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Design and Fabrication of a Compact Electric Vehicle

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ABSTRACT:

Electric vehicles (EV's) are a promising technology for achieving a sustainable transport Sector in the future, due to their very low to zero carbon emissions, low noise, high efficiency, And Flexibility in grid operation and integration & This Study is an overview of electric vehicle Technologies as well as associated energy storage systems and fabrication of electric vehicle And Charging mechanisms. Different types of electric-drive vehicles are presented. These Include battery Electric vehicles, plug-in hybrid electric vehicles, hybrid electric vehicles and Fuel cell electric Vehicles. The topologies for each category and the enabling technologies are Discussed. This Study Presents a new design model that combines Modelica for modelling and Simulation with Model Centre Like CATIA and ANSYS for optimizing design variables and Covers the electric vehicles. ANSYS Analysis, Vehicle Dynamics, Engineering Project

Keywords — Electric Vehicle, Compact Design, Chassis Fabrication, CAD Modelling, CATIA

INTRODUCTION

Electric Vehicles (EV's) have emerged as a trans-formative solution in the transportation Sector due to their environmental friendliness, energy efficiency, and reduced operational costs. Unlike conventional vehicles that rely on internal combustion engines powered by fossil fuels, EV's Utilize electric motors powered by rechargeable batteries. This shift significantly contributes to Reducing carbon emissions and promoting sustainable mobility.

The design and fabrication of compact electric vehicles are gaining increasing attention for Their applicability in urban transportation, academic research, and low-cost innovation. Compact EV's are ideal for educational and prototyping purposes due to their simplified structure, Manageable scale, and cost-effectiveness.

This project involves the complete process of designing, modelling, assembling, and analysing A small-scale electric vehicle prototype. Advanced computer-aided design (CAD) tools such as CATIA
Were used for component modelling, while ANSYS was employed for structural analysis to ensure Performance under simulated loads. The fabrication process included the assembly of components like Chassis, wheels, steering, braking systems, and electrical integration. The ultimate goal of this project Is to understand the end-to-end development of an electric Vehicle, from digital design to real-world prototyping, while learning essential mechanical and Electrical engineering principles involved in EV manufacturing

2. LITERATURE REVIEW

S. Rami Reddy, Saroj Kumar Sarangi(1) Were optimized with a Chimp Algorithm, while a Maximum power tracking controller boosted PV output& Reduced fossil fuel reliance, using Photovoltaic (PV) systems for charging MATLAB/Simulink results confirmed the controller's Effectiveness.
Shangyi Zhao & Ming Guo(2) used a Genetic Algorithm (GA) to optimized Electric vehicle Performance, leveraging GA's adaptability for complex Optimization tasks.

Greta Lombardi, et al. (3) Were improved grid stability during outages and Reduced peak demand & explored integrating hybrid concentrated solar and Photovoltaic systems with electric vehicles, Linking energy conversion and Transportation.

Jun Woo Jeong, et al. (4) Were studied about Electrified vehicle batteries mainly Used lithium-ion Technology. Charge and discharge cycles led to aging and Conclude that reducing lifespan. Additionally, low operating temperatures Increased internal resistance, further shortening battery Life.

Halil Bayram, et al. (5) Developed a one-dimensional model of a hybrid heat Pump system to Enhance electric vehicle driving range and energy consumption. And was tested in four heating Modes to meet heating demands, operated in Recirculation mode for energy efficiency.

Ahtisham Urooj & Ali Nasir(6) Reviewed energy management systems for Hybrid electric Vehicles, focusing on rule-based and reinforcement learned Techniques. The authors believed that The future of energy management would 12

M.E. Vilberger, et al. (7) Explored improved fuel cell electric vehicle energy Efficiency used Modern control algorithms based on fuzzy logic for traction Battery remnant in state of charge. Those experiment included a fuel cell vehicle Traction system with a brushless DC motor, lithium-Ion battery pack.

Hwa-Dong Liu, et al. (8) Proposed an innovative control strategy based on a Quadratic equation From a core battery changed model. Applied to a solar step-up Power converter (SSUPC) Optimized for electric vehicle charging, the 500 W SSUPC, controlled by a microprocessor, Effectively converted low input voltage Into high output voltage.

Sucharita Barik & B. Saravanan(9) Used of a lithium-ion batteries in electric Vehicles (EVs) Heightened the need for accurate State of Charge (SOC) estimated. SOC was crucial for safe EV Operation, enhancing range, and optimized battery Performance.

Muhammad Irfan, et al. (10) Addressed about Electric vehicles (EVs) were seen As a green energy Technology that could facilitated the transition to sustainable, Low-carbon transportation.

MD Shouquat Hossain & Mohammad Jakir Hossain Khan(11) Discussed About Electric vehicles (EVs) gained attention for their potential to reduced GHG Emissions. Many countries invested in EV technologies and infrastructure to Support widespread adoption.

Lingcong Guo Pan Hu Hong Wei(12) Studied about Hybrid electric vehicles Required specialized Energy storage systems. Nickel-metal hydride and lithium-Ion batteries dominated the market but Had drawbacks. Electric double-layer Super capacitors were used in passenger vehicles.

Nikhil Menon, et al. (13) Conducted a systematic review of 44 articles to Evaluated the equitable Distribution of electric vehicle charged infrastructure in The United States.

Tamara L. Sheldon & Rubal Dua(14) Examined how rising battery capacities Affected EV prices And compared those with actual trends, offered insights for Policymakers.

Shrey Verma, et al. (15) Reviewed smart electric vehicles (SEVs) and their Potential to cut the Transport sector's 18% share of global CO2 emissions and Examined digital twin technology for Optimized SEV infrastructure, discussed Benefits and challenges in its applications.

Mohd Owais Khan, et al. (16) Studied that Electric vehicles (EVs) gained Popularity due to Concerns about fossil fuel emission and presenting challenges For a smooth transition.

METHODOLOGY

The methodology adopted for the design and fabrication of a compact electric vehicle involves a Systematic approach that integrates conceptual design, computer-aided modelling, simulation, and Physical fabrication. The project was executed in the following phases:

3.1 Conceptual Design

3.2 CAD Modelling Using CATIA

Individual components of the vehicle—such as the chassis, wheels, suspension, and steering

Assembly— were model using CATIA V5. The software enabled precise dimensional control and

The ability to visualize and modify the design before fabrication.

3.3 Structural Analysis Using ANSYS

Finite Element Analysis (FEA) was conducted in ANSYS to evaluate stress distribution, Deformation, and factor of safety in critical components like the chassis and suspension. This step Ensured the mechanical integrity of the structure under expected loads.

3.4 Material Selection

Materials for the chassis and frame were selected based on strength-to-weight ratio, cost, and Availability. Mild steel was chosen for its durability and ease of fabrication.

3.5 Fabrication and Assembly

The physical structure was fabricated in the lab using standard workshop tools. Processes such as Cutting, welding, grinding, and drilling were employed to build the chassis and integrate subsystems Like the steering mechanism, brake system, and electric drivetrain.

3.6 Electrical Integration

A suitable electric motor and battery system were selected and integrated with the fabricated frame. Basic electrical testing was done to verify motor functionality and vehicle movement.

3.7 Testing and Validation

The final vehicle was tested for manoeuvrability, braking response, and overall performance. Observations were made to identify any structural or functional limitations, and improvements were Implemented accordingly.

FABRICATION OF ELECTRIC VEHICLE

The fabrication of an electric vehicle was conducted in the laboratory. The design of the electric car assembled was similar to a Formula Racing car. For propulsion, four 12V batteries were installed, allowing the car to run at a maximum speed for a certain period. During the fabrication process, the team coordinated to assemble and disassemble the vehicle, which Helped them understand the complexity of the manufacturing process. They also collaborated with AMZ University, located in Jaipur, India. Through this collaboration, they worked together to Assemble each part of the vehicle and understand the working of each component of an electric Vehicle.

4.1 MAJOR COMPONENTS:-

- Electric Motor
- Battery
- Inverter
- Charging Port
- Control Unit

4.1.1 Electric Motor

Fig 1:- Electric Motor

The electric motor is a fundamental component of an EV and serves to transfer electrical power from the battery to mechanical power to drive the vehicle. Power from the electric motor to the wheels is transferred via the drivetrain. The control unit governs its operation, managing the distribution of power among the battery, the motor, and other vehicle components. Also, there is a thermal control system to ensure the battery and motor's temperature remains stable, ensures maximum performance

4.1.2 Battery

The primary control unit act is the distribution of power within the electric vehicle system to Provide equitable use of electricity among its power unit, motor, and additional other appliances. Generally, "Vehicle Control Unit" encompasses but is not limited to different functions in cars Like safety, efficiency, and performance monitoring. The report also has graphics of "Controller Wire connections" and the "Controller Used in EV." The design skills for such systems are Programming and vehicle control systems, hence placing it under software development.

4.1.3 INVERTER

FIG 2:- INVERTER

EV inverter is among the most critical parts of our simulated electric vehicle that does the conversion Of direct current (DC) from the battery to alternating current (AC) for powering the brushless direct Current (BLDC) motor. It includes insulated-gate bipolar transistors (IGBTs) or metal-oxide-Semiconductor field-effect transistors (MOSFETs), gate driving circuits, a control-purpose Microcontroller unit (MCU), a direct current (DC)

link capacitor, and an adequate thermal Management or cooling system. This design offers effective motor driving, speed control, and Regenerative braking.

4.1.4 CHARGING PORT

EV charging port is an essential interface in our electric vehicle simulator, enabling safe electrical Energy transmission from external charger to on board battery. It may include a default compliance Connector (e.g., Type 2 or CCS), wire harness, on board charger (OBC), and monitoring battery Management system (BMS). EV charging port supplies continuous energy input, supports slow and Fast charging, and offers electrical protection when active

4.1.5 CONTROL UNIT

FIG 3:- CONTROL UNIT

Our control unit for electric vehicles is the mastermind brain that gets responsible for power Distribution, motor control, and system communication. It mainly comprises a microcontroller Unit (MCU), sensors, signal processing circuits, and software algorithms. The control unit gains Control over accelerator, brake, and battery management system (BMS) inputs to regulate motor Speed, torque, and vehicle performance in general for efficient driving.

Here is the model of our Fabricated Electric Vehicles

FIG 4:- SIDE VIEW OF FABRICATED ELECTRIC VEHICLE

FIG 5:- FRONT VIEW OF FABRICATED ELECTRIC VEHICLE

PROBLEM STATEMENT

The growing environmental concerns, depleting fossil fuel reserves, and increasing green transport Demand have proven the need for the transition from traditional internal combustion engine (ICE) Vehicles to electric vehicles (EVs). Nevertheless, technological constraints like range limitation, Efficiency-low charging mechanism, high capital expenditure, and absence of technical inputs at the Student level deter innovation and dissemination in EV technologies. This project purports to resolve Such problems by design, development, and building of a working solar charging electric vehicle and Giving students actual hands-on experience in EV components, simulation, and manufacturing Processes.

DESIGN AND FABRICATION

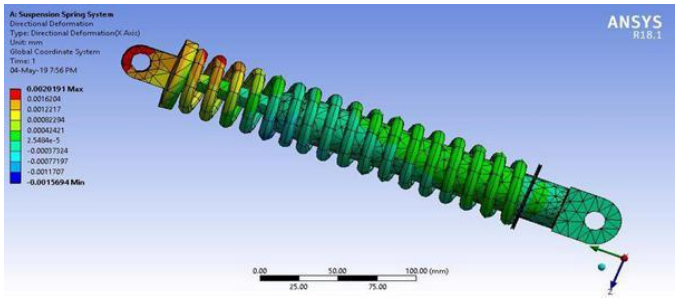

FIG 6:- SUSPENSION SYSTEM IN ANSYS

1. **Suspension System:**

Component: Suspension Spring System. Software: CATIA V5 for modelling, ANSYS R18.1 for finite element analysis (FEA).

Key Points:

- Designed a coil spring and damper assembly for an EV. Simulated the system in ANSYS under a fixed support and a 1000N force.
- Analysed the directional deformation and stress distribution (as represented by The colour gradient in the image) to check the design for strength and Performance.
- FEA outputs provide the deformation pattern, which is crucial in determining the Component's durability and fitment to an EV's weight and dynamic loading.

2. **Brake Disc:**

Component: Ventilated Brake Disc. Software: CATIA V5.

Key Points:

- The design incorporates mounting holes for the wheel hub and calliper.

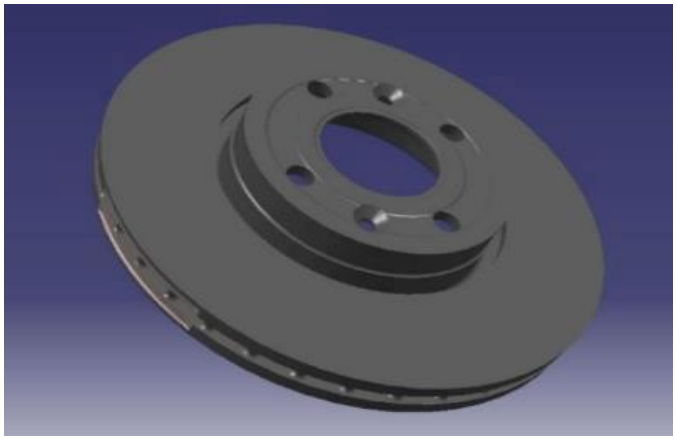

FIG 7:- BRAKE DISC

- Designed a ventilated brake disc, which is required for heat dissipation in an EV Braking system.
- Highlight the geometric design elements, such as the ventilation channels, Which play a critical role in preventing thermal stress and brake fade.

3. **Hand wheel / Steering Wheel:**

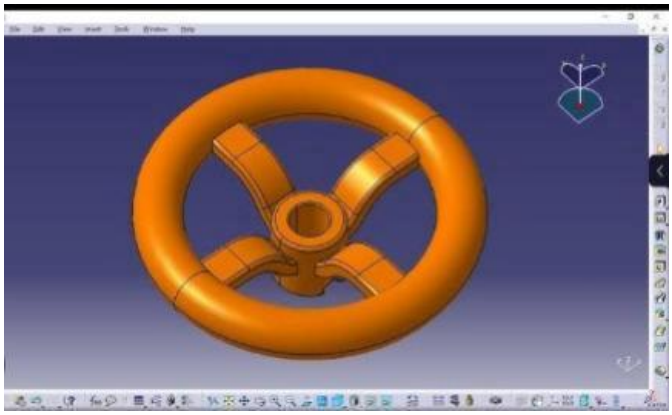

FIG 8:- STEERING WHEEL

Component: Hand wheel/Steering Wheel.

Software: CATIA V5.

Key Points:

- A control/user interface component.

- Design includes use of features like padding, shaft creation, characteristic of sophisticated solid modelling mechanical durability to mechanical durability to withstand user inputs Are emphasized.

- Designed a multi-spoke wheel rim design.

DISCUSSION

- Practical exposure in constructing a formula-style electric vehicle gave an idea about the development of the mechanical and electrical subsystems.
- Component design and analysis using CATIA and ANSYS of components like disc brake, shock absorber, steering wheel, and car tire were achieved in order to validate structural viability and testing performance.
- Group-based assembly of the vehicle while learning with the support of AMZ University, Jaipur, supported the learning process through live problem-solving in the fabrication process.
- The 12V four batteries were used as power sources for the electric vehicle with demonstration of basic operations and experimental base for observation of coordination between components.
- Literature review recognized significant advancement in battery technology, integration of solar energy, and energy management systems with the industry forces of sustainability and efficiency.
- Hypothetical consideration of solar integration and renewable energy as the main element in future EV technology, but usage is prohibited by current technology and price.
- Short driving distance and range anxiety on the part of the consumer.
- Insufficient charging infrastructure, particularly for emerging regions.
- Short on refuelling speed compared to traditional refuelling.
- High up-front cost from battery systems.
- Battery aging and environmental issues in the area of recycling and disposal.
- The program provided for the acquisition of essential engineering skills like CAD modelling, component testing, team management, and system integration during electric vehicle development.
- At the broader level, the project established the role of multidisciplinary knowledge in mechanical, electrical, and software engineering to design efficient and sustainable electric vehicles

CONCLUSION

We conclude that we had gain so much knowledge from this fabrication of an Electric Vehicle Car which included the design and analysis of main components in CATIA and ANSYS, we Designed those components by myself and later we learned that how to assemble and Disassemble of a basic formula type electric car which ignite us to put interest on electric Vehicles design and manufacturing and developed. However, limitations like range anxiety, Inconsistent charging infrastructure, and longer charging times are important to address.

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