Comparative Analysis of Exhaust Emissions: A Review of BS4 and BS6 Bike Engine Technologies

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Abstract- ***The pivot from Bharat Stage IV (BS4) to Bharat Stage VI (BS6) emission metrics in India marks a pivotal step towards reducing vehicular pollution and improving air quality. This paper compares the exhaust system differences in BS4 and BS6 bike engines, focusing on emission control technologies, performance, and environmental impact. BS6 engines incorporate innovative fragments to illustrate selective catalytic reduction (SCR), diesel particulate filters (DPF), and three-way catalytic converters, leading to influential curtailments in nitrogen oxides (NOx) and particulate matter (PM) emissions. However, these advancements have also resulted in marginal changes in power output and fuel efficiency due to enhanced emission control measures. Despite these challenges, BS6 metrics underscore a commitment to sustainable transportation by achieving substantial curtailments in harmful emissions, thereby mitigating environmental and health impacts. The findings highlight the balance between regulatory compliance, technological innovation, and environmental responsibility.***

Indexed Terms- ***BS4, BS6, emission metrics, bike engines, exhaust system, catalytic converter, fuel efficiency, nitrogen oxides, particulate matter, environmental impact.***

I. INTRODUCTION

The Bharat Stage (BS) emission metrics in India are regulatory measures to reduce air pollution from vehicles. BS4, introduced in 2017, significantly lowered permissible sulfur content and exhalation of nitrogen oxides (NOx) and particulate matter (PM). BS6, implemented in 2020, further tightened these metrics, reducing sulfur content to 10 ppm and requiring proficient mechanisms like selective catalytic reduction (SCR) and diesel particulate filters (DPF). Despite the challenges posed by this pivot, including increased vehicle costs and disruptions due to the COVID-19 pandemic, BS6 is expected to substantially reduce vehicular pollution, with NOx emissions from diesel vehicles decreasing by 70% and PM emissions by 80% compared to BS4 (Ministry of Petroleum & Natural Gas, 2017; Central Pollution Control Board, 2020). In this paper there is an attempt have been made to compare the Exhaust Differences Between BS4 and BS6 Bike Engines based on standard literature.

II. LITERATURE REVIEW

In this chapter, the main aim is to review the research paper on how the pivot from BS4 to BS6 engines represents a critical step in India's efforts to Clash air pollution and adopt globally recognized emission norms. While the shift posed challenges for manufacturers and consumers alike, the long-term benefits of reduced environmental degradation and technological advancement outweigh the short-term difficulties.

Singh et al. investigate extreme aerosol transport phenomena by utilizing atmospheric river dynamics to analyze aerosol atmospheric rivers (AARs). They use MERRA-2 re-analysis datasets and convolutional autoencoders to produce a spatiotemporal AAR Availability Prediction Model (STAARAPM). The model uses stochastic gradient descent optimization to forecast AAR availability for future periods. [1]

Delhi encounters air pollution from a variety of particulate matter sources, especially throughout the winter. An analysis of Delhi's air pollution at Diwali in November 2023 took place. According to data from the Central Pollution Control Board, PM10 levels during Diwali decreased 42% from 2021 but increased compared to 2022. These sources have been correlated with poor air quality and adverse health impacts. [2]

Raju et al. look at how indoor air pollution affects respiratory health in homes. Particulate matter, carbon monoxide, nitrogen dioxide, and volatile organic compounds are mainstream subjects of the study. The project collects data from citizens in rural, suburban, and urban regions using a survey-based methodology. It discusses indoor pollution sources, local knowledge, and respiratory illnesses like chronic obstructive lung illness, asthma, and allergies.[3]

Sankar et.al. studied that due to several variables, such as dust, burning biomass, industrial and vehicular pollution, and pollutants created by humans, the northern part of India, which borders the Himalayas, is a hotspot for pollution worldwide. These sources impact millions of inhabitants, especially during the yearly desert dust storms from Thar and the Arabian Peninsula. [4]

Kapoor et.al. concluded that the potential of ornamental plants in Thailand to enhance indoor air quality is examined. Dieffenbachia sp., Spathiphy llum wellies, and Epipremnum aureum were the three plant species that the researchers screened. Using a closed flux chamber method, they evaluated their capacity to reduce carbon dioxide levels during 24 hours. It became apparent that Epipremnum aureum absorbed carbon dioxide more efficiently. [5]
Chakraborty et al. evaluate the repercussions of aerosols on the lifetime of Mesoscale Convective Systems (MCSs), the primary cause of precipitation in tropical regions and midlatitudes, using multiyear collocated geostationary and polar-orbital satellite datasets. It then compares this repercussion with other meteorological conditions to estimate the variability of MCSs' lifetime. [6]

The study looks at PM2.5 levels and atmospheric trace chemicals in five Indian urban areas between 2016 and 2020. It finds seasonal variations that have been caused by weather, regulations, and urban activities. Chennai is the city with the least amount of pollution. [7]

Rizwan et.al. determine that in urban places, especially Delhi, air pollution is leading to several health problems. The city's PM10 level is more than ten times the upper limit, and both interior and outdoor air pollution are connected to car emissions and industrial activities. Studies conducted in Delhi reveal an increase in death and morbidity from all natural causes, underscoring the necessity of efficient interventions to lower pollution and enhance public health. [8]

Using multiple linear regression analysis for different regions, this dissertation focuses on regression analysis and pollution measurement index predictions in Delhi, the most polluted city in India. [9]

III. PROBLEM IDENTIFICATION

From the available literature, we can observe that research has been done on the BS4 bike engines that still emit dangerous emissions. To control pollution and attain environmental sustainability, BS6 emission measurements were used to satisfy global environmental standards. However, research is still being conducted to ascertain their efficacy and possible reductions from technological advancements.

IV. OBJECTIVE OF THE RESEARCH WORK

The main purpose of this research work is to observe an emphasis on BS6 emission metrics and the advantages of onboard diagnostics, catalytic converters, and fuel injection systems, the study contrasts the pollution levels of motorcycle engines built with BS4 and BS6 specifications.

V. EXPERIMENTAL DETAILS

Table 1: Differences in Permissible Limits for Pollutants

Pollutant	BS4 Limits	BS6 Limits	Curtailment (%)

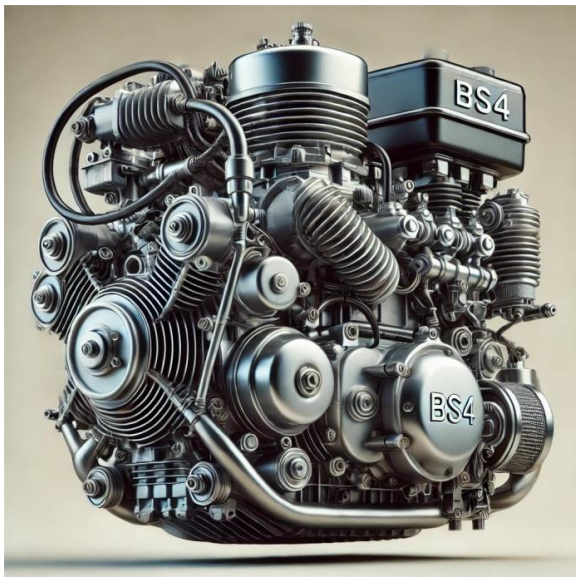
Carbon Monoxide (CO)	00.50 g/km (petrol) / 00.640g/km (diesel)	00.50 g/km (petrol) / 00.500g/km (diesel)	~22% (diesel)
Nitrogen Oxides (NOx)	00.080 g/km (petrol) / 00.250g/km (diesel)	00.060 g/km (petrol) / 00.080 g/km (diesel)	~68% (diesel)
Hydrocarbons (HC)	00.100 g/km (petrol)	00.050 g/km (petrol)	50%
Particulate Matter (PM)	00.0250 g/km (diesel)	00.0050 g/km (diesel)	80%

Table 2: Statistical comparison between Bharat Stage IV (BS-IV) and Bharat Stage VI (BS-VI) metrics. The statistical analysis includes percentage curtailment between the two stages.

Parameter	Units	Bharat Stage IV (BS-IV)	Bharat Stage VI (BS-VI)	Percentage Change
Idling Emissions				
Carbon Monoxide (CO)	%	3	0.19	↓ 93.67%
Hydrocarbons (THC/HC)	ppm	3000	97	↓ 96.77%
High Idling Emissions				
Carbon Monoxide (CO)	%	0.3	0.14	↓ 53.33%
Hydrocarbons (THC/HC)	ppm	500	98	↓ 80.40%
RPM	RPM	2500 ± 200	2501	No influential change
Lambda (Air-Fuel Ratio)	---	1 ± 0.03	1 ± 0.03	No influential change
Smoke Density	1/meter (light absorption coefficient)	1	N/A	

Exhaust System Components: Exhaust systems for BS4 and BS6 engines are made to reduce emissions; BS6 engines feature more sophisticated parts for stricter restrictions, such as a selective catalytic reduction system, diesel particulate filter, catalytic converter, and muffler.

Catalytic Converter: Motorcycle engines with BS4 and BS6 catalytic converters lower harmful emissions. With a three-way NOx curtailment and a lower sulfur concentration, BS6 metrics enhanced catalytic converters and ensured stringent emission rules without sacrificing efficiency.

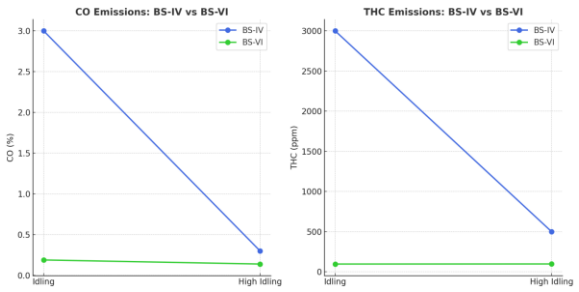


BS6 and BS4 Bike Engines

Emission Control Technologies: With the use of catalytic converters and electronic fuel injection systems, BS4 and BS6 motorbike engines have improved pollution control systems to satisfy more stringent emission standards, resulting in cleaner emissions and a smaller environmental effect.

Reduction in Harmful Emissions: There has been a notable decrease in harmful emissions since motorbike engines switched from BS4 to BS6. While BS6 engines use cutting-edge technologies like diesel particle filters and catalytic curtailment to lower NOx and PM emissions, BS4 requirements sought to reduce CO, HC, and PM.

Graphs for CO and THC emissions comparing Bharat Stage IV (BS-IV) and Bharat Stage VI (BS-VI) metrics. The left graph shows the CO emission percentages, while the right graph illustrates the THC emissions in ppm for both idling and high idling conditions.



CONCLUSION

Based on the exploratory comes about, the ensuing conclusions are regularly drawn:

- The implementation of modern engine emission control technology, including diesel particle filters and selective catalytic reduction, improves air quality and lowers vehicle pollution when BS4 emission laws are replaced with BS6 requirements.
- Even if the exhaust system components and power generation have been modified, BS6 engines offer less harmful emissions, more environmental protection, and a commitment to cleaner, more sustainable transportation solutions.
- For healthier communities and cleaner air, performance, and environmental responsibility must be balanced, as seen by ongoing technological advancements and regulatory initiatives.

REFERENCES

[1] Real-time Air Quality Index for Delhi. (n.d.). AQICN. Retrieved November 4, 2024, from https://aqicn.org/city/delhi.

[2] Singh, S., & Goyal, M. K. (2023). An innovative approach to predict atmospheric rivers: Exploring convolutional autoencoder. *Atmospheric Research,289*,106754. https://doi.org/10.1016/j.atmosres.2023.106754

[3] Raju, S., Siddharthan, T., & McCormack, M. C. (2020). Indoor air pollution and respiratory health. Clinical Chest Medicine, 41, 825–843.

[4] Sarkar, S., Chauhan, A., Kumar, R., & Singh, R. P. (2019). Impact of deadly dust storms (May 2018) on air quality, meteorological, and atmospheric parameters over the northern parts of India. Geo Health, 3, 67–80.

[5] Kapoor, M. (2017). Managing ambient air quality using ornamental plants—An alternative approach. Universal Journal of Plant Science, 5, 1–9.

[6] Chakraborty, S., Fu, R., Massie, S. T., & Stephens, G. (2016). Relative influence of meteorological conditions and aerosols on the lifetime of mesoscale convective systems.

Proceedings of the National Academy of Sciences, 113(26), 7426–7431

[7] Indian Institute of Technology Kanpur. (2016). Comprehensive study on air pollution and greenhouse gases (Rep. submitted to Gov. NCT Delhi, DPCC Delhi, 1–334).

[8] Rizwan, S., Nongkynrih, B., & Gupta, S. K. (2013). Air pollution in Delhi: Its magnitude and repercussions on health. Indian Journal of Community Medicine, 38(4).

[9] AQICN. (n.d.). Delhi air pollution: Real-time air quality index. https://aqicn.org/city/delhi.