ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.6

Design Optimization of Catalytic Convertors in Diesel Engines for the Reduction of Back Pressure using Wire Mesh Arrangement and Partial Flow Technology in Bead Design

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Abstract:
The superior performance, higher output power and comparatively less-cost fuel make the diesel engines more popular in both heavy and light duty automobile applications. The main disadvantage in diesel engines is the emission of dangerous pollutants like oxides of nitrogen (NOx) and particulate matter (PM) heavily, which affect seriously the environment and human health. The scarcity and high demand of present catalyst materials necessitate the need for finding out the alternative system. The proposed system make use of knitted steel wire mesh material along with a new bead design to improve the converter efficiency. Catalytic converters with filter materials of very fine grid size wire meshes packed inside the manifold develop more back pressure which causes more fuel consumption due to lower volumetric efficiency while the use of larger grid size wire meshes packed inside the manifold develop less back pressure which causes less fuel consumption due to higher volumetric efficiency. Because of the use of larger grid size wire mesh the back pressure developed is less but the filtration efficiency is reduced which may not be sufficient to meet the present emission norms. Thus, a compromise between reduced back pressure and improved filtration efficiency is achieved by the adoption of partial flow technology in bead design. The combined use of knitted steel wire mesh material and new catalytic bead design will help the system to compensate between filtration efficiency and fuel consumption to limit the back pressure to an optimized level. Fuel being a primary sustainable source of energy, the proposed system can effectively reduce the fuel consumption and improves the converter efficiency resulting in less emission to environment.

Keywords: Back Pressure, Bead, Grid, Mesh, Catalyst,Partial Flow, Knitted.

I. INTRODUCTION

Internal combustion engines generate undesirable emissions during the combustion process which includes oxides of nitrogen, carbon monoxide, unburnt hydrocarbons, smoke, etc. Apart from these unwanted gases, it produces particulate matter such as lead, soot, etc. The simplest and the most effective way to reduce the matter is to go for the after treatment of the exhaust. The most effective after treatment for reducing engine emission is the use of catalytic converters. Existing system uses rare earth metals as catalyst to reduce these emissions. However, these earth metals are costly and are of high demand. Conventional catalytic converters use blocks of ceramic monolith, whose efficiency to trap particulate matter is lower. The existing system provides less surface area for the reaction. Hence, the reaction time is less which reduces the convertor efficiency.

II. PROPOSED SYSTEM

- Proposed system uses knitted steel wire mesh along with partial flow technology in bead design to improve collection efficiency along with reduction in back pressure.
- To reduce the fuel consumption, the grid size of the wire meshes should be large. This reduces the filtration efficiency which does not help in meeting the present emission norms.
- So, the proposed system makes a compromise between filtration efficiency and fuel consumption by using different grid sizes of the mesh in different compartments.

III. CONSTRUCTIONAL DETAILS

- The upstream of the first compartment is filled with steel wire meshes with larger grid size which make the gas to flow freely for reduction in back pressure.
- The downstream of first compartment is filled with catalyst beads and wire mesh arranged horizontally in alternate layers so that the gas can enter at one end and come out in the opposite end.
- The upstream of second compartment is filled with steel wire mesh of smaller grid size for better uniformity of flow of exhaust gas and thus improving filtration efficiency.
- The downstream of second compartment is filled with catalyst beads and wire mesh arranged horizontally in alternate layers similar to that of first compartment.

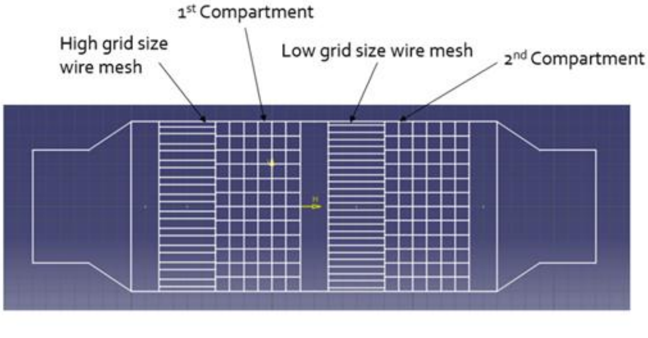

Figure.3.1. Constructional Details of Proposed System

IV. BEAD DESIGN

- Flow of exhaust gases through the system is a major criteria for attaining better filtration and limited back pressure. Bead design associated for the system makes the gases to flow freely without abrupt obstruction.
- Surface area plays a vital role in improving the converter efficiency. So more the surface area better will be the reaction time. Proposed bead system improves surface area without compensating the flow.
- Adoption of partial flow technology in bead design helps to limit the back pressure to the minimum level resulting in better engine performance and fuel saving.

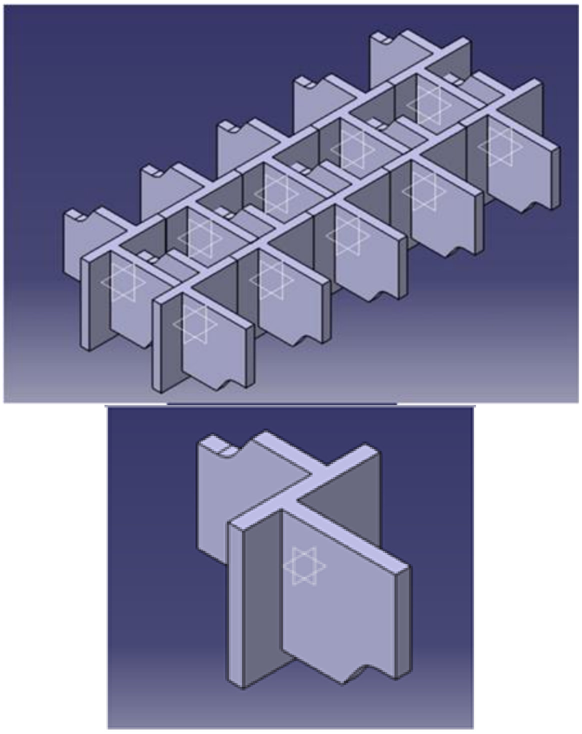

Figure.4.1. Bead Design

The design adopted in bead designing makes use of partial flow technology in which once the exhaust gas passes through bottom half of the bead section ,it creates a high pressure region at the bottom passage whereas once it passes through this opening , pressure reduces at the next section with the top passage thereby creating low pressure rregion.Thus the combined effect of flow of gases through the bead arrangement creates a net pressure drop along with an improved surface area for reaction thereby helps in reducing the back pressure of the system.

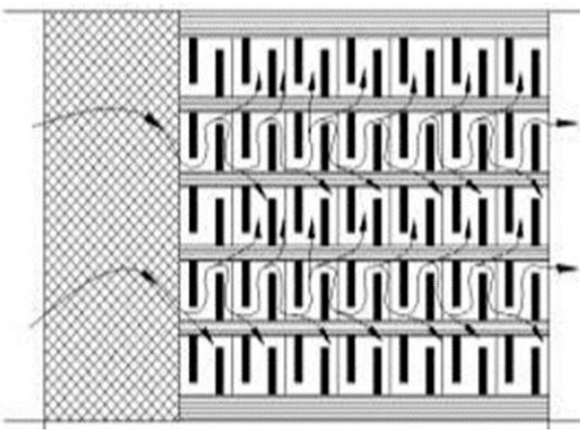

Figure.4.2 Bead and Wire Mesh arrangement

V. WORKING PRINCIPLE

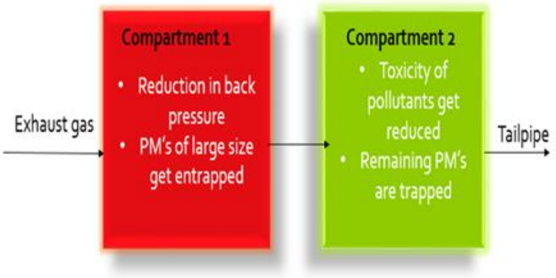

Figure.5.1.Working Diagram

- The exhaust gases first pass through the upstream of the first compartment which consists of larger grid size wire mesh. At this stage, back pressure is reduced due to the larger grid size and particulate matter of large dimensions are trapped in this stage.
- After this stage, the exhaust gases pass through the second compartment comprising of the bead layers where the exhaust gases react with the catalyst to reduce the toxicity of the pollutants.
- Second compartment is focused on improving the filtration efficiency. To attain this, gas is fed through wire mesh of smaller grid size, so that remaining particulate matters and other particles are trapped.
- Further, the gas is allowed to flow through the neighbouring bead system of the second compartment to react with the remaining pollutants.

VI. EXPERIMENTAL RIG

A test rig has been developed consisting of a 3D printed model of a catalytic convertor, DC air compressor, bourdon tube pressure gauges.

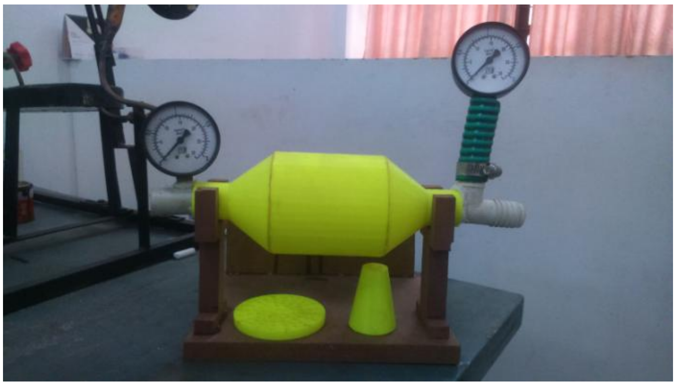

Figure.6.1.Test Rig

Air from the compressor is allowed to flow through the test rig such that pressure difference is measured in two cases: (1) Convertor with bead system only and (2) Convertor with wire mesh arrangement and proposed bead design.

- Back pressure developed in conventional catalytic converter = 25.3 kPa
- Back Pressure in the proposed system by the combination of knitted wire mesh and new bead design = 22.7 kPa
- Difference in back pressure of the two systems = 2.6 kPa

VII. RESULTS

- Use of knitted steel wire mesh reduces the back pressure of the system.
- Reduction in back pressure leads to lesser fuel consumption.

- Adoption of partial flow technology allows gases to flow more freely which also aides the limitation of back pressure.
- New bead design provides more surface area for catalyst reaction thereby increasing reaction time.

VIII. CONCLUSION

The combined use of knitted steel wire mesh material and catalytic beads will help the system able to compensate between filtration efficiency and fuel consumption to limit the back pressure to an optimized level. It helps to limit the back pressure to the minimum level resulting in better engine performance and fuel saving. The after treatment technology for PM reduction is cost effective and robust which needs no interaction with the engine management system and is totally independent

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