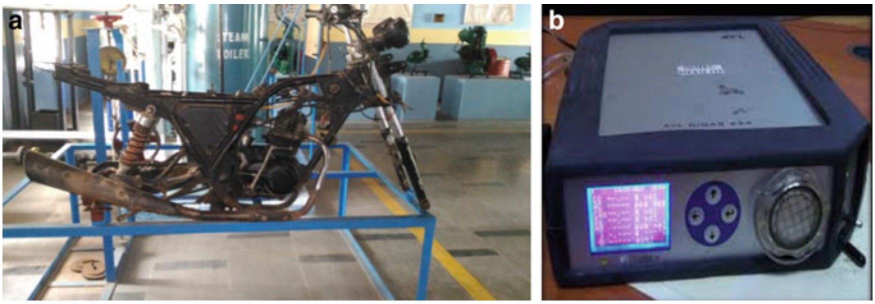

Fig. 1 **a** Experimental test rig. **b** AVL 5-way exhaust gas analyzer

Table 2 Dimensions of different manifolds

Type	Intake diameter (mm)	Throat (mm)	Outlet diameter (mm)	Length (mm)
Existing	21	–	21	75
Venture	21	19	21	75
Convergent	23	–	21	75
Divergent	21	–	23	75

and optimization. The manifolds were classified into three types as based on their internal flow structure as venture, convergent, divergent. The designs were optimized using Computational Fluid Dynamics software [11], and the flow velocity analysis of all the manifolds was performed.

The intake manifold of the above shapes is designed in CATIA according to the dimensions shown in Table 2. The cross section of the manifold is shown in Fig. 2.

These models were fabricated as depicted in Fig. 3a using casting technique. The

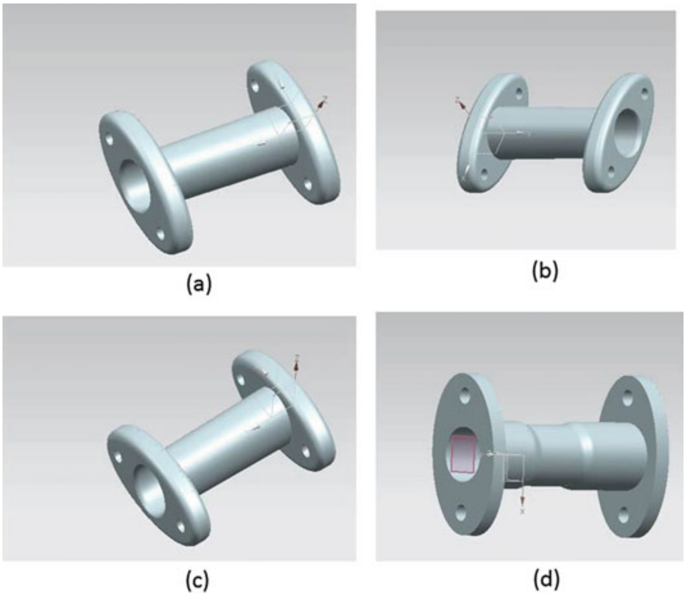

Fig. 2 **a** Existing **b** Convergent **c** Divergent and **d** Venture

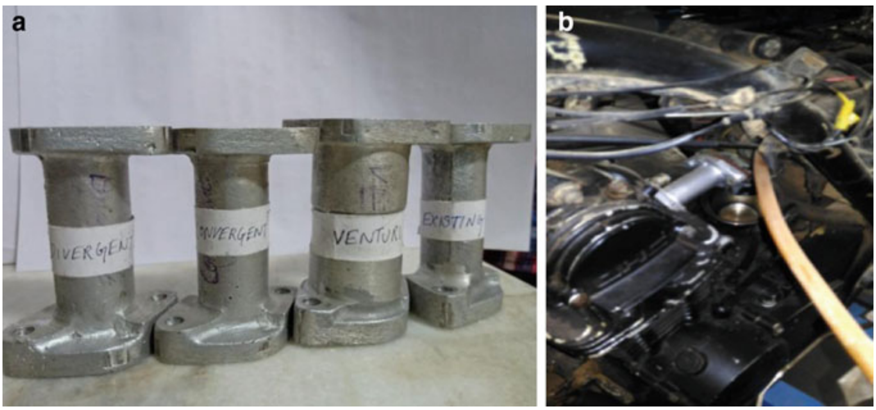

Fig. 3 **a** Fabricated manifolds **b** Manifold installation

components obtained using casting were as per the intended design. Figure 3b shows a manifold installed in the setup for emission test.

3 Results and Discussion

The emission level of the engine at different load conditions such as no load (0%), part load (50%) and full load (100%) has been evaluated at the shaft speed of 500 rpm by mounting a rope brake dynamometer onto the setup. From our study, we have concluded that changing the shape of the inlet manifold, there has been a considerable variation in the levels of pollutants in the emission. Upon compiling, we have come up with the following order of manifolds based on their ability to reduce emissions:

- Convergent.
- Venture.
- Existing.
- Divergent.

3.1 Variation in CO Emissions

Figure 4 indicates the variation in carbon mono oxide emissions at different loads for different types of manifolds usage in the experimental test rig. The emission results show that as the load increases, the emission level of CO also increases. Among the other manifolds, convergent manifold shows a decreased emission level due to the swirl action. The swirl motion in the convergent manifold is formed due to the sudden contraction in the area of the manifold. The decrease in the area leads to increase

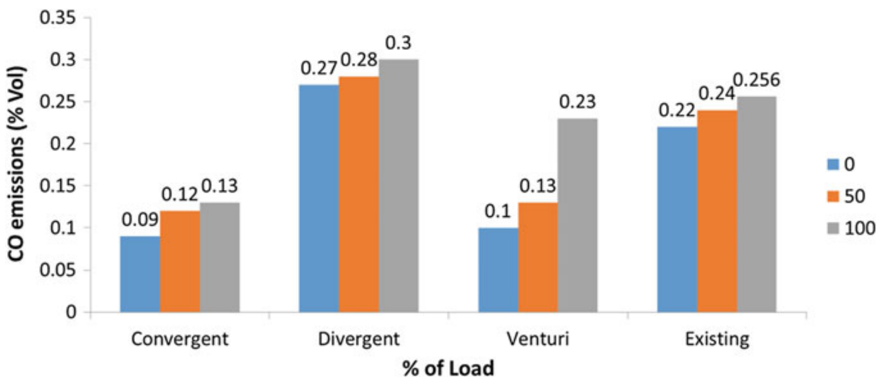

Fig. 4 Comparison of CO levels (% Vol.)

in the flow velocity of the air–fuel mixture which makes the mixture to swirl and provides efficient combustion. The efficient combustion leads to less emissions of CO.

3.2 Variation in HC and NO_X Emissions

The comparison of the emission results of hydrocarbon has been depicted in Fig. 5. Due to the swirl action and turbulent flow, the manifold with convergent geometry emits less amount of HC with comparison to other geometries. The normal and the divergent manifold emits in greater level due to the absence of throat geometry.

The bar graph shown in Fig. 6 compares the NO_X emissions of fabricated manifolds. The NO_X level has been reduced to a considerable amount of 185 ppm by

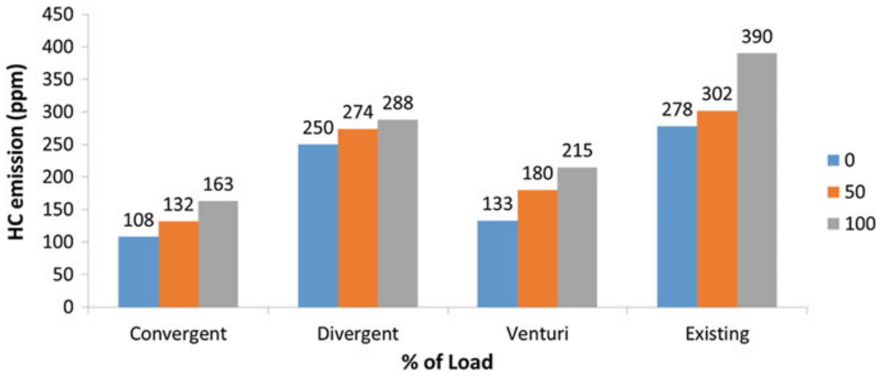

Fig. 5 Comparison of HC levels (ppm.)

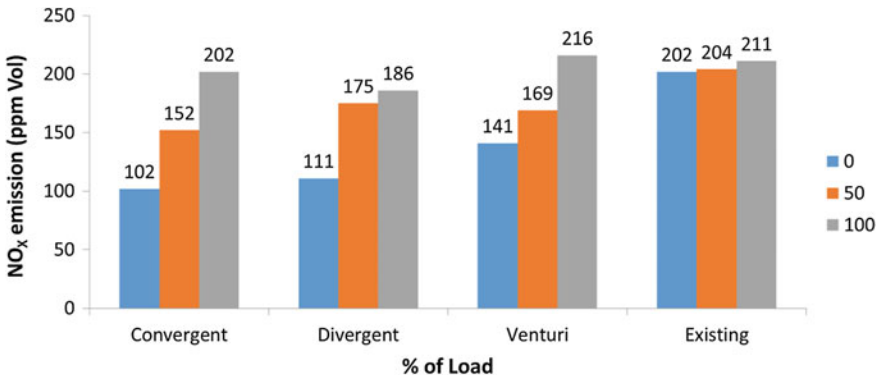

Fig. 6 Comparison of NO_x levels (ppm Vol)

using the convergent manifold at the maximum load of 4 kg. This reduction occurs due to the turbulent motion of air and fuel mixture inside the intake manifold.

4 Conclusion

The experimental evaluation of the emissions of CO, HC and NO_X using manifolds of different geometry in a test rig containing a Bajaj CT 100 engine at different load conditions was performed in the above work. The results indicate that the CO emission (0.13% of Vol.), HC emission (163 ppm HEX) and NO_X emission (185 ppm Vol.) are less by using a convergent manifold in the test setup. The venture manifold also shows a similar result, but due to its complex structure, it was not suggested. The air velocity was increased in the convergent manifold, and the emission is reduced due to the swirl motion. The emission result for the convergent manifold also agrees with the government emission norms.

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