REDUCTION OF COLD START EMISSION USING TELESCOPIC CATALYTIC CONVERTOR IN A MULTI CYLINDER SPARK IGNITION ENGINE

GANESAN MAHADEVAN
Research Scholar, Dr.M.G.R Educational &Research Institute-University, Chennai-95, India.
Emai:ganesh_maha@yahoo.com,044-32957767,9380492949.
S.SENDILVELAN
Principal, Peri Institute of Technology, Mannivakkam, Chennai-600 048, India.
Email:sendilvelan63@yahoo.com, 044-22751801, 9381010709.

ABSTRACT– Control of harmful emissions from automobiles during cold start has become a challenging task over the years due to the ever increasing stringent emission norms. Catalytic convertors are effective in reducing the emissions only after they reach the "light off" temperature. In order to reduce the light off time, numbers of methods are being tried. Each method has its own merits and demerits. Close coupled catalyst (CCC) is a passive method for reducing the light off time .However due its closeness with the engine, the high temperature of the catalyst together with the manifold and exhaust pipe form a group of components that emit powerful heat energy. This may damage some of the heat sensitive components such as air filter housing, air intake box, belt drive cover etc. Also due to the close proximity of the catalyst with the exhaust manifold, the CCC gets ageing in a short period [8].

The objective of the present work is to reduce the cold start emission by adopting an innovative approach. A telescopic catalytic convertor (TCC) is an innovative idea and has been designed, fabricated and tested for emission in a 4 cylinder petrol engine. Using the TCC the same catalyst can be kept very close to the exhaust manifold and at far away position from the exhaust manifold. The telescopic pipe consists of 3 pipes of 300mm long and varying diameter to accommodate one pipe inside the other.

One end of the telescopic pipe is attached to the exhaust manifold of the engine and the other end is attached to the catalyst.

When the engine is started in the cold condition, the catalyst is kept very close to the exhaust manifold and thus the catalyst reaches light off very fast. Once the catalyst reaches light off, the pipes are extended one after the other so that the catalyst is at the maximum distance from the exhaust manifold and the catalyst is kept at this maximum position till the engine is stopped. The emission values were recorded using the AVL exhaust gas analyzer and the temperature values at inlet and outlet of the catalyst were recorded using data logger and thermocouples at different positions of the catalyst starting from the closest position to the maximum position from the exhaust manifold. Since the catalyst is at the closest position only for a few seconds, early ageing of the catalyst is avoided.

KEY WORDS: cold start, close coupled, telescopic catalytic converter, emissions, catalyst, light-off.

1. INTRODUCTION

Air pollution generated from automobile sources is a problem to human kind. During the last 60 years the world vehicle fleet has increased from about 40 million vehicles to over 1 Billion. The figure is projected to double in another 20 years. The environmental concern originated by automobile sources is due to the fact the majority of engines employ combustion of fuels derived from crude oil as source of energy. Burning of hydrocarbon ideally leads to the formation of carbon dioxide and water. However due to incomplete and non perfect combustion, potentially harmful products like UN burnt hydro carbons and carbon monoxides are produced. Besides these pollutants, various oxides of nitrogen (NOx) are produced due to very high temperature encountered in the engine. The effects of these pollutants are adversely affecting the human life. The various methods available to reduce the emission of pollutants from automobiles are Engine design modification, fuel modification and treatment of exhaust gases.
In last decades, numerous methods have been developed to reduce toxic emissions with increasing of consciousness concerning environmental pollution resulting from internal combustion engines. Catalytic converters are the most effective means to reduce atmospheric pollutants produced by internal combustion engines. The conversion efficiency of catalytic converters declines very steeply at low temperatures. At cold start and warming period the converter efficiency is much closed to zero [1, 2].

To reduce the cold start emission, light off temperature has to be attained rapidly. Preheating is used in catalytic converter to achieve the light off temperature [3-5]. There are active and passive methods for rapid light off. The active methods include electrically heated metal catalyst, catalyzed fuel burner and rapid exhaust port oxidation. Passive methods include air gap insulation, phase Change Material and variable conductance insulation. Various methods adopted for rapid light off have been studied by various researchers [6-10]. Using Phase Change material (PCM) the excess heat generated during the running of the engine is being stored and utilized during cold start period to keep the catalyst above the light off temperature over a long period of time [5].Using air gap and insulating material over the catalyst outer surface, it retains the temperature of the catalyst even hours after the engine is stopped [7]. Electrically heated catalyst using an external heater helps the catalyst to reach light off before starting the engine. The exhaust wall pipe is made single or double wall in order to reduce the heat loss of exhaust gases which contributes the heating of main catalyst faster. The pre catalyst will attain the light off much earlier and hence reduces the cold start emission [6]. The catalyst is close coupled with exhaust manifold and hence exhaust gases take much lesser time to light off the catalyst [8, 10].

However the position of close coupled catalytic converter for rapid warm up and high conversion rates can cause problems within the engine compartment. The catalytic converter together with the manifold and exhaust pipes form a group of components that emit powerful heat energy. These components come in to close contact with some heat sensitive parts, such as air filter housing, air intake box, belt drive cover etc. It makes more sense to control the heat output of the exhaust system and the heat transfer to other components by choosing materials for the included surfaces which show good properties to reduce radioactive heat transfer [8].Also in close coupled catalyst due to the close proximity of the convertor from the engine exhaust manifold it is subjected to high temperature around 800^0C throughout the operation of engine. This accelerates the ageing of the catalyst [8].
The present work is based on the closed coupled catalyst. To overcome the damages caused to the catalyst and at the same time to achieve rapid light off, an innovative new approach using a Telescopic catalytic convertor (TCC) is suggested.

ISSN 2229-5518

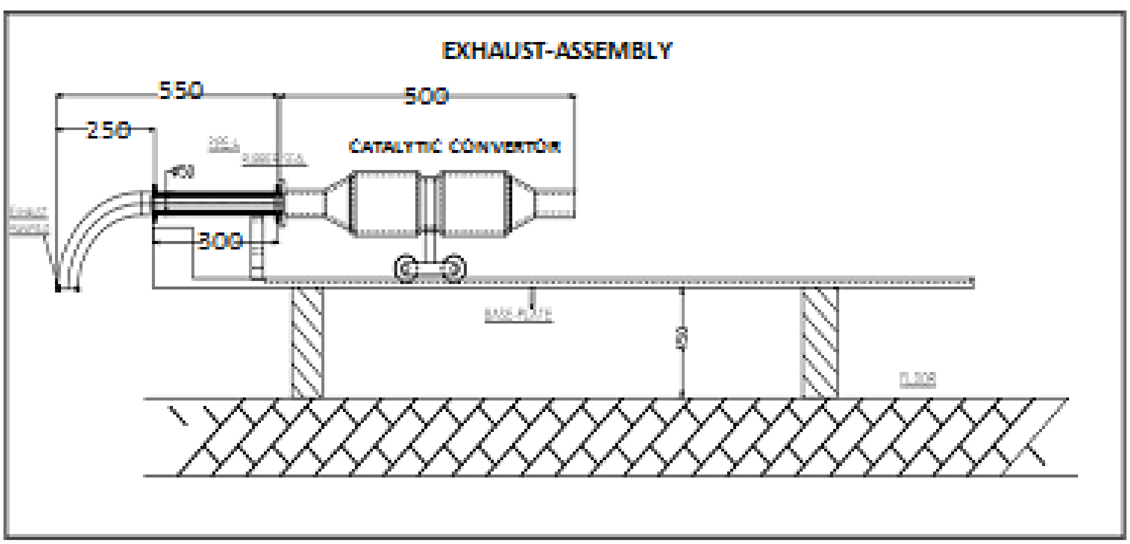
EXPERIMENTAL SET UP

Engine specifications

Engine type : Four cylinder Petrol engine
Power : 7.4 KW
Rated speed : 3000 rpm
Bore diameter : 73.02 mm
Stroke : 88.9mm
Cylinder capacity: 372cc.
Loading : Hydraulic dynamometer.

A TCC consists of number of pipes stacked one inside the other so that the length of the pipe can be extended or shortened at our will. One end of the telescopic pipe is attached to the exhaust manifold of the engine and the other end is attached to the catalytic convertor. In the present work the telescopic pipe consists of 3pipes each of which measuring 300mm length. The maximum diameters of the pipe being 50mm at the exhaust manifold end and the succeeding pipes have the diameters 38mm 32mm. The 32mm diameter pipe is attached to the catalytic convertor. The pipes can be extended or shortened using a hand lever provided.The TCC moves on rails provided on the frame as shown in Fig 1.K type thermocouples are used to measure the temperature at various points of the catalyst. AVL gas analyzer is used to test the emission of pollutants at various test conditions.

In the present work, when the engine is started in the cold condition the TCC will be in the position I and it acts as a close coupled catalyst (CCC). Since the catalyst is very near the exhaust manifold the light off occurs rapidly within few seconds. Thus cold start emission is reduced. When the catalyst reaches light off it is moved to positions II as shown in Fig2, and to position III as shown in Fig3 It will be kept in maximum position III till the engine is stopped. Since the catalyst is very close to the exhaust manifold only for a few seconds till it reaches light off the early ageing of the catalyst is prevented.



Position I-Catalyst is at 55cm from the Exhaust manifold.

Fig 1

Position –II- Catalyst is at 85cm from Exhaust Manifold.

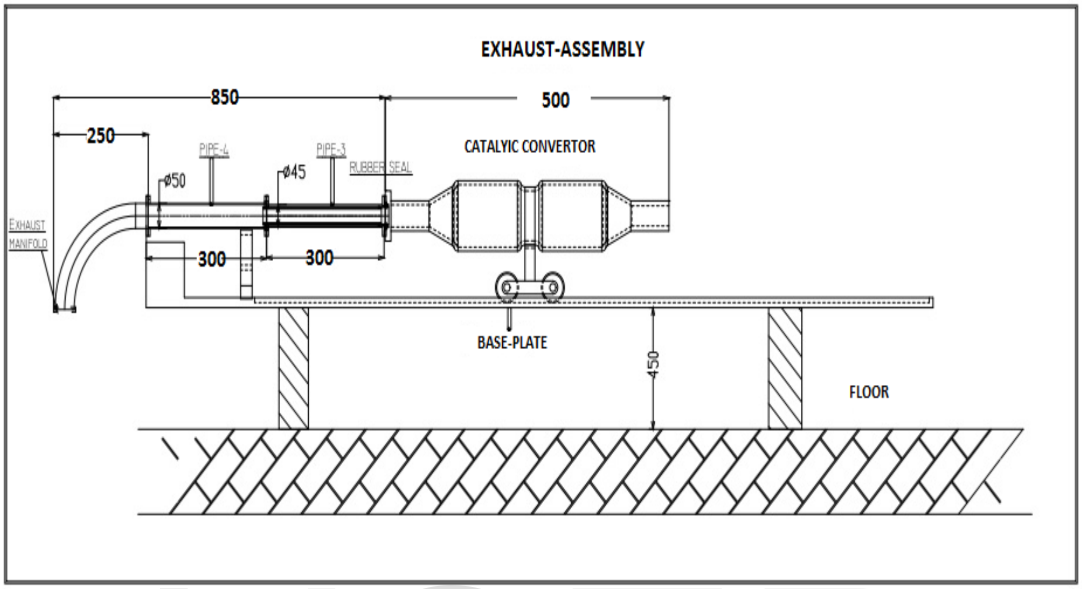


Fig 2

Position –III- Catalyst is at 115cm from Exhaust Manifold.

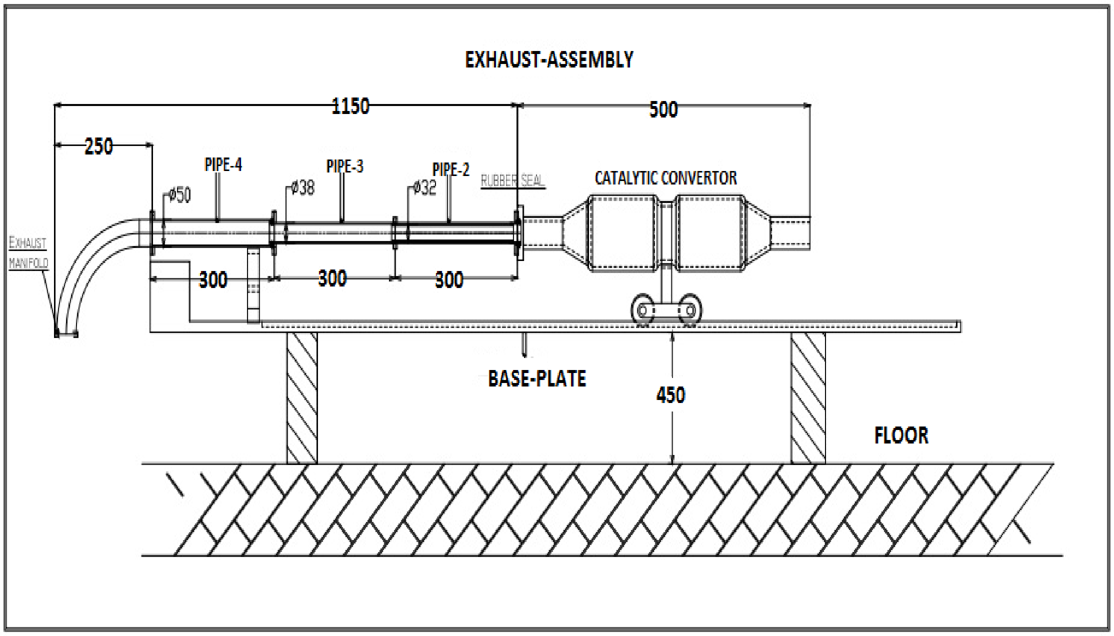


Fig 3

RESULTS AND DISCUSSION:

TEST CONDITIONS:

T1: Temperature at the inlet of the catalyst

T2: Temperature at the out let of the catalyst.

Emission test is conducted at different positions of the catalyst and the test results are compared. The following emissions are found using AVL digas analyser.

CO in % Vol

HC in ppm

CO2 in % Vol

A catalyst is said to achieve light off when the conversion efficiency of the catalyst is 50%. The emission values are noted every 10 seconds. The temperature at which the CO (%vol) reaches 50% of the initial value is referred as light off temperature and the corresponding time is referred as light off time.

Position I:

In position I the TCC is very close to the exhaust manifold at a distance of 55cm from the exhaust manifold .The light off occur at a time of 60seconds at a temperature of 237o C when the CO emission reduces from 0.1% vol to 0.05% vol., the UN burnt hydrocarbon reduces from 600ppm to 200pp

Position II:

In position II at a distance of 85cm from the exhaust manifold the light off occurs at a time of 90 seconds when CO emission reduces from 0.16 to 0.08 % vol

Position III:

When the light off occurs ar position II the TCC is moved to position III at a distance of 115cm from the exhaust manifold. At position III the light off occurs at a time of 160 seconds when CO emission reduces from 0.16 to 0.08 % vol.

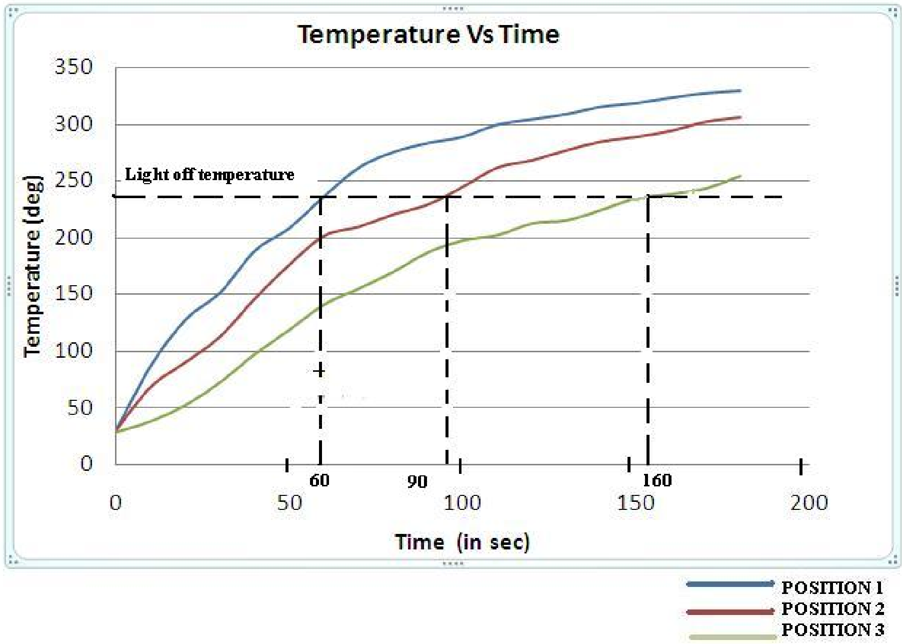


Fig 4

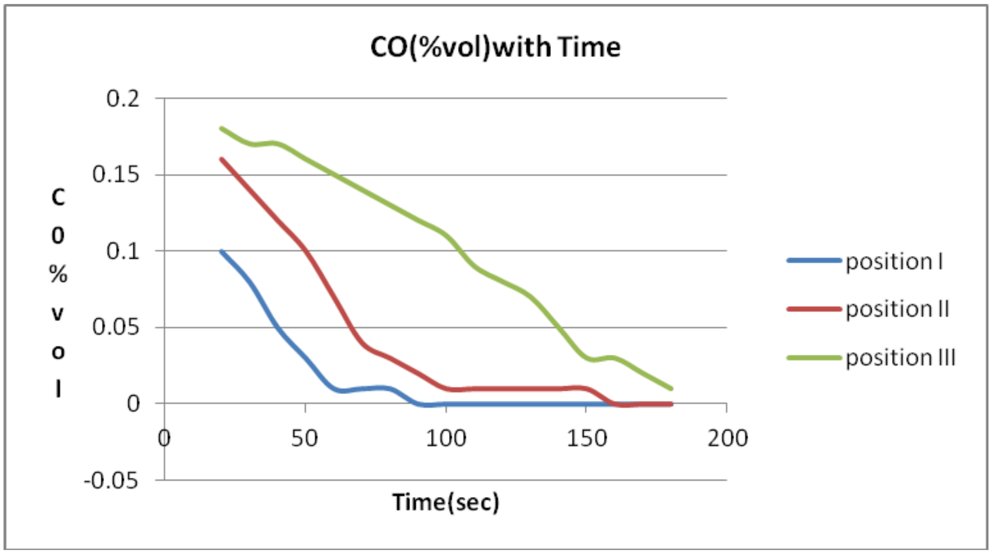


Fig 5

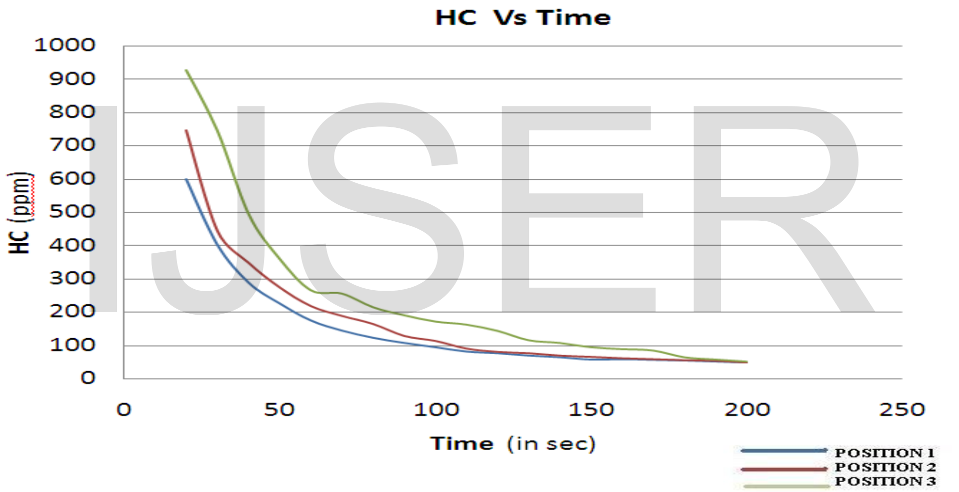


Fig 6

CONCLUSION

The telescopic catalytic convertor is a new device suggested for the reduction of cold start emission. It employs the same catalyst as the close coupled catalyst as in position I and also as a conventional catalyst kept for away from the exhaust manifold as in positionIII.

It is observed that the light off occurs at 60seconds in position I, at 90 seconds in Position II, at 160 seconds in Position III.

When the engine is started in the cold condition the catalyst acts as a close coupled catalyst as shown in fig 1 and when the catalyst reaches the light off at it is moved to the subsequent positions II and finally to position III where it is positioned till the engine is stopped.

Future work:

In the present work each pipe of the TCC is of 30cm long and light off is achieved at 60seconds.The telescopic pipes can be made of shorter length, say 20cm and 10cm each so that at nearest position, the catalyst will be still closer to the exhaust manifold and thus light off time will be further reduced. For each configuration the emission test and the performance tests can be conducted and thus the optimum configuration of the TCC can be obtained.

REFERENCES

[1] Korin.E, Reshef.R, Tshernichovesky.D, Sher.E, (1999).Reducing cold start-emission from internal combustion engines by means of a catalytic converter embedded in phase-change material, Proceedings of the Institution of Engineers, London.

[2]Karthik.R,West.D.H,Balakotaiah.V,(2004). Optimal design of catalytic converters for minimizing cold start emissions. Catal.Today 98 357-373.

[3] Boam.D.J., (1986). Energy audit on a two-litre saloon car driving an ECE 15 a cold start, Automobile Eng. 20066-67.

[4] Schatz.O, (1992).Cold-start improvement with latent heat store, Automotive Eng. J. 58-61.

[5] Darkwa.K , O'Callaghan .W.P., (1992). Green transport technology(GTT): analytical studies of a thermo chemical store for minimizing energy consumption and air pollution from automobile engines,Appl.Therm.Eng.17603-614.

[6]. M.Gumus,(2009).Reducing cold start emissions from internal combustion engines by means of thermal energy storage system, Journal of Applied thermal Engineering 29652-660

[7]. Tosihiko Hijikata, Hiroshi Kurachi, and Fumio Katsube,NGK Insulators Ltd, Huges Van Honacker, NGK Ceramics, (1996). Thermal reliability and performance improvement of close coupled catalytic converter, 960565,Society of Automotive Engineers, Inc.

[8].Hans Bauer and H.G.Haldenwanger, Audi AG, Ingolstadt, Peter Hirth and Rolf Bruck, Emitec GmbH, Lohmar,(1999). Thermal Management of Close coupled catalysts,1999-01-1231,Society of Automotive Engineers, Inc.

[9].Grigorius C.Kolstakis and Anastasios M..Stamatelos(1996))).Catalytic automotive Exhaust after treatment,Prog.Energy combustion Science,Vol23,pp1-39..

[10].Said Zidat and Michael Parmentier,(2000).Heat insulation methods for manifold mounted convertors,2000-01-0215,Society of Automotive Engineers,Inc. pp 135-141.

11Steven D. Burch - National Renewable Energy Lab.Thomas F. Potter - National Renewable Energy Lab.Matthew A. Keyser - National Renewable Energy Lab.Michael J. Brady - Chrysler Corp. Kenton F. Michaels - Chrysler Corp, (February 1995). Reducing Cold-Start Emissions By Catalytic Converter Thermal Management,. 950409, Society of Automotive Engineers, Inc.

12. Oliver J. Murphy - Lynntech Inc. Craig C. Andrews - Lynntech Inc. Rajesh Kukreja - Lynntech Inc. (March 1999). Electrically Initiated Chemically Heated Catalytic Converter to Reduce Cold-Start Emissions From Automobiles,1999-01-1233 Society of Automotive Engineers, Inc.

13. Danan Dou, Burton Williamson and Russell Richmond Delphi Corporation (2005).A Systematic Experimental Investigation of Pd-Based
Light-Off Catalysts2005-01-3848,Society of Automotive Engineers, Inc.

14.Grigorios C. Koltsakis - Aristotle University Thessaloniki Dimitrios N. Tsinoglou - Aristotle University Thessaloniki,(2003). Thermal Response of Close-Coupled Catalysts During Light-Off, 2003-01-1876. Societyof Automotive Engineers, Inc.

15. Lakshmikanth Meda - Eberspaecher North America,Xiaogang Zhang - Eberspaecher North America,Mathias Keck - Eberspaecher North America,(2005). Thermomechanical Evaluation of Close Coupled Converter System 2005-01-1623 Societyof Automotive Engineers, Inc.

16. R. M. Heck - Engelhard Corp.Z. Hu - Engelhard Corp. R. Smaling - Engelhard Corp. A. Amundsen - Engelhard Corp. M. C. Bourke - Ford Motor Co. (1995).Close Coupled Catalyst System Design and ULEV Performance After 1050° C Aging, SAE Technical Paper 952415, 1995,.