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Effect of Exhaust Back Pressure on Exhaust Emissionsby Altering Exhaust Manifold Position

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Abstract:

In our day to day life, Automobile plays an important role.Along with population, no of vehicles are also increasing drastically Four wheelers and Two wheelers are the main categories of vehicle generation. The quantity of two wheelers is about 70% of total vehicle sale. Two wheelers are fast and easy way of transport as well as fuel efficient machines. Two wheelers are also equipped with great style and comfort. They can be used to compete the long journeys and racing. Therefore there is steep increase in the number of two wheelers during the last few years. Though two wheelers are coming with all the necessary components for eliminating emissions, there is drastic increase in emission because of riding characteristics and modifications done by drivers. Therefore, all effort should be made to develop better engines in which specific fuel consumption should be less and also equipped with methods to reduce the pollution.So, this paper will help us to recognize the optimization of exhaust manifold to generate appropriate back pressure for particular two wheeler engine to reduce exhaust emission.

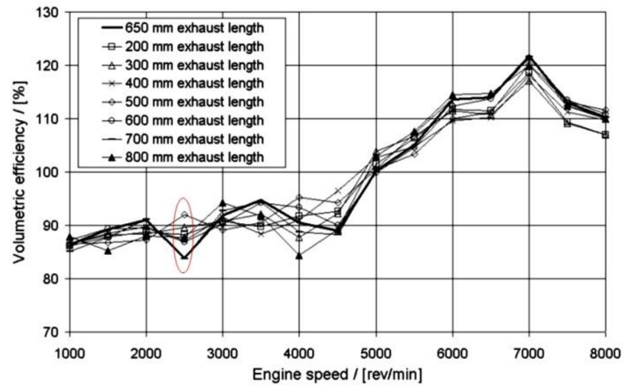
Keywords:Exhaust emission, Exhaust manifold position, Backpressure, Pollution, Emission standard

I. INTRODUCTION

Research in three-dimensional manifold shapes by the unstructured, unsteady Euler code coupled with the empirical engine cycle simulation code had done. The result suggested that the pipe radius is important to improve the exhaust gas temperature and pressure. [1]

Conclusion was made by placing the catalytic converter downstream at the exhaust pipe, decreases the exhaust temperatures and pressure. No significant change was noticed in the volumetric efficiency. On the other hand, the brake specific fuel consumption increases, and the unburned hydrocarbon emissions decreases. [2]

Effect of Gas dynamics in the exhaust system of internal combustion engines had developed. They had developed the relation of volumetric efficiency and exhaust length. This relationship is illustrated in following figures.



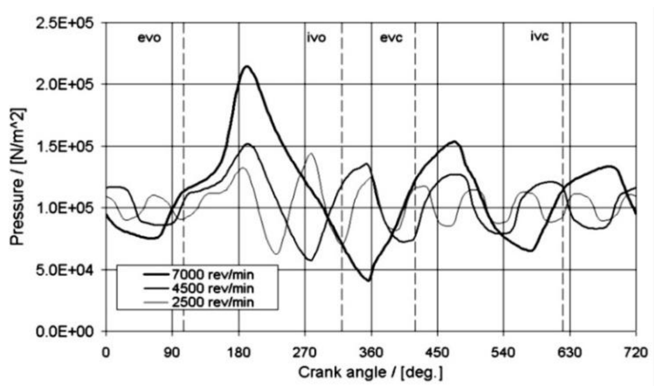


Fig 1. Variation of volumetric efficiency with engine speed for various exhaust pipe lengths

Above graphs show that the variation in pressure due to varying length of exhaust pipe affects the volumetric efficiency considerably. [3]

Investigation in the conversion efficiency of catalyst with the increase of catalyst length had done. The change in length is more important for short converters and it becomes gradually less important for long converters. Keeping other parameters constant, increasing the length of long converters may even have an adverse effect on the conversion efficiency and flow because of increased back pressure. [4]

Research work on designing of exhaust system design based on heat transfer computation had performed in 1999. According to their research the exhaust gas flow in the exhaust system is unsteady and compressible. The flow condition at each location is described by three independent parameters, namely velocity, density and back pressure. The following exhaust system design parameters they had optimized to get appropriate flow. [5]

- Exhaust manifold material, thickness and insulation
- Exhaust manifold and downpipe design (geometry)
- Position of catalytic converter in gasoline engines
- Position of particulate trap in Diesel engines

Research on optimal design of automobile exhaust system had done in 2007. The newly designed exhaust manifold shows lower back pressure which ultimately results better performance of the engine. They concluded that by reducing the angle of bend pipes, the back pressure reduced so that the exhaust gases removed easily from the engine cylinder and thus gave better breathing capability to the engine. [6]

The Effect of Exhaust Manifold Design on the Motorcycle Gasoline Engine Combustion Characteristics was examined. They had proved that the engine's volumetric efficiency can directly affect the engine's output and the emission levels. This research was done to modify the intake and exhaust manifold to understand the pipe boundary layer effects on the air's resistance entering the engine and the engine performance. These improved designed of intake and exhaust manifold resulted in good volumetric efficiency and lower back pressure. They concluded that the back pressure in the exhaust pipe can severely affect the intake flow characteristics. [7]

The research on optimization of exhaust system parameters for fuel economy improvement of small gasoline engine was done in 2008. The effects of exhaust pipe length and exhaust valve timing on the fuel economy performance of small gasoline engine were investigated based on thermodynamic cycle simulation. The calculation results demonstrated that the exhaust pipe length and exhaust valve timing exert great influences on the engine efficiency, mean pressure loss for gas exchange and indicated specific fuel consumption. [8]

II. EXPERIMENT SET UP

Definition of the core work could be given as aemission measurement of high speed, 4 stroke, Petrol engine for different exhaust manifold back pressure values. These values of back pressure have been generated by changing the angle of opening of exhaust manifold. The increment of opening angle had considered in clockwise direction as shown in fig 2.

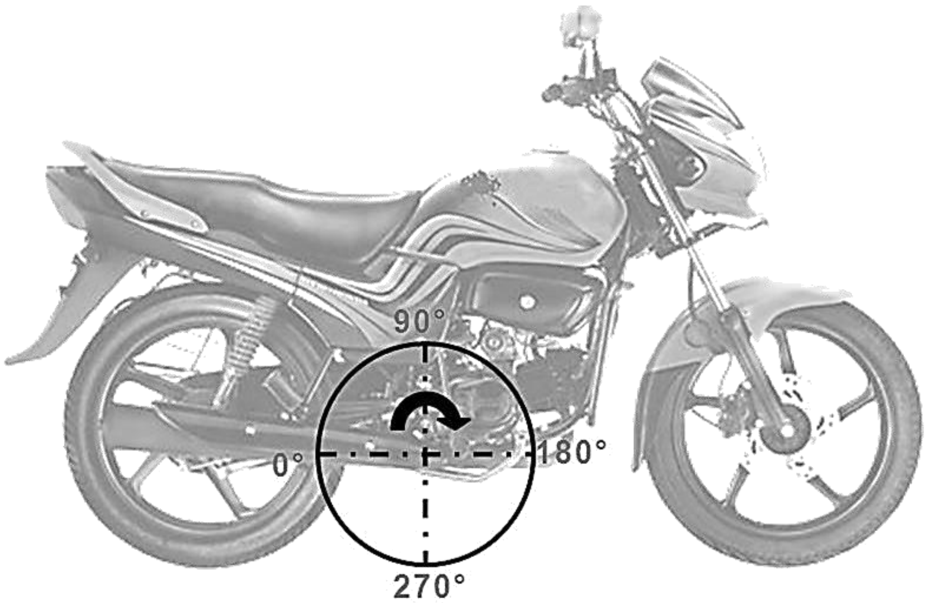


Fig 2.Exhaust opening angle configuration

Fig 2 also shows the original position provided by the company and first performance and characterization was done with the same configuration to get standard performance data. The centre for exhaust rotation has been chosen between muffler and catalytic converter same as shown in Fig 2. This would avoid difference in back pressure value arises because of catalytic converter. The dynamometer was directly connected to engine crank shaft through universal coupling. The magnet mounting nut was used to couple the crank shaft to the dynamometer.

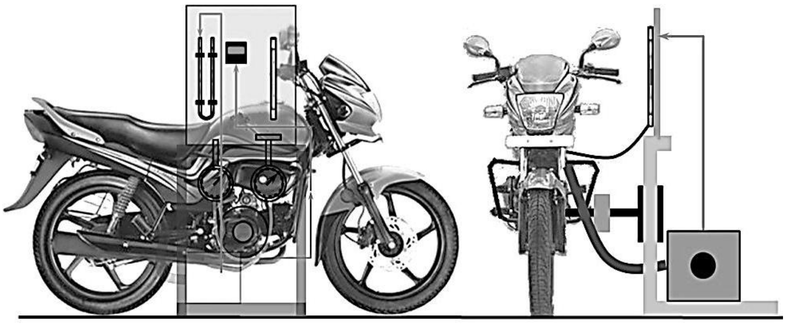


Fig 3 schematic of entire experiment

Fig. 3 shows the experimental set up. The Rope brake dynamometer was used to load the engine. Universal joint was used to couple the dynamometer to engine. It also helped to eliminate the alignment difference between two shafts. The control panel contained manometer, digital temperature gauge and burette.

III. RESULTS

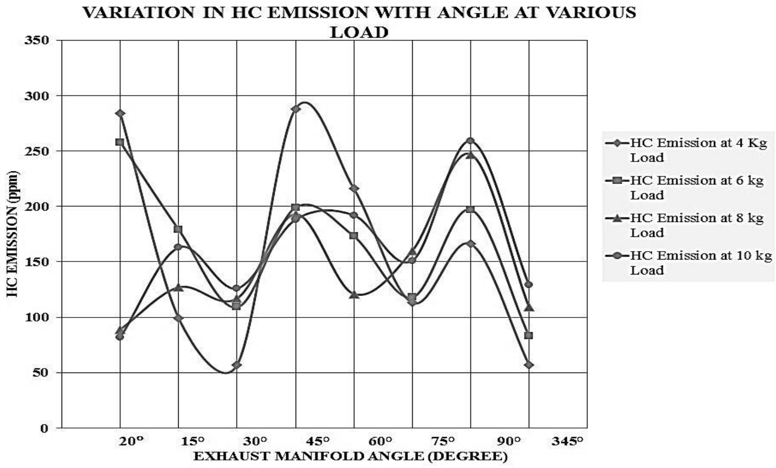


Fig 4 Variation in HC Emission with Manifold Angle for 3000 RPM

Fig 44 illustrates the variation in HC emission with respect to changing manifold angle at 3000 RPM. At 3000 RPM, values of HC fluctuate significantly for 20°. At lower loads of 4 kg and 6 kg, HC emissions are 284 ppm and 258 ppm respectively for 20°. These values are maximums for respective individual loading conditions. Afterwards, value decreases for 15° and at 30°. For a second time abrupt rise in HC emission occurs at 45°. HC emission falls one more time for 60° and 75°. Third time again HC increases for 90° but the value remains less than the maximum. One more fall take place for 345° and HC emission reaches to minimum. Hence we can observe that, HC emission curve proceeds like sine wave with increasing manifold angle at 4kg and 6 kg loads. This nature of curve must be the result of poor scavenging at higher back pressure or poor charging at lower back pressure. At higher loads of 8 kg and 10 kg, HC emissions are 89 ppm and 82 ppm respectively for 20°. This fall in values may be the result of proper loading conditions at 3000 RPM. Rests of curves behave just like 4 kg and 6kg curves. Therefore, we can conclude that the manifold at 30° and 345° provide best HC emission results at lower loading conditions at 3000 RPM. Manifold at 20° and 30° provide best HC emission results at higher loading conditions at 3000 RPM.

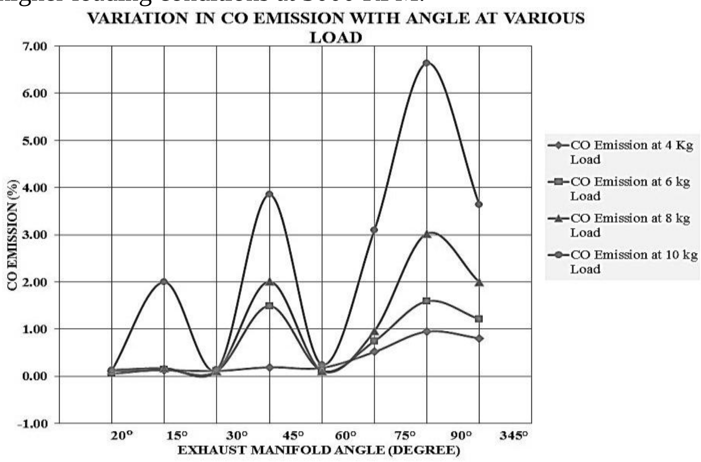


Fig 5 Variation in CO Emission with Manifold Angle for 3000 RPM

Fig 5 illustrates the variation in CO emission with respect to changing manifold angle at 3000 RPM. At 4 kg load, CO emission increases with increase in manifold angle. A little plummet occurs at 30° and value gets identical with 20°, which are 0.11 %. The maximum value of CO emission is 0.95 % at 90°. As load increases, the curve goes on oscillate like HC emission curve. Rise and falls take place for increasing order of manifold angle. Maximum peaks observed at 45° and 90°. As an abridgment, we can conclude that the manifold at 20°, 30° and 60° provide best CO emission results for engine at 3000 RPM.

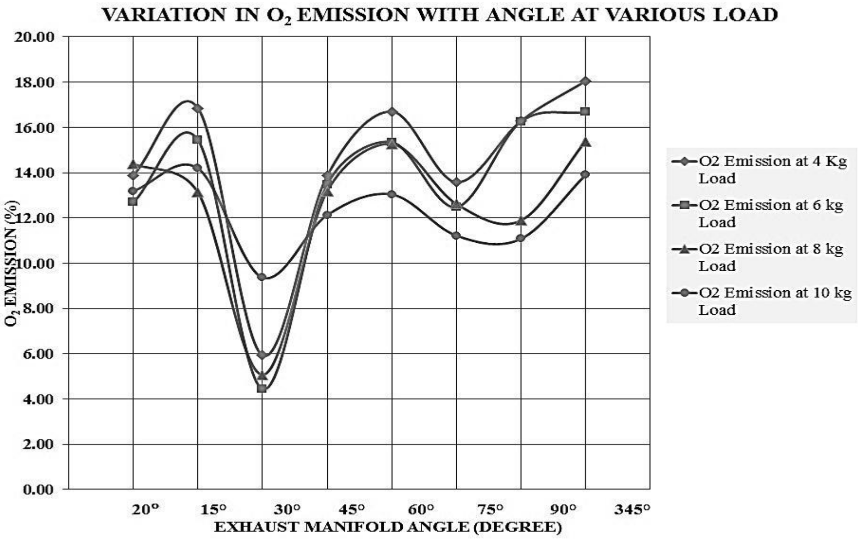


Fig 6 Variation in CO_2 Emission with Manifold Angle for 3000 RPM

Fig 6 illustrates the variation in CO_2 emission with respect to changing manifold angle at 3000 RPM. Consistent results have been obtained for 20°, 15° and 30°. After 30°, results fluctuate too much for each angle at different loads. In generalize form; we can conclude that with the exception of 20°, each angle gives better CO_2 emission for different loading conditions. The best results are for manifold at 75° which is worst for HC as well CO emissions. Predominantly conclusion arrives for 30° which also perform well for HC and CO emissions.

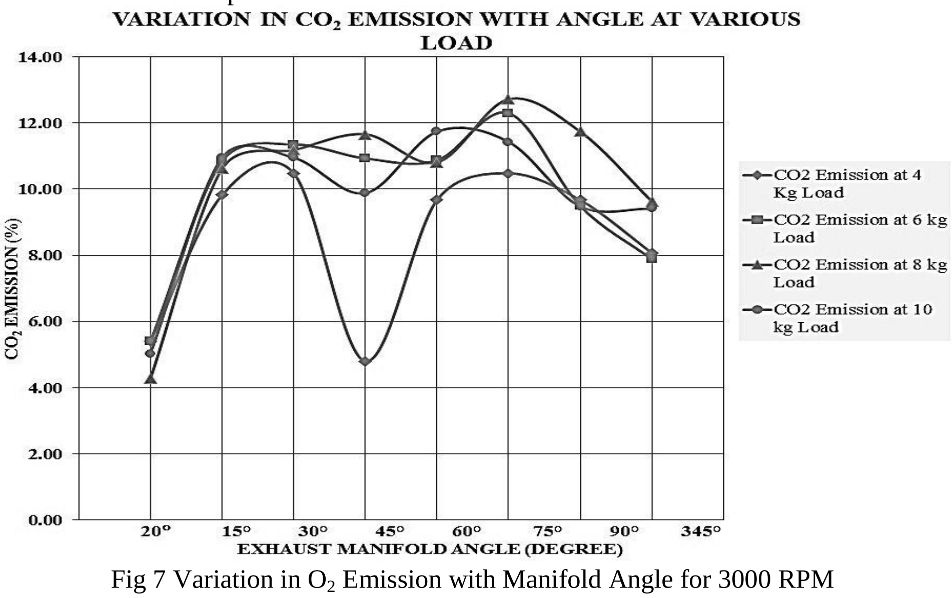


Fig 7 Variation in O_2 Emission with Manifold Angle for 3000 RPM

The amount of O_2 in the exhaust gas decides the combustion efficiency of the engine, Greater the O_2, poor the combustion efficiency. Fig 7 illustrates the variation in O_2 emission with respect to changing manifold angle at 3000 RPM. Here again, 20° and 30° preserve their position for providing favorable results in O_2 emission for 3000 RPM.

IV. CONCLUSION

1. Manifold at 30° and 345° provide best HC emission results for lower loading conditions at 3000 RPM.
2. Manifold at 20° and 30° provide best HC emission results for higher loading conditions at 3000 RPM.
3. HC emission increases 2.60 ppm with increase in manifold angle by 1°.
4. Manifold at 20°, 30° and 60° provide best CO emission results at 3000 RPM.
5. CO emission increases 0.054 % with increase in manifold angle by 1°.
6. Manifold at 20° and 30° preserve their position for providing favorable results in O_2 emission for 3000 RPM.

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