
A Comparative Study and Analysis of Emission Norms Adopted by Developed and Developing Nations

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Abstract

Some basic emission standards are followed in every country which is required to be followed by every car running on their roads. India follows Bharat Stage (BS) standards which are largely based on Euro standards that are followed in Europe. But India at present is lagging behind the European norms, which is gradually becoming a serious concern for India from environment point of view. In this paper a comparative study is made between the BS Norms and the emission norms of Europe, Japan & China in order to identify draw backs / flaws in BS Standards bases upon that ways and means are suggested for their rectification. This analysis will help in better understanding of the norms adopted by developed nations, which will help in suggesting changes in BS Norms to reduce the major pollutants for further reducing the pollution level in India. A comparative analysis among BS, Euro, Japanese & Chinese emission norms for passenger cars is made in this paper to suggest techniques for moving ahead for reduction of pollutants from passenger cars. Also various technologies are identified which can be helpful for India in reaching its goal for zero emission.

Introduction

In this paper different research papers were analyze and a comparison was made on the vehicle emission norms of different countries i.e India, Europe, Japan and China. Focus of study was how Indian norms stand when compared to the international standards. In this paper on the basis of numerical values of major pollutants i.e NO_x, Particulate matter (PM), Hydrocarbon (HC), carbon mono-oxide (CO), a comparison has been done Indian BS norms with norms followed in European nations i.e Euro norms, Japanese norms, and Chinese norms.

Current Scenario

Emission Norms perverted in most of the world are found to be in line with European standards [1], [2], [3], [4] however there are some difference present in the numerical values because of the type of cycle chosen for test, requirements, loads applied, variation in the vehicles, need and road traffic conditions of different countries like India, Japan, Europe & China. As India standards was lagging behind 4-5 years from the standards of euro because of issues like lack of proper fuel required to operate BS VI engines and even the manufactures of automobile industry are not ready to manufacture the parts required to match BS VI and EURO VI norms. But even inspite of these all problems India is very fast developing country the government of India is trying its best to improve the situations by concerning these factual problems with private sector companies and asking fuel refineries to arrange BS VI fuel. In this regard a major step was taken by oil refineries where in they had agreed to supply BS VI fuel by April 2018. This step will make easy the transfer from BSIV norms to BS VI norms by 2020 skipping BS V norms. The government of India has decided to permanently skip EURO V to remove the hazards of emission and to be in a proper competition with developed countries.

In this research paper from the analysis it can seen that for skipping BS-V and shifting directly to BS-VI, both of the emission reducing technologies DPF and SCR need to be fitted in the four-wheelers simultaneously which is a time and money consuming process, hence shifting directly to BS-VI within the specified time

limit is a great challenge for the automobile and oil industries in India. The two and three wheelers will have to be fitted with electronic fuel injection system in place of the old carburetor system, to meet the BS-VI standards. BS-VI will also be undertaking the Particulate Matter reduction which earlier was not considered by BS-III and BS-IV. The sulphur content in BS-VI fuels will be limited to only 10 ppm. Also there will be a reduction of PM and NO_x emissions from petrol and diesel engines when these norms are implemented.

An Introduction to the BS Emission Norms

The BS or Bharat Stage emission standards are norms instituted by the government to regulate the output of air pollutants from internal combustion engines. India has been following the European (Euro) emission norms, though with a time lag of five years. BS-IV norms are currently applicable in 33 cities in which the required grade of fuel is available; the rest of India still conforms to BS-III standards.[5]

India introduced emission norms first in 1991, and tightened them in 1996, when most vehicle manufacturers had to incorporate technology upgrades like catalytic converters to cut exhaust emissions. Fuel specifications based on environmental considerations were notified first in April 1996 to be implemented by 2000, and incorporated in BIS 2000 standards. Following the landmark Supreme Court order of April 1999, the Centre notified Bharat Stage-I (BIS 2000) and Bharat Stage-II norms, broadly equivalent to Euro I and Euro II respectively. BS-II was for the NCR and other metros; BS-I for the rest of India. From April 2005, in line with the Auto Fuel Policy of 2003, BS-III and BS-II fuel quality norms came into existence for 13 major cities, and for the rest of the country respectively. Subsequently, BS-IV and BS-III fuel quality norms were introduced from April 2010 in 13 major cities and the rest of India respectively. At present, BS-IV auto fuels are being supplied in over 30 cities while the rest of the country has BS-III fuels.

As per the roadmap in the auto fuel policy, BS-V and BS-VI norms were to be implemented from April 1, 2022, and April 1, 2024, respectively. But in November 2015, the Ministry of Road Transport issued a draft notification, advancing the implementation of BS-V norms for new four-wheel vehicle models to April 1, 2019, and for existing models to April 1, 2020. The corresponding dates for BS-VI norms were brought forward to April 1, 2021, and April 1, 2022, respectively. “Considering the environmental impact, rising pollution levels and health hazards due to vehicular pollution, the oil ministry took the view that the country should switch over directly from BS-IV to BS-VI fuel standards,” [6]. The Ministry is now introducing BS-VI fuel norms after due consultation with Ministry of Petroleum and National Gas, Department of Heavy Industry and Ministry of Environment and Forest all over the country by April 1, 2020.

Emission Test Procedures

The vehicle emission limits are specified based on a standard test procedure, which includes; A specified vehicle driving or engine operation schedule of varying speeds and loads which represents real life driving / usage pattern of the vehicles and engines. The test schedule of vehicle or engine operation is known as ‘driving cycle’. Use of emission sampling systems and analyzers that operate on the working principles specified in the emission regulations. The new production vehicles and engines are tested for compliance with the emission standards in a government approved laboratory. The USA and particularly the state of California have led the world in developing vehicle emission test methods and in setting the vehicle emission limits. The test cycles used in the USA, Europe and Japan for emission measurement and certification of vehicles/engines for compliance with the standards differ and so also the numerical values of the emission limits. Therefore, direct comparison between standards in different countries is generally not possible.

Units of Emission Limits

Two types of emission limits are specified in the standards For the light and medium duty vehicles, passenger cars and, two and three wheelers are in terms of mass of pollutant emitted per unit distance travelled i.e., g/km (g/mile in the USA , 1 g/km = 1.61 g/mile). For heavy duty vehicles and engines test is carried on the engine itself and the limits are specified in terms of mass of pollutant per unit of work done, i.e., g/kW-h or g/bhp-h

(1 g/kW-h = 1.34 g/bhp-h). The test cycle and measurement procedures have been accordingly developed whether test is to be done on a vehicle or on the engine

European Test Procedure

The first European test procedure for heavy duty vehicles, R-49 used 13-mode test having five different load points each at the rated and peak torque speeds and three idling speed points one in the beginning one in the middle and the third at the end. Each mode had a different weighing factor. A new test procedure has been adopted from the year 2000 along with implementation of Euro 3 standards. It consists of two separate tests each of about 30 minutes duration as below; (i) 13-mode steady state cycle (ESC) with a dynamic load response (ELR) smoke test (ii) A transient test cycle (ETC) The steady state cycle (ESC) is used to prevent abnormally high emissions if an engine is made to operate at extreme conditions where emission controls may not be very effective. On the other hand, the transient cycle (ETC) represents the actual operating conditions and is better suited for the engines operating on alternative fuels or employing after treatment devices. For certification to Euro 3 standards, the conventional diesel engines are tested by the ESC only. However, the diesel engines with advanced emission control systems such as after-treatment devices and the SI engines such as natural gas engines are tested by both the procedures. From the Euro 4 standards implemented in year 2005, all heavy-duty engines are tested by both the ESC and ETC test procedures

ESC and ELR Tests

The ESC and ELR test procedures are shown in Figs 4.4 and 4.5. Weighting factors for the ESC test for each mode The test is carried out at three engine speeds and idle. The test speeds are determined as show At each of the three speeds, emissions are measured at 25%, 50%, 75% and 100 % loads. To ensure that there are no abnormal operating conditions which could result in abnormally high emissions,testing agency is authorized to select three more modes as indicated. The dynamic load response (ELR) test is carried out for smoke emissions. The engine is accelerated from 10% load to full load at maximum possible acceleration. In this way engine runs through the entire fuel / air ratios defined by the engine fuel management system. Thus, smoke emission from the diesel engines is measured for the entire range of fuel delivery i.e. fuel-air ratios. Peak smokes emissions are compared with the permissible limits as specified in the standards.

Comparative study with analysis

NOx concentration (Gasoline)

From the literature data of stage4 to stage 6 is obtained and is shown in the table 1 & 2 for gasoline and diesel.. From the graph in figure 1 & 2 it is inferred that India is lacking behind a lot in controlling the emission of NOx pollutant for gasoline engines as compared to other countries like Europe which provides the base for BS norms. Hence some new technologies such as SCR are being introduced in BS VI in order to control the level of NOx concentration so that India can get in line with the European NOx levels. But even after introducing in new technologies, India still lacks behind in NOx control for petrol / gasoline vehicles which are one of the major concerns for India. Hence India needs to aim at coming up with more technologies for bringing down the levels of gasoline NOx emissions to come in line with European NOx levels.

Table 1: NOx emission in g/km for gasoline in different emission standards

	BS Norms	Euro Norms	China Norms	Japanese Norms
Stage 4	0.8	0.08	0.08	0.08
Stage 5	0.6	0.06	0.06	0.05
Stage 6	0.6	0.06	0.06	0.05

Figure 1 : Comparison of standard for NO_x Emission

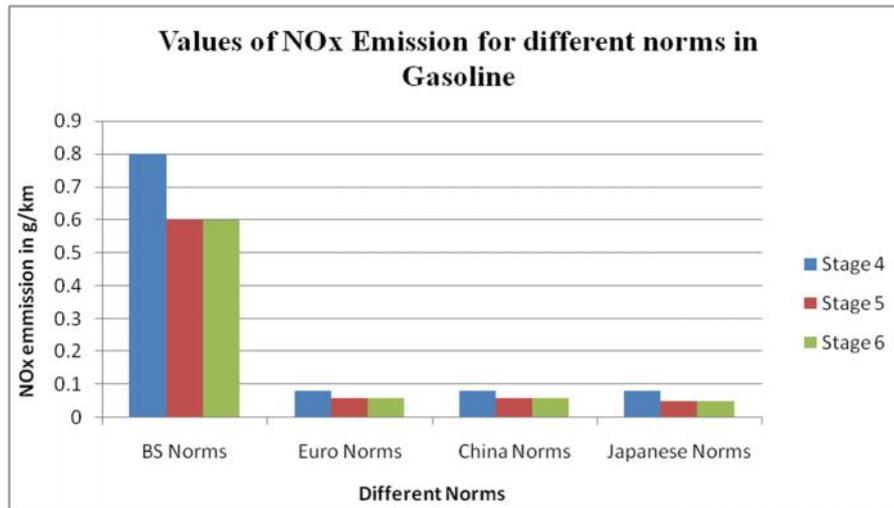
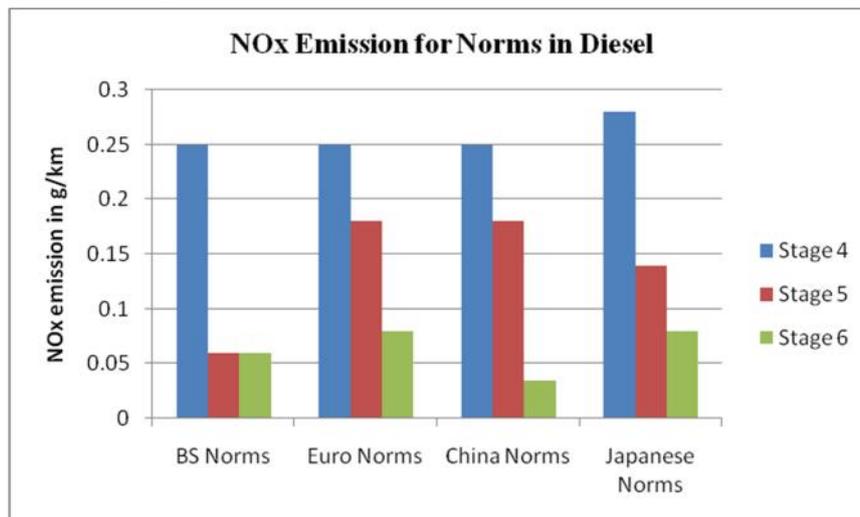


Table 2: NO_x emission in g/km for diesel in different emission standards

	BS Norms	Euro Norms	China Norms	Japanese Norms
Stage 4	0.25	0.25	0.25	0.28
Stage 5	0.06	0.18	0.18	0.14
Stage 6	0.06	0.08	0.035	0.08

Figure 2 : Comparison of standard for NO_x Emission in case of diesel engine



PM Concentration

From the literature data [6], [7], [8], [9], [10] of stage 4 to stage 6 is obtained and is shown in the table 3 & 4 for gasoline and diesel.. From the graph in figure 3 & 4 it is observe that high PM emission levels in case of Diesel engines is a big concern for India. Some new technologies such as DPF are being introduced in the upcoming BS VI standards to reduce the level of PM concentration in diesel engines but the comparative figures show that the present and upcoming technologies are not enough to help India match the level of

European PM norms. Hence India needs to come up with more modern technologies that can help India reduce the level of PM emissions in diesel engines and match the level of European norms. Alternate fuels is a great source that can help India reduce the PM emissions since they are more eco-friendly and contain PM in very low proportions.

Table 3: PM emission in g/km for gasoline in different emission standards

	BS Norms	Euro Norms	China Norms	Japanese Norms
Stage 4				
Stage 5	0.005	0.005	0.0045	0.005
Stage 6	0.005	0.005	0.003	0.005

Figure 2 : Comparison of standard for PM Emission in case of gasoline engine

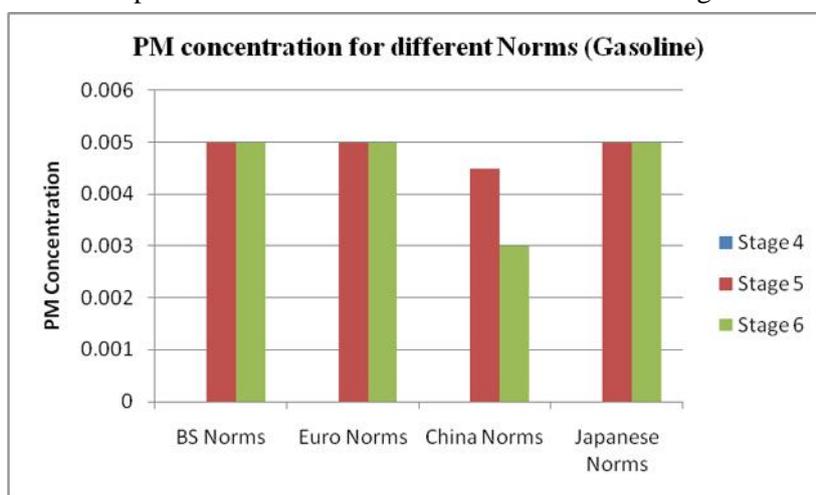
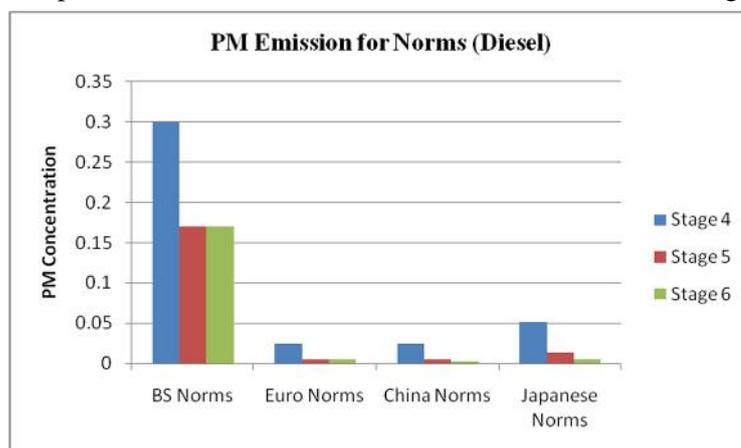


Table 4: PM emission in g/km for diesel in different emission standards

	BS Norms	Euro Norms	China Norms	Japanese Norms
Stage 4	0.3	0.025	0.025	0.052
Stage 5	0.17	0.005	0.0045	0.013
Stage 6	0.17	0.005	0.003	0.005

Figure 4 : Comparison of standard for PM Emission in case of diesel engine



Conclusion

The emission norms of the major developed and developing countries have been studied. From the study and analysis, it is concluded that India is lagging behind the European & China norms by approx. 5 years and is planning to keep pace with them by leapfrogging directly to BS VI from BS IV by 2020. However India would still lack behind in NO_x (petrol) and PM (diesel) norms even in BS VI standards, hence these are the main areas where India needs to improve in order to have better emission norms in future. Some new technologies such as DPF & SCR are being introduced in BS VI to bring down the NO_x and PM levels while some technologies such as alternate fuels and hybrids may be used in future to bring down a major drop in NO_x and PM conc. levels in BS norms. India plans to focus more on electric & CNG vehicles which may make petrol and diesel fuels obsolete in future and hence revolutionize the BS norms, reducing the level of environmental pollution in India up to a great extent.

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