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Enhanced Electric Two Wheeler Vehicle Manufacturing with Agile Principles: A Comparative Study of Key and Keyless Ignition Systems

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Abstract - This study delves into the implementation of agile production principles within the electric two Wheeler manufacturing industry, focusing on both key and keyless ignition vehicles. Agile manufacturing principles have significantly improved production processes, enabling the industry to respond swiftly to market demands and technological advancements. By embracing agility, the industry has streamlined workflows, minimized time to market, and enhanced overall operational efficiency. Utilizing the Serial S Model of agile, the industry effectively manages each phase of manufacturing, ensuring a structured yet flexible approach that allows for iterative improvements and rapid adaptability. Our study also compares both keyless ignition systems and traditional key ignition vehicles in terms of performance parameters. Keyless ignition systems offer enhanced safety features, a seamless user experience, and optimized energy management, making them the preferred choice for modern electric two wheeler enthusiasts. Through the agile production approach, this study underscores the transformative impact on electric two wheeler manufacturing, emphasizing the advantages of both keyless and key ignition systems in meeting evolving consumer needs and technological standards.

Key Words - Agile Production, Keyless Ignition, Serial S Model.

1. INTRODUCTION

The electric vehicle industry is experiencing a significant boom due to growing environmental concerns, advances in battery technology and supportive government policies. As consumer demand for cleaner and more efficient transportation options grows, pressure on electric vehicle manufacturers to innovate and accelerate market entry increases. For an electric two-wheeler company, adhering to agile manufacturing principles is critical to remaining competitive, responsive and efficient in this rapidly evolving market.

Agile manufacturing is a method that emphasizes flexibility, rapid response to change, and iterative development based on the core principles of agile software development. This approach differs from traditional production methods, which often involve lengthy planning and rigid processes. By applying agile technologies, an electric two-wheeler manufacturer can significantly improve time to market, productivity and ability to meet customer expectations. One of the most important benefits of agile manufacturing is its iterative nature. The development process is divided into smaller, manageable stages called sprints, each of which produces a part of the final product. In this way, the company can develop and refine new vehicles quickly and efficiently. For example, the introduction of variants such as keyless ignition and keyless ignition systems can be managed with minimal disruption thanks to the flexibility of a skilled team. These multidisciplinary teams work together to ensure that every aspect of the product, from design to production, is constantly optimized based on feedback and changing requirements. Customer feedback is the cornerstone of agile manufacturing. Through continuous feedback loops, the company can ensure that each product iteration better meets customer needs and market demands. This not only increases customer satisfaction, but also reduces the risk of developing features that do not add value. In the rapidly evolving electric vehicle industry, where consumer preferences and technical developments are constantly evolving, the ability to adapt to feedback is invaluable. A Serial S Model approach also enables continuous improvement, a key aspect of agile manufacturing. After each sprint, teams conduct retrospectives to assess what went well and what could be improved. This continuous improvement process helps the company identify and eliminate inefficiencies, improve product quality and streamline production flows. Over time, this leads to higher productivity and a more flexible organization that can quickly respond to market changes.

We compare key and keyless ignition systems based on parameters such as battery capacity, peak power, charging time, 0-40 km/h acceleration time and certified mileage. Agile production principles allowed the manufacturer to create two types of vehicles - key and keyless ignition - and two variants or models under these two types. Despite minor technical variations, the company maintains the same chassis and body structure in all models. This strategy is reminiscent of how a car company offers different options in different price segments, enabling a diverse range of products that meet different customer preferences while optimizing production efficiency.

In addition, thanks to the flexibility offered by agile manufacturing, the company can diversify its product range relatively easily. Developing different EV two-wheel models with small variations is achievable without extensive repairs and delays. For example, configuring a base model with additional features such as advanced infotainment systems or improved battery performance can be seamlessly integrated into an agile development cycle. This ability not only expands the company's market area, but also satisfies the different preferences of customers, thus promoting economic growth and profitability. The rapid growth of the electric vehicle industry highlights the importance of skill in manufacturing. Companies that can quickly bring new products to market, adapt to customer feedback and continuously improve their processes are better positioned to take advantage of the opportunities this growing industry presents. Agile manufacturing principles enable electric two-wheeler companies to stay ahead of the curve and deliver innovative, high-quality products that meet the dynamic demands of today's consumers.

Finally, integrating agile manufacturing principles into an electric two-wheeler company offers a strategic advantage in a fast-paced and competitive industry. By using iterative development, continuous feedback and multidisciplinary collaboration, the company can improve its productivity, reduce time to market and maintain a strong fit with customer needs. Such expertise not only supports the development of different product models, but also ensures sustainable growth and success in the booming electric vehicle market.

2. LITERATURE SURVEY

The review by Damijan Zorko, Borut Černe, Jože Tavčar and Ivan Demšar [7] examines agile concepts in software product development technology, with a specific focus on improving the power of electric motorcycles. Given a rapidly evolving market that requires regular changes to meet design needs, it is critical to maintain product competitiveness that development teams can evolve with these changes. The effect of changes on the improvement method varies mainly depending on the complexity of the product and the development phase during which the changes occur. The work emphasizes that flexibility and technologies according to the agile concept are key for the correct implementation of changes during the product improvement process. The authors offer specific tips for growing complex physical products based on agile standards. These instructions are based on an important overview of how to improve the pressure of an e-bike. Using this empirical finding, the authors seek to focus on how agile methods can be effectively integrated into the development of complex products to improve adaptability and responsiveness to market demands. The research advances the industry by providing realistic insights and tips for incorporating flexibility into product development, ensuring products are competitive in a dynamic market environment. Main focuses are design methods, layout methods including product improvements and electronic mobility, with an emphasis on agile concepts. This study is mainly suitable for development teams and groups who want to improve their product development strategies using agile methods.

The paper [1] emphasizes the importance and increasing importance of agile manufacturing (AM) in improving the competitiveness of manufacturing companies. It emphasizes that AM integrates customer-supplier processes into product design, manufacturing, marketing and support, which requires decision-making based on operational knowledge, stable unit costs, flexible production, integrated access to information and modular production facilities. AM includes enriching customer experiences, collaborating with competitors, managing change and complexity, and using human resources and knowledge effectively. The author points out that despite numerous research works on AM, there is no comprehensive framework for its development, which has been noticed by both researchers and professionals. Recognizing the critical role of AM in the competitiveness of 21st century manufacturing, the article aims to achieve three goals:

i. Identify key AM strategies and techniques.
ii. Suggest future research directions.
iii. Development of an Agile Manufacturing Systems (AMS) framework.

The proposed framework is built around four main dimensions: strategies, technologies, systems and people. By exploring the existing literature, the paper aims to strengthen AM knowledge and provide a structured approach to the further development and deployment of AMS systems. This comprehensive review and framework aims to guide future research and practical applications in the field, ensuring that AM can be effectively used to maintain and improve manufacturing competitiveness in a rapidly changing market environment.

The authors in paper [2] explore the agile software development paradigm, which has gained popularity for its potential to reduce costs, increase productivity, increase quality, and increase business satisfaction. In particular, the work focuses on the application of agile methodologies to the development of complex software projects, such as supply chain management (SCM) systems, characterized by scope, complexity and changing requirements. Traditional predictive software development models are not suitable for such projects, while agile methods that are adaptive and adapt to change and uncertainty are more suitable. The aim of the work is to analyze the agile development methods and management methods used in the development of these complex software projects. It examines how the implementation of an agile process can significantly influence the success of implementing process changes. The study identifies the risks and obstacles encountered in each development phase of complex and innovative software projects and shows how they can be overcome through agile practices. In addition, the document contains instructions for adopting, combining and using the agile method in complex software projects. These guidelines are intended to help software engineers and managers effectively implement agile methods and ensure better project outcomes. The conclusions and recommendations presented in this paper have practical implications for those engaged in software development using agile methods. They provide insight into managing the complexity and uncertainty of large development programs. The paper is a valuable resource for understanding the benefits and challenges of an agile approach in the context of complex software engineering.

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The study [3] explores the application of agile project management in the automotive industry, a new research area that has not been explored before. The goal is to identify obstacles to the application of agile methods in project management in this sector. The authors completed a questionnaire that was distributed to 148 of 240 automotive component manufacturing companies and received 56 complete responses (23.33%). Statistical analyzes including the Kruskal-Wallis test, Mann-Whitney test, and Spearman's correlation were performed to analyze the data. It provides a detailed picture of the implementation of agile project management in the Portuguese automotive industry. It identifies important barriers as "organizational", "knowledge and technology", "institutional" and "financial" barriers. Overcoming these barriers can improve the economic, environmental and social sustainability of businesses. The authors offer recommendations to overcome these obstacles and provide a framework for effective implementation of an agile methodology. The framework begins with the willingness of the company and its partners to adopt agile methods that focus on agile values to achieve a competitive advantage. An initial investment is required to deploy a skilled team of highly experienced partners who understand agile objectives. This team shares information about agile methods with other partners and improves their execution skills. The team must develop frameworks and workflows adapted to the characteristics and environment of the company. The study suggests that these aspects can be replicated in other countries, allowing a comparison of flexible implementation in different cultural and economic contexts. The study emphasizes the importance of process improvement and creating competitive advantages to face competitors in the market.

The authors in paper [4] explore the need for flexible, maintainable and adaptable systems in the automotive industry to improve performance and improve development strategies. They argue that current development models are suboptimal, resulting in poorly managed spending. To solve these problems, the paper recommends the integration of intelligent and flexible technologies and emphasizes the importance of traceability methods to overcome the inflexibility, high costs and lack of timely customer feedback associated with traditional manufacturing methods. The article highlights key requirements management (RM) functions such as traceability mechanisms, intelligent manufacturing processes and performance evaluation in the automotive industry. The authors propose a manufacturing framework that incorporates intelligent flexible principles with effective traceability management. This new approach aims to solve the complexities and inefficiencies of traditional manufacturing processes in the automotive industry. By focusing on these innovative strategies, the proposed framework provides insights into future manufacturing processes and suggests a move towards more flexible and traceable systems. The study provides a comprehensive assessment of the proposed methods and shows their potential to significantly improve the flexibility and efficiency of the automotive industry. Overall, the document emphasizes the need to adopt smarter and more flexible principles to achieve a more responsive and cost-effective production process, providing a road map for the future development of the automotive industry.

Kenaan Berger's research [5] examines the adoption of agile software methods in the automotive industry, which is rapidly changing due to trends such as electric mobility, connected cars and autonomous driving. These trends are disrupting the traditionally static competitive environment, increasing market demand for frequent delivery of innovative features and security-related updates. Traditional automotive software development methods have proven inefficient with short software release cycles, which has created the need for agile methods. The purpose of the research is to find out how car manufacturers can implement agile software development methods and overcome some obstacles. The study includes a literature review and qualitative data through expert interviews with employees of a German car manufacturer. The goal is to understand how researchers and professionals face challenges and propose solutions to integrate agile methods into software development in the automotive industry. The results show that although agile methods can reduce software cycle time, they must be adapted to meet automotive industry standards such as ISO26262 functional safety standards. Contrary to what was originally expected, there is no definitive order to comply with the regulatory requirements. The study emphasizes that, in addition to project management approaches, organizational culture and collaborative aspects play a central role in creating an environment that promotes agility. Despite the possibilities of agile methods, the study highlights an important challenge: maintaining efficiency according to official requirements, especially in the case of the agile Continuous Integration method. The study provides insight into the complexity of implementing agile methods in the automotive industry and highlights the need for tailored approaches to accommodate the strict regulatory frameworks.

The study [6] examines the application of agile project management in the automotive industry, focusing on Volvo Trucks, a subsidiary of AB Volvo. The automotive industry has evolved significantly over the last two decades and has integrated many electronic and software components, leading to rapidly changing customer demands. The industry's traditional work processes, characterized by excessive documentation, inefficient teams and unnecessary reporting, have become inadequate in this fast-paced environment. Agile project management, originally limited to software, is now a solution to these challenges in the automotive industry. The purpose of the study is to find out the factors that influence the decision of an automotive organization to change to agile methods, the challenges faced during this change and the effects after the change. The Volvo Trucks case study involved gathering empirical data through interviews and surveys to gain a comprehensive understanding of their internal processes and change journey. Analysis interprets collected data through theories of change and change management. The results show that both internal and external forces drive the need for flexible change. Internal factors include dysfunctions characteristic of traditional management methods. The major challenges of change are organizational, especially the difficulties between agile and non-agile departments in a partially agile organization. After the change, the study found that employee morale improved and job benefits such as plan efficiency and project transparency improved. The study highlights that the transition to agile methods can improve the shortcomings of traditional processes and offer significant benefits to the automotive industry.

According to the data from Anand Pillai's article [9] examines the importance of agile management in the rapidly growing electric vehicle industry. Agile management, characterized by flexibility, responsiveness and adaptation to change, is very well suited to the electric vehicle industry due to the industry's uncertainty and rapid technological development. The article highlights how agile management drives innovation, reduces costs and increases time-to-market for electric car companies. The electric car industry is highly competitive and capital intensive, requiring large investments in research, development, production and marketing. Agile management helps reduce costs by enabling rapid development and testing of new products and services, allowing companies to more efficiently allocate resources to promising projects. This approach reduces the risk of wasting resources on less profitable projects. Increased time to market is another important benefit of agile management. In the competitive electric car market, the ability to bring new products and services to market quickly is crucial. Agile management enables rapid development and testing, enabling companies to introduce new offerings faster than traditional product development methods. In addition, agile management encourages innovation by prioritizing customer value, which leads to the creation of products and services that better meet customer needs. It also promotes collaboration and communication within organizations and generates new ideas and approaches. To implement agile management in the electric vehicle industry, companies must adopt several key practices: agile planning (breaking projects into smaller, manageable tasks), continuous delivery (regular release of new features and functions), cross-functional teams (grouping together various skills and knowledge) and continuous improvement (processes carried out at regular intervals to improve efficiency and effectiveness). In conclusion, agile management is critical for electric vehicle companies to remain competitive, reduce costs, increase time to market and drive innovation. By adopting agile design, continuous delivery, cross-functional teams and continuous improvement, EV companies can better meet customer needs and stay ahead of the competition.

This discussion paper [8] examines two key questions: to what extent Tesla can be considered a digital company and whether this will lead to a stand-alone "Tesla Manufacturing System". While Tesla is generally considered a competing automaker focused on electric motors, the document argues that Tesla should be understood as a fully digital company - a digital car company with a digital product integrated into a digital ecosystem. This perspective is supported by Tesla's Silicon Valley roots, software-based approach and strategic use of user activity data. The second question examines how Tesla's software-centric background and Silicon Valley origins have influenced its manufacturing processes. Specifically, it examines the extent to which software methods are integrated into Tesla's assembly line operations. The paper argues that agile software development concepts have indeed permeated Tesla's shop, reflecting a significant shift from traditional car manufacturing methods. While it may be premature to announce the existence of a different "Tesla Manufacturing System," the document shows clear signs of a significant and potentially permanent shift in the lean manufacturing paradigm. This change is characterized by the integration of agile methods often associated with software, which represents a significant departure from traditional automotive techniques. The article concludes that Tesla's identity as a digital company and its innovative application of software development principles in manufacturing foster a unique production method that distinguishes it from traditional car manufacturers, suggesting a significant evolution in production paradigms, influenced by e.g. digital and agile methods.

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3. MODEL OF AN EV TWO WHEELER MANUFACTURING COMPANY WITH AGILE PRINCIPLES

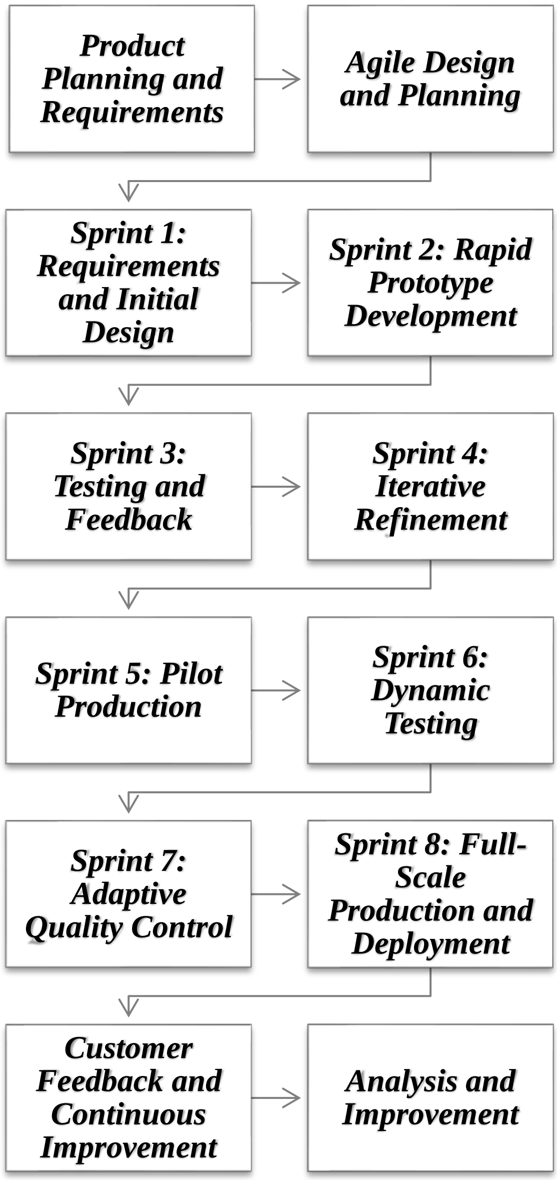

Fig. 1: Serial S Model Implemented in the EV Manufacturing

Let us now take a look at the methodology of agile which is used for the production of EV two wheeler one by one.

I. Product Planning and Requirements

Product design and requirements form the basis of the agile production process of the two-wheeled electric vehicle. At this stage, the company precisely outlines the goals and specifications of the product and sets the direction for further development work. Agile principles guide this process, emphasizing customer centricity, iterative design and adaptability. Cross-functional teams work closely together to gather market insights, analyse customer needs, and define product requirements. Techniques such as user stories, personas and prioritized backlogs are used to capture and prioritize features based on their value to the customer. In addition, continuous feedback loops ensure that changing customer preferences and market trends are taken into account during the design process. By prioritizing features that create maximum value and iteratively refining requirements based on feedback, a company can reduce the risks associated with uncertainty and ensure that the final product meets customer expectations. This iterative and adaptive approach lays the foundation for successful product development and lays the groundwork for following agile manufacturing operations.

II. Agile Design and Planning

Agile planning and design requires iterative refinement of the product concept based on continuous feedback. Teams engage in rapid ideation, prototyping and validation to ensure they meet customer needs and market trends. Agile methods such as design sprints enable cross-functional collaboration and rapid decision-making, which accelerates the design process. By breaking the project down into manageable steps, the team can quickly adapt to new information and pivot as needed. This iterative approach encourages innovation and reduces the risk of investing resources in a product that does not meet market expectations. In addition, flexible planning techniques such as capacity-based planning and adaptive roadmaps enable the team to respond effectively to changing priorities and resource constraints.

III. Sprint 1: Requirements and Initial Design

Sprint 1 focuses on establishing the foundation of the project by gathering detailed requirements and creating an initial design concept. Agile teams work closely with stakeholders to define user stories, prioritize features and create a clear vision for the product. Through iterative discussions and feedback sessions, the team refines the product base and creates a plan for the next sprints. By breaking work down into small, manageable tasks, the team can produce added value incrementally and adapt to changing demands. This iterative approach enables early validation of design decisions and ensures that the project stays on schedule to achieve its goals. In addition, agile methods such as daily stand-up meetings and sprint retrospectives promote transparency and continuous improvement, allowing the team to troubleshoot and fine-tune processes as needed.

IV. Sprint 2: Rapid Prototype Development:

Sprint 2 focuses on rapidly developing prototypes based on original design concepts. Agile teams use iterative development cycles to quickly build and test prototypes and gather valuable feedback from users and stakeholders. By breaking down the development process into small, manageable tasks, the team can deliver working prototypes in a short amount of time. This rapid prototyping method enables early validation of design assumptions and identification of

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potential problems or improvements. In addition, agile methods such as user stories and acceptance criteria ensure that prototypes meet the needs of end users and align with project goals. Through constant collaboration and iteration, the team can iteratively refine prototypes and ensure that the final product meets customer expectations and quality standards.

V. Sprint 3: Testing and Feedback:

Sprint 3 focuses on testing the prototypes developed in the previous sprint and gathering feedback from users and stakeholders. Agile teams conduct a variety of tests, including usability testing, functionality testing, and performance testing, to ensure that prototypes meet quality standards and user expectations. By involving end users early in the testing process, the team can identify usability issues and gather valuable feedback for iteration. In addition, flexible methods such as user stories and acceptance criteria provide clear guidelines for testing and validation, ensuring that prototypes meet the needs of end users and align with project goals. Through continuous collaboration and iteration, the team can address issues identified during testing and iteratively improve prototypes, ensuring the final product meets customer expectations and quality standards.

VI. Sprint 4: Iterative Refinement:

Sprint 4 is dedicated to iterative improvement of prototypes based on feedback from testing. Agile teams prioritize and implement changes in design, functionality and user experience by continuously improving prototypes. By breaking the improvement process into small, manageable tasks, the team can gradually implement improvements in a short period of time. This iterative processing method enables rapid adaptation to changing demands and market conditions and ensures that the final product meets customer expectations and quality standards. In addition, agile methods such as sprint retrospectives and continuous feedback loops allow the team to reflect on their process and identify opportunities for improvement. Through constant collaboration and iteration, the team can iteratively refine prototypes and ensure that the final product meets customer expectations and quality standards.

VII. Sprint 5: Pilot Production:

Sprint 5 marks the transition from prototype production to pilot production of a two-wheeled electric vehicle. Agile teams focus on scaling manufacturing processes and solving challenges or bottlenecks identified during prototyping. Using agile manufacturing principles such as cross-functional collaboration and iterative improvement, the team can streamline manufacturing processes and optimize supply chains to meet market demand. This stage may include small-scale production runs to validate production processes and ensure product quality before full-scale production. Through continuous monitoring and feedback, the team can identify and resolve issues that arise during pilot production and ensure that the final product meets quality standards and customer expectations.

VIII. Sprint 6: Dynamic Testing:

Sprint 6 emphasizes dynamic testing of pilot production units to identify and correct potential defects or problems. Skilled teams conduct rigorous testing throughout the manufacturing process, including component testing, assembly testing, and end-to-end testing. By involving end users early in the testing process, the team can gather valuable feedback and identify usability issues. In addition, flexible methods such as user stories and acceptance criteria provide clear guidelines for testing and validation and ensure that the final product meets quality standards and user expectations. Through continuous monitoring and feedback, the team can identify and resolve issues that arise during dynamic testing and ensure that the final product meets customer expectations and quality standards.

IX. Sprint 7: Adaptive Quality Control:

Sprint 7 focuses on implementing adaptive quality control measures to maintain product quality and consistency. Agile teams continuously monitor production processes, identify potential quality problems and implement corrective actions when necessary. Using agile manufacturing principles such as cross-functional collaboration and continuous improvement, the team can quickly respond to changing production conditions and customer feedback. This adaptive approach to quality control ensures that the final product meets quality standards and customer expectations. In addition, agile methods such as sprint retrospectives and continuous feedback loops allow the team to reflect on their process and identify opportunities for improvement.

X. Sprint 8: Full-Scale Production and Deployment:

Sprint 8 marks the transition to full-scale production and the introduction of EV two-wheelers. Agile teams focus on scaling manufacturing processes, optimizing supply chains and increasing production capacity to meet market demand. Using agile manufacturing principles such as cross-functional collaboration and iterative improvement, the team can streamline manufacturing processes and ensure product quality. Through continuous monitoring and feedback, the team can identify and solve problems that arise during full-scale production and ensure that the final product meets quality standards and customer expectations.

XI. Customer Feedback and Continuous Improvement:

After the product is introduced, the company asks for and considers customer feedback to promote continuous improvement. Smart principles of transparency, control and adaptation guide the company to find out areas of development and optimize the product based on real use and customer

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preferences. Using agile methods such as sprint retrospectives and continuous feedback loops, the team can reflect on their process and identify opportunities for improvement. Through continuous collaboration and iteration, the team can iteratively improve the product and ensure it meets customer expectations and quality standards.

XII. Analysis and Improvement:

Finally, the company conducts an in-depth analysis of the entire agile manufacturing process to identify strengths, weaknesses and areas for improvement. Agile teams reflect on their experiences, collect metrics on key performance indicators, and collaborate to implement changes that improve efficiency, quality, and customer satisfaction. Using agile methods such as sprint retrospectives and continuous feedback loops, the team can reflect on their process and identify opportunities for improvement. Through continuous collaboration and iteration, the team can iteratively improve the product and ensure it meets customer expectations and quality standards.

3. COMPARATIVE ANALYSIS OF ALL THE MODELS

This comparison focuses on two types of EV two-wheel drive vehicles: key and keyless ignition. There are two models M1 and M2 under key ignition and two models M3 and M4 under keyless ignition system. The most important parameters are evaluated, such as battery capacity, maximum power, charging time, acceleration from 0-40 km/h and certified mileage. Agile manufacturing principles enabled these models to be produced and refined seamlessly, facilitating rapid iteration and market responsiveness. This approach ensures that the vehicles meet the diverse needs of customers and maintain efficiency and quality across all models.

The battery capacity of a two-wheeled electric vehicle refers to the amount of electrical energy the battery can store, usually measured in kilowatt-hours (kWh). This is shown in the form of graph among all the models in Fig. 2. This determines the range of the vehicle and how long it can run on a single charge, which directly affects the efficiency and effectiveness of the vehicle.

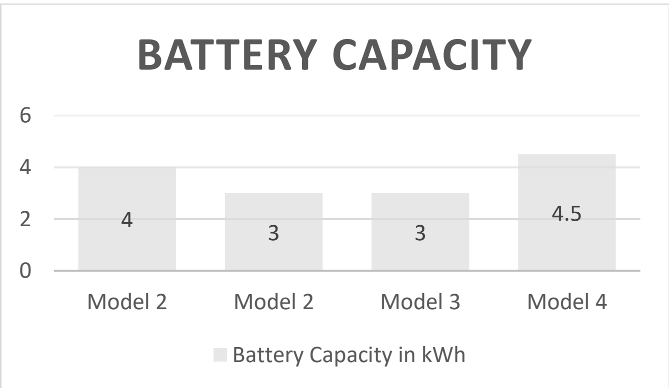

Fig. 2: Battery capacity of the models

The charging time of an electric two-wheeler means the time it takes to charge the battery from empty to full. This metric is very important for users because it influences the usability and comfort of the vehicle. Fig. 3 below compares the charging times of the four models. This visual representation helps highlight the differences in charging efficiency between these models.

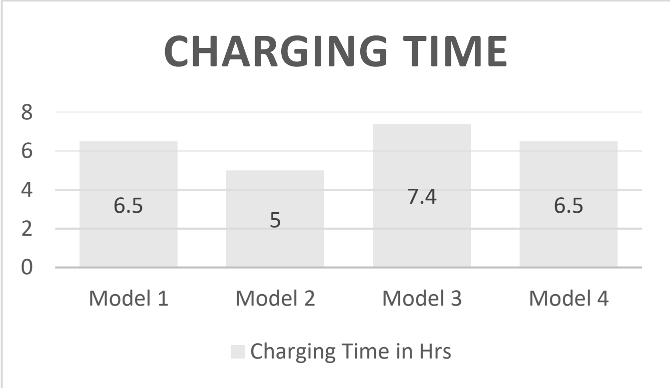

Fig. 3: Charging time required for all the models

The peak power of a two-wheeled electric vehicle refers to the maximum electrical power the engine can produce, usually measured in kilowatts (kW). This indicates the vehicle's ability to perform tasks such as rapid acceleration or climbing steep hills. The Fig. 4 below illustrates the maximum performance of four different models. This visual comparison helps highlight the performance differences between the models and shows how each version handles demanding situations.

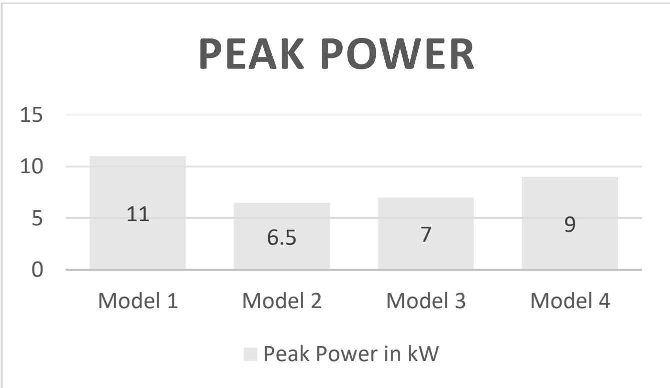

Fig. 4: Peak power of the models

Certified range is the maximum distance an EV two-wheeler can travel on a single charge under standardized test conditions. This measure helps consumers understand the vehicle's efficiency and performance. Below, Fig. 5 illustrates the certified ranges of the four models: two with key ignition and

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two with keyless ignition systems. This visual comparison highlights the differences in range across the models.

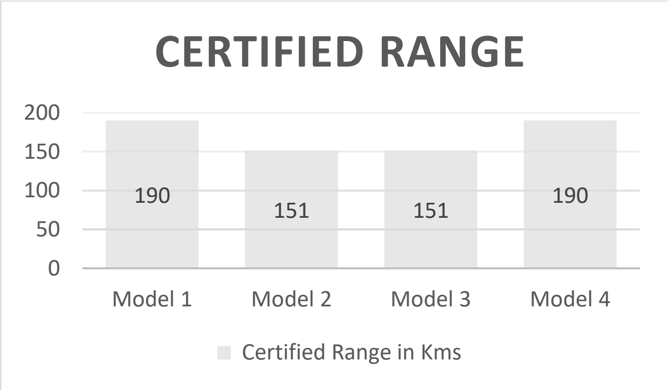

Fig. 5: Certified range of the models

The 0-40 km/h acceleration time of a two-wheeled electric vehicle shows how quickly the vehicle can reach 40 km/h from a standstill, reflecting its performance and power. This gauge is crucial to understanding the responsiveness and agility of the vehicle. The Fig. 6 below illustrates the acceleration times of four models. This visual representation highlights the performance differences between the various models and provides a clear comparison of their acceleration characteristics.

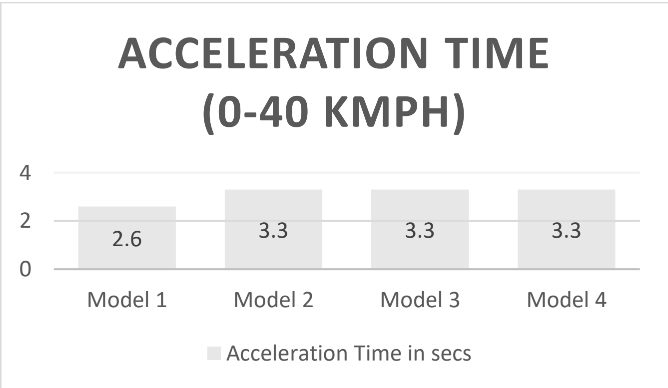

Fig. 6: Acceleration time take by the models

The top speed of an electric two-wheeler is the maximum speed it can reach under optimal conditions. This metric is crucial for understanding vehicle performance, especially in urban traffic. The Fig. 7 on the right compares the top speeds of four models. This visual representation highlights performance differences and helps consumers make informed choices based on speed requirements.

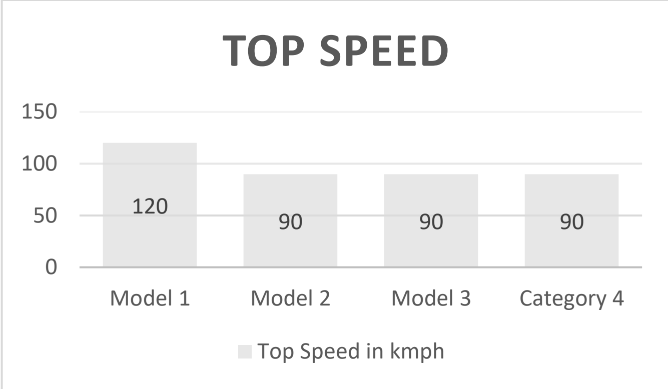

Fig. 7: Top speed of the models

4. CONCLUSION

Agile manufacturing has revolutionized the automotive industry, especially in the production of electric two-wheelers. This methodology focuses on flexibility, iterative development and rapid response to change, which are crucial in a fast-paced market driven by innovation and changing consumer demands. For an electric two-wheeler company that produces keyed and keyless vehicles, agile principles significantly streamline the development and production process. The company can effectively create and refine two models for each vehicle type, making minor technical changes while maintaining the chassis and body structure of all models. This uniformity simplifies production processes and reduces costs, while flexible iteration enables continuous improvement based on real-time feedback. Agile methods allow cross-functional teams to collaborate and ensure that planning, design and production are closely aligned. Sprints allow incremental development where each phase focuses on delivering a specific component or function. This approach ensures that any problems are identified and resolved in a timely manner, reducing the likelihood of costly post-production repairs.

Customer feedback is an important part of agile manufacturing. By continuously collecting and engaging user feedback, a company can make data-driven decisions that improve product quality and customer satisfaction. This feedback loop ensures that vehicles meet market demands and maintain a competitive advantage. Agile manufacturing also enables rapid scalability. When developing new models or variants, the iterative process ensures that they can be quickly integrated into the production line without major disruption. This agility is particularly useful in the booming EV market, where being first to market with new features can be a significant competitive advantage.

Overall, the use of agile manufacturing principles allows electric two-wheeler companies to increase production efficiency, shorten time to market and respond quickly to consumer and technological developments. By maintaining a flexible and iterative approach, the company can produce different vehicle models that serve different customer segments and ultimately lead to growth and profitability.

5. FUTURE SCOPE

This comparative study lays the foundation for further research in several key areas. Future research could examine the long-term performance and reliability of key-start compared to keyless EVs, including their impact on user satisfaction and market acceptance. In addition, examining the environmental and economic impacts of different battery technologies and their charging infrastructure can provide deeper insights. Another promising area is the integration of advanced technologies such as the Internet of Things with predictive maintenance and smart charging solutions. Finally, expanding the comparison to include new features such as self-driving driving capabilities could significantly contribute to the evolving landscape of electric two-wheelers.

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