

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

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Abstract:
Emission legislation requirements has brought different challenges & opportunities to automotive field. The challenge is to meet the stringent emission regulations as well as to satisfy customer requirements in terms of fuel economy, oil consumption, maintenance & NVH. Cost to customer is unavoidable consideration while designing any new engine or it’s variant. These challenges have turned in to opportunities for design & development individual to come up with a better product. Modern engines not only meet emission regulations but also should meet customer expectations. Bharat Stage VI Light weight emission norms are supposed to be implemented in India from 2020 where emission limits have become very stringent. In addition to emission norms, vehicle manufactures have to comply On Board Diagnostics norms. The paper gives insight on proposed emission norms for Diesel cars. Paper also focuses on causes & control of pollutants. Selection of emission control technologies & general methodology to meet emissions is also mentioned.

Keywords: automotive field, unavoidable, general methodology, Bharat Stage VI

1. INTRODUCTION

1.1 EMISSION GASES FOR ENGINE

Selection of on engine combustion technology & after treatment devices is an important decision. It is not only important to meet the emission legislation requirements but it is also important to consider the parameters like packaging within existing space of an automobile. Effectiveness of emission reduction in terms of UBHC/CO/NOx/PM. Effect on back pressure & fuel economy, size & cost of the after treatment device, maintenance & serviceability aspect of the after treatment device. To optimise the car in order to meet the Bharat Stage VI norms, vehicle has to be optimised in areas such as Engine, transmission, fuel injection system, after treatment system, all types of electronic controls, rolling resistance, gross vehicle weight. Car is made to run on the rolling Chassis Dynamometer for 1220 seconds on Indian Driving Cycle & exhaust gas sampling is done by the exhaust gas analyser which are highly accurate.

1.2 EMISSION MEASUREMENT METHOD & EQUIPMENT

Car driver will follow the Indian driving cycle & vehicle will run into various speeds in different gears as per the cycle. Gas analyzer will collect the samples of the exhaust as. Rolling resistance will be applied to the vehicle with the help of the dynamometer. Fan speed gets changed as per the speed of the vehicle to simulate real life condition. Humidity & temperature are maintained. Following instruments are used to major the pollutants, Carbon Monoxide (CO) will be measured by Non Dispersive Infra Red analyzer.

Carbon Dioxide (CO2) measurement is done by Non Dispersive Infra Red analyzer. Chemiluminescent detector measures Nitrogen Oxides (NOx). Flame ionisation detector measures Hydrocarbon (HC). Particulate Matter (PM) measurement is done by PTFE (Poly tetra fluoro Ethylene) filter paper method.

Figure 1.1 Rolling Chassis Dynamometer & gas analyzer

1.3 CAUSES & CONTROL OF POLLUTANTS

HC gets produced due to too rich Mixture, too lean Mixture operating temperatures below Ignition, poor atomization-Large Fuel Droplet Size, higher Crevice volumes. HC can be controlled by increasing compression ratio, reduced quench area, reduced dead volumes, optimum injection timing, rapid needle closing – no dribble, no secondary or after injection ,high injection pressure, ring pack optimisation & oil consumption control. CO formation is mainly due to incomplete combustion of carbon containing fuels, inadequate oxygen availability and low cylinder temperature. CO can be controlled by Combustion chamber optimisation, high air-fuel ratio – high excess air, turbocharging, multi-valve configuration, swirl optimisation, controlled wall wetting, optimum injection duration, reduce late burning. Higher compression ratio, higher cylinder temperatures. NOx formation is mainly due to high temperature in combustion chamber i.e more than 1300 °C, excess air. Nitrogen Oxides (NOx) is a representation of mono Nitrogen oxides & resultants are different Nitrogen Oxides.

N₂ + O → NO + N
N + O₂ → NO + O
N + OH → NO + H
NOx control is done by retardation of injection start, low swirl, Catalytic reduction, Water/Steam injection, Lowering excess air operation, Staged combustion, Lowering pre-hear air temperature, Exhaust gas recirculation (EGR), Selective Catalytic Reduction (SCR), Selective Non Catalytic Reduction (SNCR), Lean NOx trap (LNT). All components excluding water, collected on a prescribed filter after dilution with air at a temperature below 51.7 deg C, are called Particulate Matter (PM). Most have a fine particle size distribution (<2.5μm) however ultra-fine (<0.1 μm) particles are also present. Most important constituents are larger molecular Pyrolytic Aromatic Hydrocarbons (PAHs) and nitro-PAH compounds. Inadequate air – high soot, poor combustion. Sulphur in fuel Aromatics are causes of PM formation.

PM is controlled by soot control, high injection pressures, combustion improvement and swirl optimization & Sulphur control in fuel. Soot is a mass of impure carbon particles resulting from the incomplete combustion of hydrocarbons i.e Carbon & Ash. Soot is formed due to high Temperature, inadequate air – high soot, lack of Oxygen. Soot is controlled by reduced wall wetting, good atomization, enhanced mixing by re-entrant PM is controlled by soot control, high injection pressures, combustion improvement and swirl optimization & Sulphur control in fuel. Soot is a mass of impure carbon particles resulting from the incomplete combustion of hydrocarbons i.e Carbon & Ash. Soot is formed due to high Temperature, inadequate air – high soot, lack of Oxygen. Soot is controlled by reduced wall wetting, good atomization, enhanced mixing by re-entrant bowl shape & distribution of fuel in combustion chamber. Intake swirl optimization further brings down the soot percentage. Tradeoff between HC, NOx & PM is very important while meeting emission norms for any car.

Figure 1.2 Contents of PM

Figure 1.3 HC/NOx Vs EGR rate

The amount of EGR mixing puts limits on engine power. More than 30% mixing of EGR is not advisable as it brings down maximum engine power. Figure 2 shows that with increase in percentage of EGR, HC emissions goes up & NOx levels comes down.

Figure 1.4 PM/NOx Vs EGR rate

Figure 1.4 shows general tradeoff between NOx & PM. PM trap is often used to bring down the Particulate Matter values. Fuel injection timing needs to be retarded to bring down the peak combustion temperatures. It adversely affects the maximum power & specific fuel consumption (SFC). Higher swirl ratio is recommended for EGR engine for proper mixing of air & exhaust gas. Piston bowl design can be modified for proper mixing & combustion. Diesel OxyCat is required to bring down HC & CO values. Precious metals like Platinum/Palladium/Rhodium works as catalyst in OxyCat & performs the oxidation. With increase in % of EGR, PM emissions goes up. & hence tradeoff is required.

1.4. COMBUSTION PROCESS & EMISSION CONTROL

Combustion process can be divided into three categories which ultimately affects the exhaust emission of the car. Pre-combustion parameters are fuel quality, turbo charging & intercooling, swirl & ambient conditions to a limited extent.

During combustion piston bowl, crown & skirt design piston ring design, fuel injection timing, fuel pressure, fuel injection rate, injector design-Spray pattern, hole diameters, number of holes, angle of holes, combustion temperature control, cam timing, number of valves per cylinder are the critical factors to meet Bharat Stage VI norms & long durability targets. On engine emission control techniques are Combustion optimization, Cooled Exhaust Gas Recirculation (EGR), Variable Geometry Turbocharging, High Pressure Common Rail Fuel System, very precise Electronic Controls, Split Injection injection rate control, HCCI (Homogeneous charge compression ignition).
In common rail fuel system, fuel is extracted from tank & after filtration, fuel is pressured to very high pressures such as 1400-1800 bars & pressure is maintained with the help of common rail. Fuel is injected into combustion chamber as per the command from electronic control unit (ECU). Use of crank speed sensor, rail pressure sensor, accelerator pedal sensor, coolant temperature sensor, oil pressure sensor, delta pressure sensor, temperature & manifold pressure sensor, exhaust manifold pressure sensor, water in fuel sensor, metering valve are typical name of electronic controls used to control the emissions.

1.5. EMISSION CONTROL BY EGR & AFTER TREATMENT

![Figure 1.6 Working of EGR system](http://ijesc.org/)

Some portion of exhaust gas is recirculated from exhaust manifold to EGR cooler. The percentage of the EGR is being decided based on the calibration strategy (for part load & full load operating conditions) to meet the required emission norm. The EGR cooler brings down the temperature of exhaust gas by exchanging the heat with engine coolant. The EGR control valve regulates the amount of exhaust gas going to engine based on the calibration strategy. Exhaust gas is mixed with intake air before going to combustion chamber. Mixing of exhaust gas limits the fresh oxygen in the charge & hence reduces the combustion temperature. Reduced combustion chamber brings down NOx levels. To accommodate EGR cooler & EGR valve, exhaust manifold requires modification. Addition of air & intake mixing device, temperature & pressure sensor, EGR mass flow sensor, coolant in & out pipe lines for EGR cooler needs to be done.

1.6 ON BOARD DIGNOSTICS (OBD II)

Meeting BS VI Emissions norms will not be a only tasks to manufacturers 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 to 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.

1.7 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

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. 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.

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. There are two types of piston rings,

- Compression rings
- Oil scraper rings

Fig 3.6 Piston Ring

These are made of cast iron on account of their ability to retain bearing qualities and elasticity indefinitely. The primary function of the piston rings is to retain compression and at the same time reduce the cylinder wall and piston wall contact area to a minimum, thus reducing friction losses and excessive wear. The other important functions of piston rings are the control of the lubricating oil, cylinder lubrication, and transmission of heat away from the piston and from the cylinder walls. Piston rings are classed as compression rings and oil rings depending on their function and location on the piston.

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 3.7 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 3.8 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.

Fig 3.9 Engine Cam and 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.

Fig3.10 Engine Valves
3.9 Manifolds

There are two types of manifolds

3.9.1 Inlet manifold

It is a pipe-like structure that connects the carburettor with the inlet valves. The air-fuel mixture from the carburettor passes through the inlet manifold to the inlet valves.

Fig 3.11 Inlet manifold

3.9.2 Exhaust manifold

This pipe-like structure connects the outlet valve to the atmosphere. The exhaust gas from the cylinder passes through the exhaust manifold into the atmosphere.

Fig 3.12 Exhaust manifold

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.

Fig 3.13 Engine Bearing

3.12 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 3.14 Engine Flywheel

3.13 Materials used for engine parts

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Parts</th>
<th>Materials of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cylinder head</td>
<td>Cast iron, Cast Aluminium</td>
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<tr>
<td>2.</td>
<td>Cylinder liner</td>
<td>Cast steel, Cast iron</td>
</tr>
<tr>
<td>3.</td>
<td>Engine block</td>
<td>Cast iron, Cast aluminium, Welded steel</td>
</tr>
<tr>
<td>4.</td>
<td>Piston</td>
<td>Cast iron, Aluminium alloy</td>
</tr>
<tr>
<td>5.</td>
<td>Piston pin</td>
<td>Forged steel, Casehardened steel</td>
</tr>
<tr>
<td>6.</td>
<td>Connecting rod</td>
<td>Forged steel, Aluminium alloy</td>
</tr>
<tr>
<td>7.</td>
<td>Piston rings</td>
<td>Cast iron, Pressed steel alloy</td>
</tr>
<tr>
<td>8.</td>
<td>Connecting rod bearings</td>
<td>Bronze, White metal</td>
</tr>
<tr>
<td>9.</td>
<td>Main bearings</td>
<td>White metal, Steel backed Babbit base</td>
</tr>
<tr>
<td>10.</td>
<td>Crankshaft</td>
<td>Forged steel, Cast steel</td>
</tr>
<tr>
<td>11.</td>
<td>Crankcase</td>
<td>Forged steel, Cast iron, cast steel</td>
</tr>
<tr>
<td>12.</td>
<td>Timing gears</td>
<td>Cast iron, Fiber, Steel forging</td>
</tr>
<tr>
<td>13.</td>
<td>Push rods</td>
<td>Forged steel</td>
</tr>
<tr>
<td>14.</td>
<td>Engine valves</td>
<td>Forged steel, Steel, alloy</td>
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<tr>
<td>15.</td>
<td>Valve springs</td>
<td>Carbon spring steel</td>
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<tr>
<td>16.</td>
<td>Manifolds</td>
<td>Cast iron, Cast aluminium</td>
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<tr>
<td>17.</td>
<td>Crankcase</td>
<td>Cast iron, Welded steel</td>
</tr>
<tr>
<td>18.</td>
<td>Flywheel</td>
<td>Cast iron</td>
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<tr>
<td>19.</td>
<td>Studs and bolts</td>
<td>Carbon steel</td>
</tr>
<tr>
<td>20.</td>
<td>Gaskets</td>
<td>Cork, Copper, Asbestos</td>
</tr>
</tbody>
</table>

4. BS 1V VS BS VI

4.1 BS 1V

The Bharat Stage Emission Standards (BSES) is an organisation 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

Here are a few key differences between BS4 and BS6 emission norms –

1. 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.

2. 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.

3. The Onboard Diagnostics (OD) is now mandatory for all vehicles under the BS6 emission norm.

4. 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, its engine will be affected and increase the emission.

5. Another crucial difference between the two is in terms of Sulphur and Nitrogen Oxide emitted. The Sulphur trace in BS6 fuel is five times lesser than the ones in BS4 fuel. Moreover, nitrogen oxide levels of BS6 diesel and petrol engines are said to be brought down by 70 percent and 25 percent, respectively.

4.4 BS4 vs BS6 BASED ON POLUTANTS

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

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.

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

4.6 BENEFITS OF BS-VI ENGINE

The advantages of moving from BS4 to BS6 compliant vehicles are as follows –

- 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. Just like choosing between BS4 and BS6 engines is imperative to stay safe on the Indian roads, so it is essential to choose a vehicle insurance plan. Selecting the right car insurance plan will allow you to safeguard your vehicle in case of an accident financially. In fact, you can compare different plans online and then choose the one that fulfills all your requirements.

5. DISCUSSION AND REVIEW

5.1 TRANSITION FROM BSIV TO BSVI 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 is 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 lesser 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 mono oxide, 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.

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 a 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 have fallen over the past year. Most of the automobile firms are looking at the products that do not require much change before the new BSVI norms take effect. Two-wheelers and four-wheeler producers have pulled limit extension plans, as they anticipate that request could fall.

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.

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.

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 10,000 ppm CO at the ideal air-fuel ratio will produce over 60,000 ppm 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-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 (N$_2$O), 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.

**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

**7. EMISSION TEST**

**7.1 EMISSION GAS FOR DIESEL ENGINE**
1. carbon dioxide (CO$_2$),
2. carbon monoxide (CO),
3. hydrocarbons (HC)
4. oxides of nitrogen (NOx).
5. Particulate matter (PM)

**7.2 EMISSION VALUES RANGES**

<table>
<thead>
<tr>
<th>BSIV ENGINE EMISSION</th>
<th>Year</th>
<th>carbon monoxide (CO)</th>
<th>hydrocarbons (HC)</th>
<th>oxides of nitrogen (NOx)</th>
<th>Particulate matter (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
<td>0.85 g/Kwh</td>
<td>0.38 g/Kwh</td>
<td>0.28 g/Kwh</td>
<td>0.02 g/Kwh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BSVI ENGINE EMISSION</th>
<th>Year</th>
<th>carbon monoxide (CO)</th>
<th>hydrocarbons (HC)</th>
<th>oxides of nitrogen (NOx)</th>
<th>Particulate matter (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>0.5 g/Kwh</td>
<td>0.32 g/Kwh</td>
<td>0.2 g/Kwh</td>
<td>0.05 g/Kwh</td>
</tr>
</tbody>
</table>

**7.3 EMISSION RESULT FOR LIGHT VEHICLES**

<table>
<thead>
<tr>
<th>Category</th>
<th>Emission value for light vehicle (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO</td>
</tr>
<tr>
<td>BS IV</td>
<td>0.85</td>
</tr>
<tr>
<td>BS VI</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Figure 7.1 BS4 VS BS6 Emission Level**

**8. CONCLUSION**

BS-VI will definitely going to bring drastic change in automotive market in India. We will get more fuel efficient and very low

- Emission producing vehicles in near future. Downsizing and downspeeding will yield smaller and powerful engines. Diesel vehicles will get more expensive as they required more after treatment to stay clean. This will attract OEMs towards alternative fuels and hybrid technologies. To achieve emission limits specified in BS-VI ample

- Amount of engine electronics will required. This will enhance business of domestic and MNC automotive electronic suppliers. Vendors and engineering solution providing companies for Eco testing, fuel system testing and emission testing are also going to benefit a lot. Through all these efforts people can ensure

- Significant reduction in air pollution from automobiles. This will bring remarkable improvement in air quality in highly populated cities as automobiles are main source of air pollution in cities.

**9. REFERENCE**


