EXPERIMENTAL STUDY OF EFFECT OF BIODIESEL COMBUSTION ON PERFORMANCE OF CATALYTIC CONVERTER

PROJECT REFERENCE NO.: 39S_BE_1449

COLLEGE: BAHUBALI COLLEGE OF ENGINEERING, SHRavanabelagola
BRANCH: DEPARTMENT OF MECHANICAL ENGINEERING
GUIDE: MR. MANJUNATH N
STUDENTS: MR. PAVAN B N
MR. PRAMOD D K
MR. SAGAR S
MR. SREE ESHWAR D

KEYWORDS: Performance, Deposition, Composition, Catalytic Converter, Diesel, Bio Diesel, B100 Pongamia.

INTRODUCTION:
A catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine. First widely introduced on series-production automobiles in the U.S. market for the 1975 model year to comply with tightening Environmental Protection Agency (EPA) regulations on auto exhaust, catalytic converters are still most commonly used in motor vehicle exhaust systems.

Two-way catalytic converter is widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions, and they were also used on spark ignition (gasoline) engines in USA market automobiles through 1981, when the two-way converter's inability to control NOx led to its supersession by three-way converters.

Since 1981, three-way catalytic converters have been used in vehicle emission control systems in North America and many other countries on road going vehicles.

Generally, engines fitted with 3-way catalytic converters are equipped with a computerized closed-loop feedback fuel injection system, which is employing one or more oxygen sensors. Though early in the deployment of 3-way converters, caruretors equipped for feedback mixture control were used. While a 3-way catalyst was used in an open-loop system, NOx reduction efficiency was low. Within a narrow fuel/air ratio band surrounding stoichiometry, conversion of all three pollutants is nearly complete. However, outside of that band, conversion efficiency falls off very rapidly.

Catalysts are needed to reduce emissions to acceptable levels without dramatically reducing performance and fuel economy. This is true of HC, CO and NOx, but NOx is the emission that is most dependent on the catalyst for emissions compliance.

There are actually two types of catalysts. Reduction catalysts cause NOx to be reduced into O2 and N2. Oxidation catalysts cause HC and CO to oxidize with any available oxygen into CO2 + H2O. Unfortunately oxidation will only occur when there is enough free oxygen, and reduction will only occur in a relative absence of free oxygen.

Rhodium is generally the most efficient reduction catalyst. Platinum and palladium are used for oxidation.

2-way catalytic converters are oxidation catalysts. They oxidize CO and HC but do not reduce NOx. 3-way catalysts oxidize and reduce. They oxidize CO & HC and reduce NOx.
Proper air/fuel mixture control and exhaust oxygen content is required for proper 3-way catalyst performance. In general, oxidation and reduction cannot both occur at their highest efficiency at the same time.

Reduction efficiency is not at its highest unless the oxygen content is very low. This usually doesn't happen unless the air/fuel mixture is at least a little bit rich. Oxidation only reaches its highest efficiency when the oxygen content is fairly high. That happens when the mixture is at least slightly lean.

The fact that petroleum based fuels will neither be available in sufficient quantities nor at reasonable price in future has led growing interest in alternative fuels like vegetable oils, alcoholic fuels, CNG, LPG, producer gas, biogas. Biodiesel has become highly pronounced in the present context. Thermodynamic test based on engine performance evaluations have established the feasibility of using a variety of alternative fuels. They offer almost same power output with slightly lower thermal efficiency due to their lower energy content compared to diesel.

Biodiesel are introduced in 18th century, it is used as alternative fuel for vehicles that is produced by chemically reacting a vegetable oil or animal fat with an alcohol such as methanol. Biodiesel, produced from different vegetable oils (soybean, rapeseed and sunflower, for example) seems very interesting for several reasons, it can replace diesel oil in boilers and internal combustion engines without major adjustments.

Biodiesel is a clean burning renewable fuel made from vegetable oils, animal fats and recycled cooking oil and greases. It is an eco-friendly, efficient alternative to conventional petroleum based diesel and can be used in a variety of ways. Biodiesel has physical and chemical properties similar to conventional petroleum based diesel.

Biodiesel is a fuel equivalent of petro diesel with the exception of its derivation from biological sources. Both non-toxic and renewable, biodiesel essentially comes from plants and animals. The major source of biodiesel is soybean oil, but other oils include rapeseed, canola, palm, cottonseed, sunflower, and peanut. All of which can be replenished through farming and recycling. Biodiesel can even be made from recycled cooking grease! Although biodiesel can be used in its pure form, it is usually blended with standard diesel fuel. Blends are indicated by the abbreviation Bxx, where xx is the percentage of biodiesel in the mixture. Much attention has been focused on the thought of it one day replacing fossil fuels as the world’s primary transport energy source. Biodiesel is safe and can be used in diesel engines with few or no modifications needed.

**SCOPE:**

In recent days biodiesel plays important role because as the scientific study says that current rate of usage of petroleum product will last up to 100 years. So it is compulsory to move with alternative fuels, among the alternative fuels biodiesels are promising. From this study the usage of B100 pongamia is increase and the effect of emission from the vehicle or to the engine is revealed. Till now the studies are made on engine performance and emissions of biodiesel, but there are no studies made on effect of biodiesel combustion on performance of catalytic converter.

This project involves the study of effects on performance of three way catalytic converter when it is subjected under the combustion of pure pongamia biodiesel.

The estimated cost of the project is approximately Rs.60,000.

**OBJECTIVES:**

1. To study the performance of Catalytic Converter (CC) when diesel and pure biodiesel (pongamia) is used as fuel.
2. To study the micro-structure and composition of deposition in catalytic converters.
3. To study suitability of catalytic converter for pure biodiesel.
METHODOLOGY:

Biodiesel is a form of diesel fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. It is safe, biodegradable, and produces less air pollutants than petroleum based diesel. Biodiesel can be used in its pure form (B100) or blended with petroleum diesel. Common blends include B2 (2% biodiesel), B5 and B20. In this project we are using pure biodiesel (B100) that is pongamia biodiesel.

Testing is conducted on 3.7KW kirlosker diesel engine. Initially engine is subjected under the combustion of pure pongamia biodiesel for specified number of hours (say 50 hours) by assembling catalytic converter to exhaust path. By paper testing method the performance of the CC is determined. After that by dismantling the converter its microstructure and composition of deposition are analyzed using Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS). Again the same procedure is repeated to the new catalytic converter in diesel mode. Comparative studies are made and results are obtained by SEM pictures and EDS graph.

Table 1: Description of samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>New ceramic bed structure</td>
</tr>
<tr>
<td>Sample 2</td>
<td>Specimen obtained from the ceramic bed of CC facing towards engine side in diesel mode</td>
</tr>
<tr>
<td>Sample 3</td>
<td>Specimen obtained from the ceramic bed of CC facing towards tail side in diesel mode</td>
</tr>
<tr>
<td>Sample 4</td>
<td>Specimen obtained from the ceramic bed of CC facing towards engine side in biodiesel mode</td>
</tr>
<tr>
<td>Sample 5</td>
<td>Specimen obtained from the ceramic bed of CC facing towards tail side in biodiesel mode</td>
</tr>
</tbody>
</table>

Requirements to perform test,
1. Three way catalytic converters (3 numbers)
2. Diesel Engine test rig
3. Scanning electron microscope(SEM)
4. Energy Dispersive Spectroscopy (EDS)
5. Fuels: Diesel and B100 Pongamia.

RESULT:
1. The performance of catalytic converter is determined for diesel as well as biodiesel.
   i. Using paper testing method the performance of CC is determined. The emission particle present in B100 Pongamia is less compared to diesel. The emission after passing through the CC for the 0th hour the emission particle stucked on the paper are observed. The amount of particles sticked on paper in B100 Pongamia emission less compared to diesel emission.
   ii. The performance of CC is good for B100 Pongamia when compared to diesel usage.

2. The microstructure and composition of deposition in catalytic converter are analyzed.
   i. The square structured ceramic bed is used in the CC. the SEM pictures concluded that deposition on B100 Pongamia mode is more than diesel due to moisture present in the emissions of Pongamia. The compositions present in the deposition of B100 Pongamia emission and diesel emission are studied by EDS.
3. The suitability of the 3 way catalytic converter for pure biodiesel is revealed.
   i. The emission passing through CC cleared that the emission particles present in B100 Pongamia mode is less than the diesel mode and also the deposition in ceramic bed of CC in B100 Pongamia mode is more. By SEM and EDS analysis it is clear that the same 3 way CC used for diesel engine is suitable when B100 Pongamia is used.

CONCLUSION:

B100 Pongamia is rich with the oxygen of 11% due to this complete combustion takes place. Higher the oxygen molecule present the fuel leads to moisture in the exhaust emissions. From the experiment the results are concluded the percentage of deposition in the ceramic bed of Catalytic converter used in B100 Pongamia mode is more when compared to ceramic bed of Catalytic converter used in diesel mode is tabulated below.

Table 2: Percentage of Deposition difference between diesel mode and B100 pongamia mode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample 2 and 4</th>
<th>Sample 3 and 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (%)</td>
<td>0.32</td>
<td>1.54</td>
</tr>
<tr>
<td>Height (%)</td>
<td>6.69</td>
<td>0.76</td>
</tr>
<tr>
<td>Diagonal Length (%)</td>
<td>7.20</td>
<td>2.47</td>
</tr>
</tbody>
</table>

The average percentage difference of deposition thickness are 4.7% and 1.5% for the ceramic bed CC facing towards the engine side and rear side respectively When tested for 50 hours.

The particulate matter emitted after passing through the catalytic converter is much more reduced when compared to diesel emission after passing through the catalytic converter. The percentage of deposition difference is less and not so appreciable. Therefore the small difference in deposition won’t affect the performance of catalytic converter. Hence the same catalytic converter which is used in market for diesel emission is suitable when B100 pongamia is used as combustion fuel.