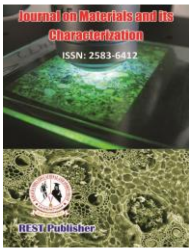
Journal on Materials and its Characterization
Vol: 3(1), March 2024
REST Publisher; ISSN: 2583-6412
Website: http://restpublisher.com/journals/jmc/
DOI: https://doi.org/10.46632/jmc/3/1/1



Differentiating Motorcycle Performance Between BS4 and BS6 Generation of KTM RC 390 Motorcycle using Data Visualization

***Harsh Kumar, Mimansha Singh**
ABES Engineering College, NH09 - Ghaziabad, Uttar Pradesh, India.
Corresponding Author Email: harsh.20b1541056@abes.ac.in

Abstract: *This research project is crucial to understanding how motorcycle design is influenced by transitioning from Bharat Stage (BS) 4 to Bharat Stage (BS) 6 emission standards, particularly in the context of the KTM RC390 models from 2017 and 2020. The importance of this research is twofold. To begin with, it lets us evaluate how changes to emission standards would affect things like engine management systems, emissions control technologies, environmental compliance, fuel economy, performance, and performance on motorcycles. The second benefit is that it gives people the tools they need to make educated decisions when buying motorbikes. In order to make my results more understandable, I want to use data visualization tools such as Matplotlib, Tableau, and Google Charts to show the differences between the two models. Next, I will create an intuitive website that presents this data in an easy-to-understand format. I want to do this by making use of the state-of-the-art FRAMER tool for website creation and design. Essentially, this study connects motorcycle design to pollution requirements, which helps consumers make better selections and uses technology to display facts clearly.*

1. INTRODUCTION

The KTM RC390 motorbike, more especially the 2017 BS4 and 2020 BS6 versions, is the subject of my project, which is taking place within an age of quickly changing emission rules. Knowing how these versions vary in terms of performance is crucial since they reflect two separate eras of technical development in the automobile industry. Engine management systems and emissions control technology must be updated to meet new emission regulations, such the one that is being implemented for the transition from BS4 to BS6. Motorcycle performance, fuel economy, and user experience are all affected by these modifications, in addition to environmental compliance. Since these motorbikes are sold to a demanding and enthusiastic clientele, honesty and well-informed choices are of utmost importance. To provide a data-driven study of these performance differences, my research uses insights and data sets from the Engine Control Unit (ECU). I want to reveal the complex interplay between technology, regulation, and motorbike performance by investigating power output, fuel economy, pollutants, and throttle response. Adapting to emission requirements, regulators assessing the efficacy of such limits, and customers making purchase choices all rely on this study.

2. LITERATURE REVIEW

The literature study part of my thesis includes an exhaustive survey of previous work that has addressed topics like motorcycle performance, electronic control unit analysis, and how pollution regulations have affected automotive technology. Jong-Hyun Lee and Chang Wook Ahn [1] introduce an evolutionary machine learning algorithm that can identify a driver's tendencies by efficiently learning from the extensive data collected by the vehicle's electronic control unit (ECU) sensors. The effectiveness of the algorithm is confirmed through system building, data collection, analysis, and comparison testing. The results of the studies shown that the suggested approach outperforms the average accuracy of current classifiers by 7.03% and obtains a classification accuracy of 92.48% when applied to a massive dataset of ECU data. A special design for an Engine Control Unit (ECU) was givrn by P. Sridhar Acharya and K. Krishna Prasad [2] which will control the firing of engine based on the density of a vehicle in the city along with the accelerator given by the rider/driver. Using GPS techniques the entire information of the vehicle like speed in kmph, longitude, latitude, timing factor etc. should be monitored by the central server using the SIM and the server should send the maximum speed limit for that vehicle depending on the density of vehicles in the corresponding area.F Fachrizal et al. [3] performed a comprehensive analysis and determine the performance difference of using a standard electronic control unit (ECU) compared to re-programming the ECU of a motorcycle. The experiment was carried out on a Honda CRF 150cc motorcycle manufactured in 2018. The research methods are experimental research and use descriptive statistic method. Research findings inform that the maximum torque of the standard ECU is 13.7 Nm at 4700 rpm, and the maximum power is 9.2 KW at 7000 rpm. The re-programming ECU has a maximum torque of 17.1 Nm at 5700 rpm, and a maximum power of 12.1 kW at 7200 rpm. The apparent increase in torque is around 80.11 % and in power is around 76 %. It can be concluded that the reprogramming ECU provides a more optimized engine performance on a CRF150L motorcycle. Ji Zhang et al. [4] develop a completed remote upgrading system for an on-board ECU, involving the overall scheme of remote update, security technology and functional design. the internal network of vehicles can be connected with external internet, which means that cars can communicate with remote server and even any other networked devices. The ECU update technology is accomplished through information interaction between remote server and vehicle terminal equipment. Therefore, the development of networking technology makes the ECU remote update technology have the application environment and technology foundation. Remote update of on-board ECU can greatly simplify the ECU firmware upgrade process, avoid vehicle recalls caused by ECU complicated control software, reduce the cost of OEMs, and eliminate many troubles in maintenance. All studies included in this publication provides a clear vision of the Electronic Control Unit (ECU) of a vehicle and how powerful it can be. A slight change or update in the ECU can lead to a drastic change in the performance of a vehicle. The tools and methods used for comprehensive study conducted by the authors plots a layout of all the important and necessary tools needed to execute my research on the performance difference of the two generation of a motorcycle.

3. PROPOSED MODEL

The proposed model for my research project is designed to comprehensively analyze and quantify the performance differences between the KTM RC390 2017 BS4 variant and the KTM RC390 2020 BS6 variant, with a specific emphasis on the influence of Engine Control Unit (ECU) configurations. In order to do this, I have laid up a methodical and data-driven strategy with clear objectives to fully comprehend the differences in the two motorbike models' power output, fuel economy, emissions, and throttle response.

- Data Collection: Gathering complete ECU files from the 2017 BS4 and 2020 BS6 KTM RC390 models will be the first step of my study. I will use this data to build my analysis and learn about the intricacies of ECU settings.
- Performance Metrics: In order to compare the performance, I will establish and rank important performance indicators such as power production, fuel economy, emissions, and throttle response. To compare ECU setups and their effects on motorcycle performance, I will utilize these measurements as a starting point.
- Data Analysis: I will examine the ECU data that has been acquired using state-of-the-art data analysis tools and methods, such as statistical analysis and machine learning approaches. Achieving important insights and patterns that may not be readily evident using typical analytic approaches requires this key step.
- Visualization: I will visualize the performance differences between the 2020 BS6 variation and the 2017 BS4 variant in an instructive and interesting way to make our results more accessible and easy to understand. In order to convey intricate data patterns, these visualizations will make use of charts, graphs, and other visual components.
- Web Page Development: In keeping with my goal of making our study findings easily available to a large audience, I will create a specific website to house the project's findings. Our study will be accessible to stakeholders, hobbyists, and consumers via this web portal, which will contain dynamic visualizations, detailed reports, and an easy-to-use interface. In the context of the motorcycle industry's reaction to changing regulatory environments, this project is in line with our commitment to openness and information sharing.

Through the implementation of this suggested methodology, my goal is to provide stakeholders insightful information on the performance gaps caused by changes in emission rules and technical improvements in the motorbike sector. Those interested in understanding how the KTM RC390 models have responded to shifting regulatory environments may find a clear and accessible resource in our study, which takes a data-centric approach.

4. METHODOLOGY

In order to achieve our goal of projecting performance differences between the KTM RC390 2017 BS4 and KTM RC390 2020 BS6 variations, our technique is crucial to the project. Our methodical strategy is detailed in this section:

Thorough data collecting is the first step of my research. To make sure we have a good grasp on all the factors that affect the motorbike's performance, we pull ECU insights and information from both versions. In order to guarantee the correctness and integrity of our dataset, data preparation is an essential phase where we manage missing values, eliminate outliers, and fix data quality concerns.

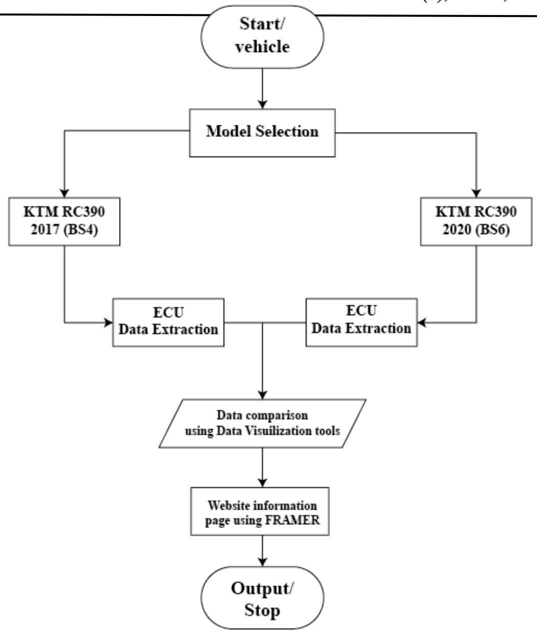


FIGURE 1. Methodology of the ECU Insights gained

A. Data Science

1. Python: Given Python's flexibility in data analysis, machine learning, and visualization, we choose it as our main programming language. Data processing and visualization are accomplished with the use of libraries such as NumPy, Pandas, Matplotlib, Seaborn, and Plotly.

2.Machine Learning Frameworks: To build and train models, you need Scikit-Learn and TensorFlow. To guarantee that our predictions are accurate, these frameworks include a variety of tools for deep learning and regression analysis.

B. Web Development

1.Methods for Building online Pages: JavaScript, HyperText Markup Language (HTML), and Cascading Style Sheets (CSS) are the tools used to build online pages. During back-end development, popular frameworks such as Flask or Django are taken into consideration to power the website.

C. Hardware Systems

1. 1. Workstations for Computers: Data preparation, modeling, and visualization operations need high-performance workstations with multi-core processors and enough of RAM.

2. 2. Data Storage: Ample space for storing and managing model checkpoints, web development files, and massive datasets is necessary.

C. 3. Graphics Processing Unit (GPU): We may use GPUs to speed up model training, especially for deep learning methods, depending on how complicated our machine learning models are.

D. *Performance Calculation*

Motorbike engines are rated according to their Brake Horsepower (BHP). This number indicates how much power the engine generates before other losses occur, such as those caused by friction and heat. The formula to calculate Brake Horsepower is:

$$BHP = \frac{T \times N}{Constant}$$

Where:

- T is the torque produced by the engine in pound-feet (lb-ft).
- N is the engine speed or RPM (revolutions per minute).
- The constant is a conversion factor that depends on the units used for torque and RPM. If torque is measured in pound-feet and RPM in revolutions per minute, the constant is typically 5252.

Measure Torque: Torque is typically measured using a dynamometer (dyno). It is the force that causes an object to rotate around an axis, and in the context of an engine, it's the twisting force produced by the engine's crankshaft.

Measure RPM: The engine speed is measured in revolutions per minute (RPM). This can be obtained from the motorcycle's tachometer or directly from the dynamometer during testing.

Calculate BHP: Use the formula mentioned above to calculate Brake Horsepower. Make sure to use consistent units for torque and RPM. If torque is measured in Newton-meters (Nm).

$$BHP = \frac{T \times N}{Constant}$$

If torque is measured in Nm, use a different constant (e.g., 9.5488)

$$BHP = \frac{T \times N}{9.5488}$$

Remember that this formula gives you the brake horsepower, which is the power output at the engine's crankshaft.

E. Digital Measurements

Speeduino Standalone ECU Speeduino is a very little cost engine Standalone Management System (EMS) based on the Arduino platform Parts that will be required willing mapping. Some of them are free and some are paid since they can be borrowed or are just not needed. Speeduino V0.4 PCB board, Arduino Mega 2560, VR conditioner PCB Laptop with Arduino IDE and Tuner Studio installed, 20-22 ga multicolour wires length and soldering iron will be dependent on favorable condition

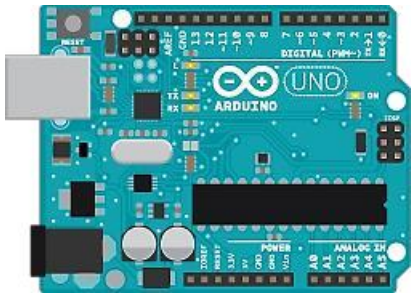


FIGURE 2. Speeduino V0.4 PCB board, Arduino Mega 2560

Diagnostic ECU is generated to obtain the correct ECU data from both the vehicles. A constructed board diagram along with working of the ECU input / output methods is understood from the research done by F Fachrizal et al. [3] performed a comprehensive analysis and determine the performance difference of using a standard electronic control unit (ECU) compared to re-programming the ECU of a motorcycle. The input and output process there is an algorithm with the CF approach where CF can perform diagnostic calculations on ECU damage. So that this model will create a security line on the ECU so that vehicle users can find out the state of the ECU by applying the internet of things (IoT) application.

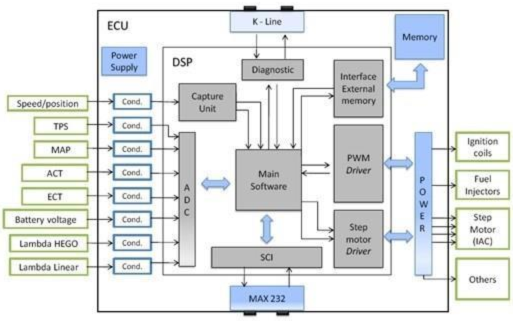


FIGURE 3. New Model with Diagnostic ECU

Our analysis will yield a comprehensive understanding of how changes in ECU configurations and the transition from BS4 to BS6 emission standards impact performance metrics such as power output, fuel efficiency, emissions, and throttle response. We anticipate the creation of compelling visualizations that will effectively illustrate these performance differences. These visual representations will make complex data accessible to a broad audience, aiding enthusiasts, buyers, and industry stakeholders in their decision-making processes.

5. RESULTS / OUTCOMES

The expected outcomes of our project are multifaceted, aiming to provide valuable insights into the performance differences between the KTM RC390 2017 BS4 and KTM RC390 2020 BS6 variants.

The data visualization between the data came out successful with a accuracy of 96.31% in comparison of the verified data from the KTM Orange Factory, Mattighofen, Austria. The performance difference between both the generation of the motorcycle is significantly small but noticeable using the data visualization of BHP data of both the motorcycles.

1. Performance BHP data (Bharat Stage IV)

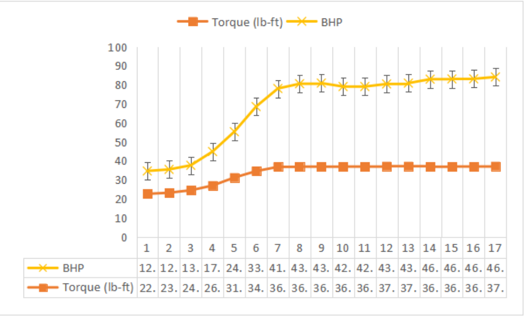


FIGURE 4. KTM RC90 GEN 1 BS4 - BHP Data

2. Performance BHP data (Bharat Stage VI)

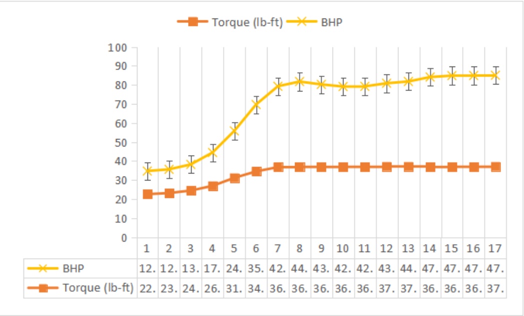


FIGURE 5. KTM RC90 GEN 2 BS6 - BHP Data

I anticipate the creation of compelling visualizations that will effectively illustrate these performance differences. These visual representations will make complex data accessible to a broad audience, aiding enthusiasts, buyers, and industry stakeholders in their decision-making processes. The data is verified through the currently available data of the vehicle with similar specifications. Both the motorcycles are measured on same parameter and the data is plotted along with Torque and BHP records from 1000 RPM to maximum of 7000 RPM. In the process of obtaining the data a total of 17 steps of dynamo runs are performed for both the vehicles resulting is a data visualization of same data matrices. One of the key performance metrics we focused on in our comparative analysis of the KTM RC390 GEN1 BS4 and KTM RC390 GEN2 BS6 variants is Brake Horse Power (BHP). The line chart presented below vividly illustrates the BHP values for both motorcycle generations, providing a clear visual depiction of how the models compare in terms of this crucial performance parameter.

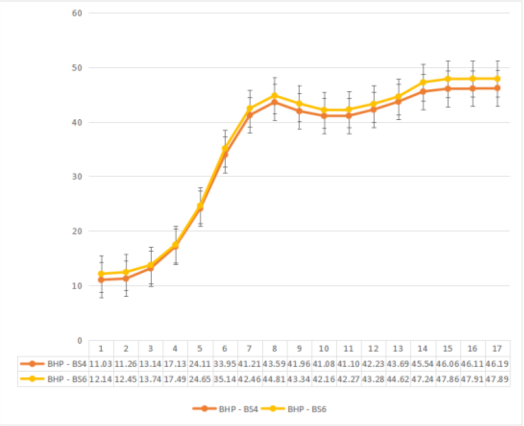


FIGURE 6. Performance comparison between BS4 & BS6 KTM RC 390 motorcycle

My research yielded a comprehensive understanding of how changes in ECU configurations and the transition from BS4 to BS6 emission standards impact performance metrics of Break Horse Power (BHP).

6. CONCLUSION

There are many different types of people involved in the motorcycle business and beyond who may be affected by the broad and significant conclusions drawn from my project: 1. Using statistics for Consumer Decisions: Motorcyclists and those looking to purchase a motorcycle may benefit from insights on performance that are backed by statistics. To help people choose the motorbike that is ideal for their needs and tastes, they will have access to helpful details on how the two KTM RC390 models perform in various environments. 2. Advice to Manufacturers: Our findings may help motorcycle makers with design and technical choices. Our performance data and insights may help businesses optimize critical performance parameters while adjusting their models to meet changing emission rules. 3. Evaluating Regulatory organizations: By looking at how emission rules affect motorcycle performance in the real world, environmental agencies and regulatory organizations may gauge how effective emissions standards are. The arguments concerning the balance between environmental requirements and vehicle performance may benefit from our work. 4. Academic Research: Scholars and researchers interested in motorcycle performance, pollution regulations, and the function of ECUs in vehicle dynamics will find our project's methods and results to be a helpful resource. It lays the groundwork for future studies in this area.
5. Sharing Your information: We will share the information and insights we obtain from our initiative with others via academic papers, conference presentations, and possible partnerships. This will make sure that more people hear about our study, that it adds to the conversation in academia, and that it is used to guide business decisions.

REFERENCES

[1]. Jiang, Y., Ren, G., Liu, B. and Pi, B., 2008. A Study of Electronic Control Unit (ECU) Design and Hybrid Simulation for Motorcycle Engine (No. 2008- 01-1736). SAE Technical Paper.

[2]. Kashikar, A., Suryawanshi, R., Sonone, N., Thorat, R. and Savant, S., 2021. Development of muffler design and its validation. Applied Acoustics, 180, p.108132.

[3]. Sopnur, S., Mahurkar, V., Kodam, N. and Shinde, O., 2020. Remapping of ECU Engine (KTM 390). International Journal of IC Engines and Gas Turbines, 6(1), pp.15-18.

[4]. Aithal, A. and Donakonda, R., 2011. Two Wheeler Engine Control Unit- Development, Challenges and Solutions (No. 2011-28-0003). SAE Technical Paper.

[5]. Cox, B.L. and Mutel, C.L., 2018. The environmental and cost performance of current and future motorcycles. Applied Energy, 212, pp.1013-1024.

[6]. Lee, J.W., Choi, K.Y. and Lee, J.W., 2017. Collecting big data from automotive ECUs beyond the CAN bandwidth for fault visualization. Mobile Information Systems, 2017.

[7]. Jelecevic, E. and Minh, T.N., 2019. Visualize real-time data using AUTOSAR.

[8]. Ferdaus, F. and Raghukiran, N., 2021, April. Aerodynamic Performance Improvement by Streamlining The Front Fairing of a Racing Vehicle. In IOP Conference Series: Materials Science and Engineering (Vol. 1128, No. 1, p. 012007). IOP Publishing.

[9]. Hamberger, A. and Daňa, M., 2019. Measuring the performance characteristics of a motorcycle. Manufacturing technology, 19(4), pp.573-578.

[10]. Simon, B., Vittore, C., Matteo, M. and Martino, P., 2008. Application of the “optimal maneuver method” for enhancing racing motorcycle performance. SAE International Journal of Passenger Cars-Mechanical Systems, 1(2008-01-2965), pp.1311-1318.

[11]. Akitsu, Y., 2012. Research on engine torque control with acceleration performance for MotoGP class racing motorcycles (No. 2012-32-0123). SAE Technical Paper.

[12]. MATSUYAMA, K., SUGI, M. and YABE, N., 2012. Practical Use of the Engine Testing Dyno with the Vehicle Simulation for the MotoGP Race Engine Development. Engine Design Concepts for World Championship Grand Prix Motorcycles, 1(1), p.101.

[13]. Garg, S., Keswani, N. and Sharma, R., 2020. Validation and Designing of Intake System for 1 Cylinder SI Engine in Formula Student Racing Vehicle.

[14]. Kumar, M.N., Jagota, V. and Shabaz, M., 2021. Research Article Retrospection of the Optimization Model for Designing the Power Train of a Formula Student Race Car.

[15]. Siddh, D., Mahesh, G. and Harish, R., 2022. CFD Analysis of Exhaust System of a Formula Racing Vehicle. International Journal of Vehicle Structures & Systems (IJVSS), 14(6).

