Emission Control Analysis On BS-VI Diesel Engine In Heavy Vehicle

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ABSTRACT

Bharat Stage VI Heavy Weight emission norms are the sixth stage for vehicular emissions in India. The BS-VI Heavy Weight emission norms are much needed for a country such as India to keep the pollution in check. BS-VI norms are stricter and more restrictive in terms of BS-IV Heavy Weight norms allowing for cleaner air and also less pollution in the process. The new BS VI Heavy Weight emission norms would require both the automobile sectors as well as oil companies to make advancements and changes to their respective products. For the best results and for the better performance of the car the BS VI Heavy Weight based engines will have to run on BS VI fuel. The new generation modern engines which are running on low-quality fuels will emit more toxic gases compared to that generated by the BS IV Heavy Weight engines. The modern age engine blueprints usually require low Sulphur content to maintain a strong performance. This research aims at comprehending information on a new perspective of understanding the concept and how helpful it will be in understanding the shift from Bharat Stage IV to VI Heavy Weight for various stakeholders.

Keywords: Bharat Stage I V, Bharat Stage VI, Strategies, Sulphur, Car Manufacturers

1. INTRODUCTION

Environmental awareness and emission legislation have made it necessary to achieve cleaner exhaust gases from gasoline and diesel engines. Additional systems are needed to reduce hazardous components from exhaust gas. The performance of these systems depends highly on sensors and controls. Reducing emissions like Hydrocarbons (HC), oxides of carbon (COx), oxides of nitrogen (NOx) and particulate matters (PM) in diesel and gasoline engines will become one of the greatest developmental challenges for the future. The primary goal of the future is to maintain the engines as a propulsion source with highest fuel economy. To resolve this challenges EATS sensors are introduced in the exhaust system to measure those emissions, temperature, pressure from the exhaust stream and give it as an input for the ECU from those inputs we easy introduce the next successful step and resolve those emissions Either in the way of introducing catalyzes or the chemical injection to the exhaust stream.

To succeed those complexity sensors having some limitations, it needs to withstand high temperature and vibration without affecting its measuring efficiency because it’s very sensitive so we have to know about the importance in the types of sensors used nowadays in field of exhaust and also handling, defects, design and packaging.

1.1 EMISSION REGULATIONS

According to our norms latest revision shown as in the table 1 emission must reduced and screened properly to protect our environment.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Year</th>
<th>CO</th>
<th>HC + NOx</th>
<th>PM</th>
<th>PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline Vehicles</td>
<td>g/km</td>
<td>Diesel Vehicles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>14.3</td>
<td>2.6</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>1996</td>
<td>17.3</td>
<td>2.7</td>
<td>0.8</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>2000</td>
<td>2.72</td>
<td>0.97</td>
<td>0.14</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>2.72</td>
<td>0.97</td>
<td>0.14</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>2.72</td>
<td>0.97</td>
<td>0.14</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>2.72</td>
<td>0.97</td>
<td>0.14</td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.1 EMISSION REGULATIONS

In view of the increasingly strict laws for emissions from motor vehicles and other sources of pollutants, the need for a new generation cost effective and reliable gas sensor has become a high priority in the survey list. Such sensors must be able to provide a stable and unambiguous signal in harsh environment.
1.2 PASSENGER VEHICLES

1.3 COMMERCIAL VEHICLE

DOC - Diesel Oxidation Catalyst
DPF - Diesel Particulate Filter
CDPF - Catalysed Diesel Particulate Filter
SCR - Selective Catalytic Reduction
SCRF - Selective Catalytic Reduction Filter
LNT - Lean NOx Trap
ASC - Ammonia Slip Catalyst

With the development of urban economy in China, pollution due to vehicle’s emission has become a significant environmental problem. By the end of 2015, the gasoline vehicle population in China reached 172 million, for which the quantity of emission accounted for 65.5% of the total emission of vehicles. Therefore, a strengthened control on gasoline vehicle’s exhaust emission is a significant measure to improve the urban air quality. To determine more targeted energy saving and emission reduction strategies, the approach to determine a reasonable and accurate emission inventory of gasoline vehicles becomes one of the most important and challenging tasks. A series of related studies about vehicle emission inventory is available at home and abroad. Sun et al. [2] took into account the dynamic changes of emission standards and fuel quality, and considering the differences of driving conditions for each vehicle type in urban road, suburban road, and highway, they established a high-resolution vehicle emission inventory based on COPERT model and GIS technology. Li et al. selected Chang-Zhu-Tan urban agglomeration as the research region and established the vehicle emission inventory in this region. Further, they analyzed the space-time distribution characteristics and contribution rate of regional vehicle emissions. They contrasted the remote sensing data of three pollutants and proposed the adjustment of the basic emission factors from the local study to improve the model. Li et al. [8] investigated the emission profile of exhaust PM 2.5 of 12 light gasoline vehicles by using vehicle test bench and particle dilution sampling system and analyzed the PM2.5 emission characteristics of light gasoline vehicle exhaust. Ni et al. tested gasoline vehicle emissions and fuel consumption at different altitudes. They further studied the mechanism of gasoline vehicle emissions and fuel consumption at different altitudes through emission characteristics of CO.

1.4 CALCULATION FRAMEWORK

Basic Emission Factors. Since 1999, China has begun to adopt the European emission standard (National Phase-I emission standard corresponding to the emission standard of Euro I), and by 2015 it has implemented the five national standards. In light of the investigation results released by the National Bureau of statistics (China Statistical Yearbook 2015), China’s vehicles that have been implementing different emission standards from National Standard I to National Standard V accounted for 2, 4, 12, 54, and 28%, respectively. Based on the national average environmental condition, vehicle condition, and road condition, and related industry standards, the basic emission factors of gasoline vehicle were obtained. Table 1 lists the basic emission factor data of various factor.

1.5 ANALYSIS OF INFLUENCING FACTORS

Environmental condition and vehicle situation are the two standing out factors influencing the gasoline vehicle exhaust. On the one hand, significant regional differences are observed in temperature, humidity, and altitude, which directly affect the engine operating conditions [14]. On the other hand, running velocity, deterioration factor, fuel quality, and vehicle load coefficient also have an immediate implication on its exhaust. For these reasons, the emission correction factors of gasoline vehicle considering regional differences are conducive not only to a more accurate and real local vehicles emission condition, but also to a more realistic emission inventory.

1.6. ENVIRONMENTAL PARAMETER CORRECTION FACTORS.

China is a country with a vast territory of around 9.6 million square kilometers. Te far-fung land area and diverse geomorphological characteristics shape a huge environmental difference in different regions of China, making the hot and humid southern area in contrast with the cold and dry northern area. Based on the information released in China Climate Bulletin in 2015, the representative higher and lower values of altitude, temperature, and humidity are listed in Table 2. Differences in environmental conditions exert direct impacts on engine operating conditions. In the high altitude and frigid region with thin air, engine excess air coefficient becomes larger bested by less oxygen, lower atmospheric pressure, and larger intake resistance. Moreover, CO and HC exhaust, on the premise of oxygen deficit and incomplete combustion increases significantly, which is also aggravated due to low environmental temperature, poor gasoline atomization effect, and insufficient burning of combustible gas mixture in hot and humid environment. In contrast, the engine becomes

IJESC, March 2021 27877 http://ijesc.org/
inefficient, troubled by high environmental temperature, slow engine cooling and heat dissipation.

Table 1.2 Emission factors for different types of gasoline vehicles.

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM10</th>
<th>PM2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minivan</td>
<td>0.47</td>
<td>0.69</td>
<td>0.49</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>CI1</td>
<td>0.37</td>
<td>0.69</td>
<td>0.34</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>CI2</td>
<td>0.48</td>
<td>0.69</td>
<td>0.49</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>CV1</td>
<td>0.68</td>
<td>0.69</td>
<td>0.49</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>CV2</td>
<td>0.37</td>
<td>0.69</td>
<td>0.49</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>CV3</td>
<td>0.37</td>
<td>0.69</td>
<td>0.49</td>
<td>0.34</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Ultimately leading to aggravation in pollutant emission with increasing fuel consumption. In high relative humidity environment, water molecules present in the air enter into combustion chamber through the engine intake system. This results in incomplete combustion of combustible gas mixture and carbon deposition. This easily leads to surface ignition under high temperature, inducing preignition defagr ation and some other tough operating conditions of engine, and thereby dramatically increasing the emission amount of Nox and PM 2.5/10 1.7 3.2. Average Velocity Correction Factors. Vehicle operating conditions in different provinces and cities in China vary significantly owing to the different landforms, population densities, and road conditions of various regions.

Table 1.2 Emission factors for different types of gasoline vehicles.

1.7 APPLICATION ANALYSIS

Regional Parameters of Zibo. According to 2015 Statistical Yearbook of Zibo Statistical Bureau, Zibo’s vehicle population was 719,000 in 2015. Te huge emission from vehicles resulted in great pressure to the atmospheric environment in Zibo. Pursuant to statistical data of atmospheric environmental quality released by Zibo Environmental Protection.

1.8 ON BOARD DIGNOSTICS (OBD II)

Meeting BS VI Emissions norms will not be only tasks to manufactures but they have to comply Indian OBDII norms. OBDII helps to detect the malfunctioning in exhaust emissions of car. In case of malfunctioning, it generates fault code with the help of Electronic Control Unit (ECU). Fault code is displayed on the Dashboard to the driver in terms of Malfunction Indication Lamp (MIL). Driver is supposed to go the dealer to resolve the emission fault code. Otherwise, corrective actions like car shut down or de rate in power will take place to avoid the non compliance to the emissions after certain hours of running after the generation of fault code. Fault code will also help to technician to fix the problem in the car in less time.

1.9 AVAILABLE CONTROL TECHNOLOGIES

Today, viable emission control technologies exist to reduce diesel exhaust emissions from both new engines and vehicles, as well as in-use engines through the use of retrofit kits. The major technologies are listed below. Technologies designed to control particulate matter (PM) include:

- Diesel oxidation catalysts (DOCs)
- Diesel particulate filters (DPFs)
- Closed crankcase ventilation (CCV)
- Technologies designed to control oxides of nitrogen (NOx) include:
  - Exhaust gas recirculation (EGR)
  - Selective catalytic reduction (SCR)
  - Lean NOx catalysts (LNCs)
  - Lean NOx traps (LNTs)

The descendents of early two-way catalysts for gasoline engines that were used to oxidize hydrocarbons and CO are oxidation catalysts. Diesel oxidation catalysts have been installed on engines for well over 20 years in millions of retrofit applications and tens of millions new vehicles worldwide. Although originally developed to reduce gaseous emissions such as HC and CO, oxidation catalysts have demonstrated 20-50 percent reductions in total particulate matter on a mass basis.

2. PROBLEM DESCRIPTION

The damage to the internals of a diesel fuel system is inevitable if we keep on running BS4 diesel vehicles on BS6 fuel. This might be sorted by additive products which we could be added along with diesel while refilling to keep these essential systems lubricated alongside not harming the...
environment. Additives might increase the efficiency of the engine even higher than before depending upon the additive. We hope that additives make their entry in the automotive market and save our old engines until they are alive. Stay tuned for further BS6 updates and news. Tell us in the comment section about the doubts you have regarding BS6. Running a car on low sulphur may lead to many small and big long-term problems. The old fuel contains nearly 50mg/kg of sulphur whereas the new bs6 fuel only has 10mg/kg which more than sufficient to do damage to the old BS4 Diesel engines. Reduced cetane number leads to reduced power and fuel economy. As high as a 7% loss in fuel economy.

3. COMPONENTS OF ENGINE

An engine is a device that converts thermal energy into mechanical work. The thermal energy is produced by the combustion of air fuel mixture inside the cylinder by means of a spark produced by the spark plug. Since it uses thermal energy it is called as thermal engines. It is a source of power for many applications.

3.1 CYLINDER

It is the part of the engine in which the conversion of thermal energy to mechanical work takes place. The piston reciprocates inside the cylinder. Since energy conversion takes place inside the cylinder it must withstand high pressure and temperature. It must be able to resist wear and tear and must dissipate heat. So material selection is an important consideration. Ordinary cast iron is used in light duty engines but in heavy duty engines alloy steels are used. The cylinders are provided with liners so that they can be replaced when worn out. Liners are made of nickel chrome iron.

3.2 CYLINDER HEAD

The cylinder head closes one side of the cylinder. They are usually cast as a single piece and are bolted to the top of the cylinder. Between the cylinder and the cylinder head, gasket is provided. Gasket is provided in order to act as sealing (to prevent gases escaping during the expansion stroke) and also to reduce shock.

3.3 PISTON AND PISTON RINGS

Piston is the main part of the engine. The main function of the piston is to compress the charge and to transmit the gas force to the connecting rod during the power stroke. Piston rings are circumferential rings that are provided in the piston grooves. The piston rings are not fully circular; there is a clearance (Ring gap) between the two ends. This is provided because during the expansion stroke piston rings expand.

3.4 PISTON RING

The upper rings are the compression rings. They help in sealing and preventing the gas from leaking past the piston into the casing. The lower rings are the oil scraper rings. They are provided to remove the oil film from the cylinder walls.

Fig 3.1 Engine Cylinder Block

3.5 CONNECTING ROD

The connecting rod connects the piston and the crankshaft. The piston is connected to the connecting rod by means of gudgeon pin. It converts the reciprocating motion into rotary motion. The upper end of the connecting rod is called small head that is connected to the piston and the lower end is called big end. The connecting rod is connected to the piston through the piston pin. It is made of case hardened alloy steel with precision finish. There are three different methods to connect the piston to the connecting rod.

Fig 3.2 Engine Connecting rod

3.6 CRANKSHAFT

It is steel forged and smooth finished. Both the ends of the crankshaft are supported in the bearings. One end is provided with the flywheel. The crankshaft is provided with counter weights for balancing. This is connected to the piston through the connecting rod and converts the linear motion of the piston into the rotational motion of the flywheel. The journals of the crankshaft are supported on main bearings, housed in the crankcase. Counter-weights and the flywheel bolted to the crankshaft help in the smooth running of the engine.

Fig 3.3 Engine Crank Shaft
3.7 CAM AND CAMSHAFT

The main function of the camshaft is to open and close the valves at the appropriate time. The cam is operated by means of gear arrangement driven by the flywheel. The cam converts rotary motion into linear motion that operates the rocker arm. The motion of the rocker arm operates the valves. Sometimes two camshafts are provided to operate inlet valve and exhaust valve separately. The valves are operated by the action of the camshaft, which has separate cams for the inlet, and exhaust valves. The cam lifts the valve against the pressure of the spring and as soon as it changes position the spring closes the valve. The cam gets drive through either the gear or sprocket and chain system from the crankshaft. It rotates at half the speed of the camshaft.

3.8 VALVES

Valves play a major role in allowing the air fuel mixture into the cylinder (inlet valve) for combustion and also releasing the exhaust gases from the cylinder after combustion (outlet valve). To allow the air to enter into the cylinder or the exhaust, gases to escape from the cylinder, valves are provided, known as inlet and exhaust valves respectively. The valves are mounted either on the cylinder head or on the cylinder block.

3.9 MANIFOLDS

There are two types of manifolds

3.10 ENGINE BEARINGS

The crankshaft and camshaft are supported on anti-friction bearings. These bearings must be capable of withstanding high speed, heavy load and high temperatures. Normally, cadmium, silver or copper lead is coated on a steel back to give the above characteristics. For single cylinder vertical/horizontal engines, the present trend is to use ball bearings in place of main bearings of the thin shell type.

3.11 ENGINE FLYWHEEL

This is usually made of cast iron and its primary function is to maintain uniform engine speed by carrying the crankshaft through the intervals when it is not receiving power from a piston. The size of the flywheel varies with the number of cylinders and the type and size of the engine. It also helps in balancing rotating masses.

Fig 3.6 Engine Flywheel

4. BS 1V VS BS V1

4.1 BS 1V

The Bharat Stage Emission Standards (BSES) is an organization that manages regulations imposed on emissions from all types of vehicles in India. It established the first emission norm in the year 2000, known as ‘India 2000’. Following this, BS2 and BS3 were introduced in the year 2005 and 2010, respectively.

BS4, also known as BS-IV, came into effect from 2017 and primarily focused on making emission standards more stringent. From all the regulations managed by the BSES, some of the emission-related changes involve tailpipe emission, Electronic Control Unit (ECU), ignition control, and so on.

4.2 BS VI

As we mentioned earlier, BSES manages the output of emissions from vehicles in India. The standards to maintain this output is set by the Central Pollution Control Board which is further governed by the Ministry of Environment, Forest and Climate Change.

The BS6 emission standard, as the name suggests, is the sixth iteration of the norm. It further pushes to reduce pollution across the country compared to the current BS4 standard.

4.3 DIFFERENCE BETWEEN BS4 AND BS6 ENGINE

- The Onboard Diagnostics (OD) is now mandatory for all vehicles under the BS6 emission norm.
- With the implementation of BS6 standards, the Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR) have been established as well. This was previously not present in the BS standard.
- Along with the implementation of BS6 emission norms, India is all set to introduce the Real Driving Emission (RDE). It is said to measure the real-time emission of the vehicles against the laboratory conditions.
- With the introduction of BS6 emission norms, there is also a change in the fuel used in the vehicles. So, the vehicles that are BS6 compliant will require BS6 fuel. If the vehicles happen to use the BS4-grade fuel, it will not adhere to the BS6 emission norms. Likewise, if the BS4 compliant vehicles use the BS6 fuel, it will not adhere to the BS6 emission norms.
fuel, its engine will be affected and increase the emission.

### 4.4 BS4 vs BS6 BASED ON POLLUTANTS

To understand the difference between the permissible emission norms of BS4 vehicles and BS6 vehicles, consider the following table.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Pollutants</th>
<th>BS4 (BSIV)</th>
<th>BS6 (BSVI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol-Based</td>
<td>Nitrogen Oxide (NOx)</td>
<td>80 mg</td>
<td>60 mg</td>
</tr>
<tr>
<td></td>
<td>Particulate Matter</td>
<td>~</td>
<td>4.5 mg/km</td>
</tr>
<tr>
<td>Diesel-Based</td>
<td>Nitrogen Oxide (NOx)</td>
<td>250 mg</td>
<td>80 mg</td>
</tr>
<tr>
<td></td>
<td>Particulate Matter</td>
<td>25 mg</td>
<td>4.5 mg/km</td>
</tr>
</tbody>
</table>

**Table 4.1**: BS4 vs BS6 Based On Pollutants

### 4.5 BSI, BSII, BSIII, BSIV, AND BSVI EMISSION NORMS

The Bharat Safety Emission Standard (BSES) manages the pollutant emission from vehicles running on the Indian roads. As we mentioned before, the permissible emission levels are set by the Central Pollution Control Board that works under the Ministry of Environment, Forest and Climate Change.

The standard is denoted by an abbreviation ‘BS’ – which stands for Bharat Stage. It is followed by the iteration of the respective emission norm. The emission levels in India are based on the European Norms, also known as EURO 1, EURO 2, and so on.

The first standard was implemented in India in the year 2000 and is known as ‘India 2000’. The BSII (BS2) and BSIII (BS3) standards were introduced in the year 2005 and 2010, respectively. The BSIV (BS4) emission standard was introduced in the year 2017.

Since there was a significant delay between the implementation of BSII and BSIV standards, the introduction of the BSVI standard was fast-tracked instead of BSV (BS5).

As a matter of fact, each iteration imposes more stringent permissible emission standards compared to the previous one.

To get an overview of the emission standards implemented along with their timelines, consider the following table.

<table>
<thead>
<tr>
<th>Mission Standard</th>
<th>European Reference</th>
<th>Implementation Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>India 2000</td>
<td>EURO 1</td>
<td>2000</td>
</tr>
<tr>
<td>Bharat Stage II</td>
<td>EURO 2</td>
<td>2005</td>
</tr>
<tr>
<td>(BS2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bharat Stage III</td>
<td>EURO 3</td>
<td>2010</td>
</tr>
<tr>
<td>(BS3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bharat Stage IV</td>
<td>EURO 4</td>
<td>2017</td>
</tr>
<tr>
<td>(BS4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bharat Stage V</td>
<td>EURO 5</td>
<td>Skipped</td>
</tr>
<tr>
<td>(BS5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bharat Stage VI</td>
<td>EURO 6</td>
<td>2020</td>
</tr>
<tr>
<td>(BS6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.2**: Norms Mission Standard

### 4.6 BENEFITS OF BS-VI ENGINE

- The BS6 emission norms are said to reduce the nitrogen oxide emission by 25 percent in petrol cars.

- Due to upgrade in the engine control software, there is an ever more precise fuel injection control for further cleaner emission control.

- We believe that this article helps you understand the difference between BS4 and BS6 engines. So, if you are planning to buy a new vehicle this year, choosing the engine power will be no hassle.

### 5. DISCUSSION AND REVIEW

#### 5.1 TRANSITION FROM BS IV TO BS VI IMPACTING THE STAKEHOLDERS

Customer

Most of the cities in India have started selling and implementing BS-VI fuels so the customers who are owners of the older generation cars that are the cars that conform to Bharat stage IV standards can choose to opt for BS-VI fuel at the petrol stations. This will produce a different result that is there is a direct interrelationship between the sulphur content that is present in the fuel and the emission produced by it in simple words the lesser the sulphur in the fuel the vehicle will emit less particulate matter (PM) which translates into cleaner combustion in the process [5]. Petrol usually has less sulphur content in it, so it usually emits lesser carbon monoxide, NOx and other toxic hydrocarbons. Recent studies also suggest that a BSIV compatible vehicle along with BSVI fuel can reduce the particulate matter (PM) emissions into half [6]. A reduction in the sulphur content in the fuel can bring down the quality and energy content in the fuel and also bring down the efficiency in the process [7]. ULSD fuels could also reduce the efficiency of the fuel due to low sulphur content but most of these fuels are spiked with additives to address, these concerns all this can cause a drastic increase, in the price of the fuels in the gas stations most of the companies are choosing to invest in oil companies that are implementing BS-VI fuels.

Potential buyers are also planning to hold back on the idea of purchasing a new car and also most of them decided to wait and purchase the new BSVI compliant cars the next year. It is quite natural for a rational customer to wait for a few months and invest in new BSVI cars than to consider investing in BSIV compliant cars at the moment. The decisions by the customer to wait for investing in a new car has been causing much trouble for car manufacturers because the stocks of unsold BSIV cars have been piling up and they are unable to sell the BSIV cars due to low customer demand. In order to clear demand adopted attractive marketing strategies in order to attract customers.

#### 5.2 EFFECT ON THE COST OF THE VEHICLES ONCE BSVI IS IMPLEMENTED

India will start to implement the BSVI emission regulations from 1st April 2020 which will be in par with the Euro-VI norms. With the new emission norms coming in, the technology will also have to be upgraded in order to keep the emissions in check. Particularly the new diesel engine vehicles, it will be effortless for petrol engines to meet the BSVI emission norms with mostly upgraded Electronic control unit (ECU). The ECU is the one who controls the electrical system and the various other sub-systems in the vehicle. However, diesel cars require a massive change in their technology in order to reduce their overall emissions. The new upgrades to diesel cars are going to increase the prices of diesel cars even further. The price gap between diesel cars and petrol cars are said to be around 2.5 lakhs if it takes into consideration all the features such as a premium hatchback, premium sub-compact sedan or an entry-level compact sedan [8]. The increase in the price of the diesel cars is because diesel cars will add to several new layers into it after the
treatment such as the Diesel particulate filter (DPF) and the selective catalytic reduction system (SCR). The SCR injects Diesel exhaust fluid into the exhaust gasses thus reducing the amount of Nitrogen Oxide (NOx) produced by the exhaust of the vehicles.

5.1.1 Manufacturers

Leading car manufacturers such as Maruti Suzuki have already started announcing their plans to start manufacturing BSVI vehicles by the end of 2019 with their commitment towards a cleaner and greener environment the BSVI cars that are produced by Maruti Suzuki will have an upgraded hardware and software system along with an upgraded exhaust as well the cars which are compliant with BSIV norms can run on BSVI fuel too, and there is no operational concern in the process [10]. The leading car companies had to increase their investment to upgrade the existing available models and make them BSVI compatible the number of new product launches by the leading automobile manufacturers has fallen over the past year.

5.1.2 Impact on The Performance and Fuel Efficiency

We are moving to more stringent emission norms, it is a more significant challenge for automakers in various ways. Since lowering the exhaust emissions generally takes a toll on fuel efficiency and performance. The car manufacturers have to make sure that they not only have to minimise the amount of pollution caused by the exhaust of the cars, but the car manufacturers also have to make sure to work with the BSVI cars in such a way that the overall performance and efficiency of the car stays intact. The new BSVI engine technology usually engages a slower combustion process. Furthermore, the exhaust system of the vehicle after treatment will increase the amount of the back pressure on the engine and some of these systems like particulate filters and the Nitrogen Oxide (NOx) traps will have to undergo a regeneration process which basically involves the exhaust material build up in the filter being combusted by using fuel. The backdrop of this is that the process which involves reducing the amount of sulphur in the diesel engines can impact the quality and performance of the fuel this drastically affects the vehicles performance and efficiency. Most of the automobile manufacturers are adopting various strategies to confront challenges. Tata Motors for example has worked on the torque and power features of the car to ensure the car’s performance is up to the mark. Mahindra automobile manufacturers have tweaked the power trains of their engines to retain the driveability of the car the power train of the car is that component that converts the power generated by the engine into movement of the car this mainly includes the engine, the transmission, the driveshaft, axles or basically anything from the engine to the rotating wheels. Mahindra also claims to have achieved a decrease in the friction of the engine to around 30 per cent thus improving the fuel efficiency and the tweaking the performance of the car in the process.

5.1.3 Government

The petroleum and the natural gas ministry told the court that the vehicles which are not compatible with the BSVI standards would not be allowed to run on the Indian roads. This statement had created much confusion in the minds of the auto-car makers, and the ministry has informed the automakers that they would get three months to exhaust their entire stock consisting of BSIV compatible vehicles after the new BSVI norms are enforced. The court also said that the car manufacturers would not be able to register for BSIV compliant vehicles after 31st March 2020.

5.1.4 Environment

The place we live in that is our natural habitat is becoming a less friendly place to undertake lifestyle activities. Air pollution is a huge problem faced by our country, and proper measures have to be put in place to curb air pollution. So, the Indian government had decided to implement a more comprehensive emission standard that is the shift from BSIV norms to BSVI emission norms. The BSVI emission standards are equivalent to Euro-VI Norms which is in place in most of the European countries the government is in the process to develop vehicles with the latest technology to make sure the vehicles emit fewer pollutants in the air and also contemplating towards improving the air quality in the metropolitan cities as well.

6. MAJOR TYPES OF POLLUTANTS

In about seven months, India will fully adopt the stricter BS6 emission norms – a transition that can be termed as the biggest technological leap the country’s auto industry has taken towards clean air. The shift, by skipping BS5, has not only happened in record time – around three and a half years – but also under great pressure, as both the oil companies and the auto industry worked relentlessly to prepare in time for the challenging deadline of April 2020. However, not all automakers have managed to make this transition fast enough, resulting in many models and power trains being phased out. It has also entailed a significant cost, one that will inevitably be passed on to the consumer. Naturally, the talk surrounding the shift has raised many questions and left many car buyers flummoxed. But we’ll break it down and tell what you need to know.

6.1 TYPES OF POLLUTANTS

Internal combustion engines (ICEs) are primarily notorious for the production of

1. Carbon Dioxide (CO2),
2. Carbon Monoxide (CO),
3. Hydrocarbons (HC)
4. Oxides of nitrogen (NOx),
5. Particulate matter (PM), or carbon soot, is another by-product of diesel as well as direct-injection petrol engines.

Carbon Dioxide (CO2):

During complete combustion, the typical combustion products from engines are carbon dioxide, nitrous oxides, particulates, water vapor, and numerous other contaminants. Several of these combustion products are linked to health problems. During incomplete combustion, carbon monoxide, a deadly toxin, is produced.

Carbon Monoxide:

Carbon monoxide is produced during incomplete combustion. A gasoline engine producing 10,000ppm CO at the ideal air-fuel ratio will produce over 60,000ppm when the fuel is increased. More amount of CO2 in exhaust emission is an indication of the complete combustion of fuel. This supports the higher value of exhaust gas temperature. The NOx concentration increases with increase of engine load for all the fuels.

Hydrocarbons (HC):

The four main pollutant emissions from diesel engines (carbon monoxide-CO, hydrocarbons-HC, particulate matter-PM and nitrogen oxides-NOx) and control systems for these emissions (diesel oxidation catalyst, diesel particulate filter and selective catalytic reduction) are discussed. The major products of the complete combustion of petroleum-

IJESC, March 2021

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based fuels in an internal combustion engine are carbon dioxide (13%) and water (13%), with nitrogen from air comprising most (73%) of the remaining exhaust. A very small portion of the nitrogen is converted to nitrogen oxides and some nitrated hydrocarbons.

**Oxides of nitrogen (NOx):**
In the exhaust of internal combustion engines, NOx refers to a class of compounds called nitrogen oxides. In DI diesel engine exhaust, nitric oxide (NO) is usually the most abundant nitrogen oxide and constitutes more than 70-90% of total NOx at engine-out conditions. A. Internal combustion engines can produce all three nitrogen oxides. Nitrous oxide (N₂O), also known as ‘laughing gas’.

**Particulate matter (PM):**
Diesel Particulate Matter Emissions Are Usually Abbreviated As PM Or DPM. The Latter Acronym Being More Common In Occupational Health Applications. The Existing Medical Research Suggests That PM Is One Of The Major Harmful Emissions Produced By Diesel Engines. Automakers generally adopt a two-pronged approach which involves working on the engine and the after-treatment. In terms of the in-cylinder measures, enhanced combustion chamber and fuel injector design will refine the combustion process and result in finer atomisation of fuel. And, on the other hand, the release of pollutants like PM and NOx is arrested using exhaust treatment systems. Direct-injection petrol and diesel engines rely on particulate filters to reduce the emission of PM or soot into the atmosphere. A higher level of NOx – a challenge especially with diesel engines – is tackled either by employing a Lean NOx Trap (LNT) or a Selective Catalytic Reduction (SCR) system.

As the name suggests, LNT works by filtering out NOx content from the exhaust gases. SCR, on the other hand, injects a water-based urea solution (AdBlue) into the exhaust flow to reduce the nitrogen-oxide emissions into inert nitrogen and water. Though more effective than LNT, SCR’s complex and expensive setup limits its applications. Jeep and Mercedes are two automakers that have introduced SCR-based diesel vehicles in the Indian market.

**6.2 IMPACT ON THE COST**
Industry experts believe the high cost of upgrading diesel vehicles to meet BS6 norms will certainly make them more expensive but will not push them beyond the reach of customers. Petrol-car prices are expected to go up in the range of Rs10,000-20,000, while diesel cars could get dearer by Rs 80,000-1,00,000.

**7. EMISION TEST**

**7.1 EMISSION GAS FOR DIESEL ENGINE**
1. carbon dioxide (CO2),
2. carbon monoxide (CO),
3. hydrocarbons (HC),
4. oxides of nitrogen (NOx),
5. Particulate matter (PM)

**7.2 EMISSION VALUES RANGES**

**BSIV ENGINE EMISSION**

<table>
<thead>
<tr>
<th>Year</th>
<th>carbon monoxide (CO)</th>
<th>hydrocarbons (HC)</th>
<th>oxides of nitrogen (NOx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>-1.5 g/Kwh</td>
<td>-0.46 g/Kwh</td>
<td>-0.40 g/Kwh</td>
</tr>
<tr>
<td></td>
<td>-0.01 g/Kwh</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Particulate matter (PM)**

<table>
<thead>
<tr>
<th>Year</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS IV</td>
<td>1.5</td>
<td>0.46</td>
<td>3.5</td>
<td>0.02</td>
</tr>
<tr>
<td>BS VI</td>
<td>1.5</td>
<td>0.13</td>
<td>0.40</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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**7.3 EMISSION RESULT FOR LIGHT VEHICLES**

**Table 7.1 Emission value for light vehicle (g/km)**

<table>
<thead>
<tr>
<th>Category</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS IV</td>
<td>1.5</td>
<td>0.46</td>
<td>3.5</td>
<td>0.02</td>
</tr>
<tr>
<td>BS VI</td>
<td>1.5</td>
<td>0.13</td>
<td>0.40</td>
<td>0.01</td>
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</tbody>
</table>

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**8. CONCLUSION**

In case of fuel specifications in terms of BSVI the main understanding is that the consequence of the fuel effects on the emission of controlled air pollutants has reduced because of the recent advancements in the engine after treatment technologies. The modern age engines usually require very low sulphur content in the fuel in order to maintain a strong performance during their need. The efforts put in for the transition from BSIV to BSVI can incredibly help in the reduction of air pollution from automobiles. This will bring a substantial enhancement in the air quality of highly populated cities as exhaust emission from vehicles are the primary source of air pollution in cities. The researchers could find out more on the strategies adopted by the foreign car manufacturers in order to cope up with the transition from BSIV to BSVI. Researchers can further investigate on the sale strategies adopted by top car manufacturers in order to sell their BSIV compliant vehicles existing in their inventory. The newly introduced BS-VI norms are going to bring a radical change in the Indian automobile sector industry. India will also get low emission producing and more fuel efficient vehicles soon. Diesel engines will be more expensive as compared to that of petrol engines because they need more adjustment and after-treatments in order to stay clean. So, this will make sure to attract the original equipment manufacturers.
(OEM) towards hybrid fuels and another environment friendly alternative technology solution providing companies are also going to benefit a lot from the transition.

9. Reference


