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MODELLING AND ANALYSIS OF SOLAR POWERED SMART WHEEL CHAIR WITH BLUETOOTH CONTROL FOR PHYSICALLY CHALLENGED PEOPLE

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ABSTRACT

This project presents the modelling and analysis of a solar-powered smart wheelchair with Bluetooth control designed for physically challenged individuals. The system aims to improve mobility, independence, and energy efficiency by integrating renewable energy with smart technology. Solar panels are used to capture sunlight and convert it into electrical energy, which is stored in a rechargeable battery to power the wheelchair. A microcontroller-based control system is implemented to manage the movement of the wheelchair, while Bluetooth technology enables wireless operation through a smartphone. This allows users or caregivers to control directions such as forward, backward, left, and right with ease. The modelling includes mechanical design, electrical components, and energy management, while analysis focuses on battery performance, charging efficiency, and system reliability. The proposed system is eco-friendly, cost-effective, and enhances the quality of life for users by providing a smart and sustainable mobility solution.

1. INTRODUCTION

1.1 Introduction

Mobility plays a vital role in ensuring independence and improving the quality of life for physically challenged individuals. Conventional wheelchairs often require manual effort or frequent electrical charging, which can limit their usability. To address these challenges, this project introduces the modelling and analysis of a solar-powered smart wheelchair with Bluetooth control. The system utilizes solar energy as a renewable power source, where solar panels convert sunlight into electrical energy and store it in rechargeable batteries. A microcontroller is used to control the movement of the wheelchair, while Bluetooth technology enables wireless operation through a smartphone, allowing easy navigation. The modelling involves designing the mechanical structure, electrical system, and control mechanism, while the analysis focuses on performance parameters such as battery

efficiency, charging rate, and reliability. This smart wheelchair offers an eco-friendly, cost-effective, and user- friendly solution, enhancing mobility and independence for physically

challenged individuals.

1.2 Components used

Components:

- **Solar Panel** – Consists of photovoltaic (PV) cells made of silicon that convert sunlight into electricity.
- **Battery** – Made of electrochemical cells (lead-acid or lithium-ion) to store electrical energy.
- **Charge Controller** – Includes electronic circuits, voltage regulators, and protection components to manage charging.
- **Microcontroller** – Consists of a processor, memory, and input/output pins (e.g., Arduino board).
- **Motor Driver** – Contains ICs (like L298N), transistors, and heat sinks to control motors.
- **DC Motors** – Made of coils, magnets, shaft, and brushes to convert electrical energy into motion.
- **Bluetooth Module** – Includes a wireless communication chip, antenna, and interface pins.
- **Chassis/Frame** – Composed of metal or alloy structure for support.
- **Wheels** – Made of rubber and metal rims for movement.

2.LITERATURE REVIEW

The field of assistive mobility systems has evolved significantly over the years with the integration of advanced technologies such as renewable energy systems, wireless communication, and intelligent control mechanisms. Wheelchairs, being one of the most important mobility aids, have undergone continuous development to improve efficiency, safety, and user comfort.

This chapter presents a detailed review of existing research works related to smart and solar-powered wheelchairs.

R. Simpson et al. [1] presented a comprehensive review of smart wheelchair technologies and their evolution over time. The study discussed various control interfaces such as joystick control, voice control, head movement control, and brain-computer interfaces. The author highlighted that traditional control methods are not suitable for all users, especially those with severe disabilities.

The research emphasized the importance of intelligent navigation systems that can assist users in obstacle avoidance and path planning. Additionally, the paper discussed the integration of sensors and artificial intelligence to improve decision-making capabilities. The study concluded that smart wheelchairs can significantly enhance independence and reduce reliance on caregivers.

S. A. Fehr et al. [2] conducted an extensive study on the effectiveness of power wheelchair control interfaces for individuals with severe disabilities. The research focused on evaluating different control systems and their usability for patients with limited motor skills. The authors found that conventional joystick-based control systems are difficult to operate for certain users. The study suggested alternative input methods such as sip-and-puff systems, voice recognition, and touch-based interfaces. It also highlighted the need for customizable control systems that can adapt to individual user requirements. The findings of this research are crucial in designing user-friendly smart wheelchair systems.

P. Jayaprakash et al. [3] developed a solar-powered wheelchair system aimed at reducing dependency on conventional energy sources. The study described the design and implementation of photovoltaic panels integrated with a battery storage system. The authors analyzed the efficiency of solar panels under different environmental conditions and demonstrated that solar energy can effectively power mobility devices. The system was found to be particularly useful in rural and remote areas where electricity supply is limited. The study also discussed the cost-effectiveness and environmental benefits of using renewable energy in assistive devices.

3.MODELLING OF SOLAR POWERED SMART WHEEL CHAIR WITH BLUETOOTH CONTROL FOR PHYSICALLY CHALLENGED PEOPLE BY USING SOLID WORKS

3.1 INTRODUCTION TO SOLID WORKS

SolidWorks is a powerful 3D CAD software that is widely used for computer-aided design, simulation, and product development in the field of mechanical engineering. SolidWorks has a user-friendly interface that makes it easy for engineers to design and develop products in three dimensions.

In the current project, SolidWorks has a significant role to play in terms of designing and visualizing the Solar Powered Smart Wheelchair with Bluetooth Control. Using SolidWorks CAD software, it is possible to accurately design all the components of the wheelchair, such as the chassis, wheels, battery arrangement, solar panel mounting arrangement, motor arrangement, and electronic component arrangement.

3.2 FEATURES OF SOLIDWORKS

- 3D Modelling: Enables users to create highly detailed 3D designs with precision.
- Parametric Design: Allows modification of components based on predefined constraints.
- Simulation & Analysis: Includes finite element analysis (FEA) for structural evaluation.
- Rendering & Visualization: Provides realistic animations and visual representations.
- Manufacturing Integration: Supports CAM processes for direct manufacturing applications.
- File Compatibility: Works with various file formats, enhancing collaboration.

Applications of SolidWorks

- Product Design: Used for creating detailed mechanical and industrial product models.
- Structural Analysis: Helps evaluate stress, strain, and material propertie Automotive & Aerospace: Assists in designing components for vehicles and aircraft.

3.3 MODELLING OF SOLAR WHEEL CHAIR

3.3.1 Step 1: Design of Wheelchair Frame (Chassis)

1. Open SolidWorks → New Part
2. Select Top Plane → Sketch
3. Draw rectangular base frame using lines
4. Apply dimensions (length, width)
5. Use Extrude Boss/Base to give thickness
6. Add support members using Weldments / Structural Member



Fig 3.4 Battery Housing Design

Step 5: Solar Panel Mounting Structure

1. Design rectangular frame
2. Use Structural Members
3. Add tilt mechanism (optional)
4. Mount above wheelchair



Fig 3.5 Solar Panel Mounting Structure

4. FINITE ELEMENT ANALYSIS

4.1 INTRODUCTION OF FEA:

In structural engineering, FEA helps analyse bridges, buildings, and aircraft components, ensuring they can withstand forces such as wind, pressure, and impact. In mechanical engineering, it aids in evaluating machine parts, turbines, and automotive components, enhancing durability and safety. Overall, Finite Element Analysis is an essential tool in engineering that helps predict how structures and components will behave under different conditions. By reducing the need for physical prototypes and expensive testing, FEA saves time and resources while improving product efficiency and reliability.

4.3 MATERIALS AND MECHANICAL PROPERTIES:

S.N O	MATERI AL USED	MODULUS OF ELASTICITY (E) (N/mm²)	POISSON' S RATIO	DENSITY (kg/m³)	YIEL D STRE SS (N/mm²)	REMARK S
1	Mild Steel (AISI 1020)	2.0×10^5	0.29	7850	250	Strong, low cost
2	Aluminum Alloy (6061-T6)	6.9×10^4	0.33	2700	276	Lightweight
3	Stainless Steel (304)	1.93×10^5	0.3	8000	215	Corrosion resistant
4	High Density Polyethylene (HDPE)	500-1500	0.35-0.45	800-1200	20-40	Seat & covers
5	Polyurethane Foam	10-100	0.30-0.40	30-60	5-Jan	Cushi on mater ial
6	Rubber (Natural)	10-Jan	0.48-0.50	1000-1200	--	Tires
7	ABS Plastic	2.1×10^4	0.35	1020	40	Electronics casing

Table 4.3 Materials and Mechanical Properties

4.2 PROCESS OF FEA USING ANSYS

STATIC STRUCTURAL ANANLYSIS OF SOLAR POWERED SMART WHEEL CHAIR

STEP 1: GEOMETRY

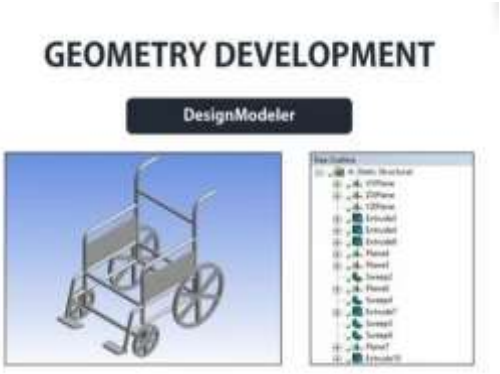


Fig 4.1 Geometry Development of Solar Powered Smart Wheel Chair

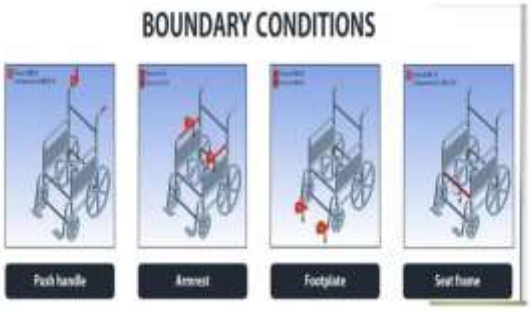


Fig 4.2 Boundary Conditions of solar powered smart wheel chair

STEP 3 : Meshing

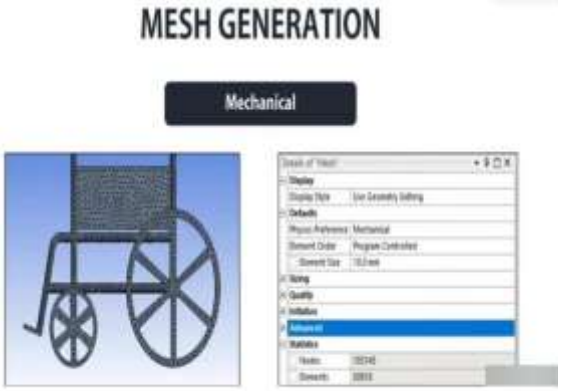


Fig 4.3 Meshing on solar powered smart wheel chair

The mesh consists of tetrahedral mesh. In that mesh dividing the Nodes and Elements. Example: There are 103145 Nodes and the 50818 Elements used in these mesh.

STEP 4: Stress Analysis

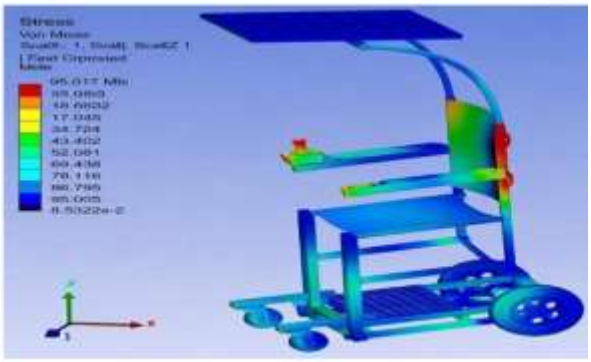


Fig 4.4 Stress analysis on the Wheel Chair

Static structural analysis in ANSYS shows wheelchair with fixed supports and 800 N load. Maximum stress~95 MPa occurs at joints; deformation is minimal, confirming safe design for a 81.5 kg user.

STEP 5: Equivalent stress(Von-Mises)

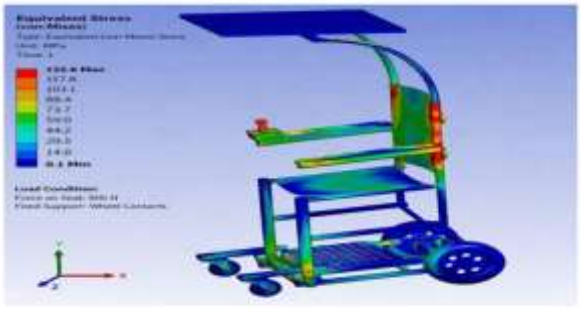


Fig 4.5 Equivalent Stress on Solar Powered Smart Wheel Chair

STEP 6: Safety Factor

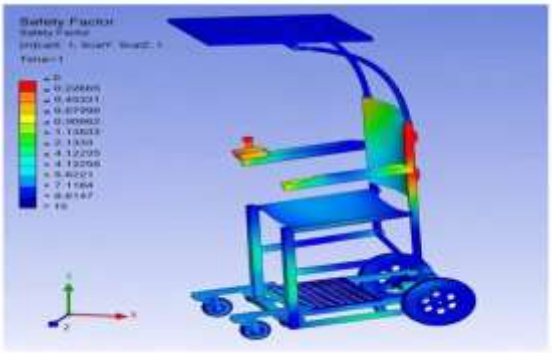


Fig 4.6 Safety Factor of Solar Powered Smart Wheel Chair

4.1.1.7 Step 7: Total Deformation

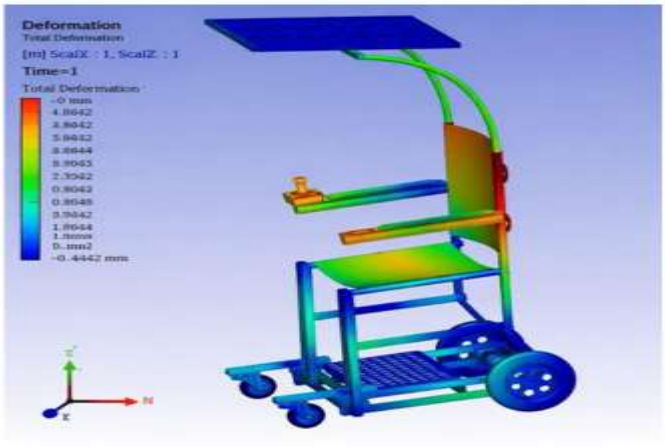


Fig: 4.7 Total Deformation Of Solar Powered Smart Wheel Chair

4.5 Graphs

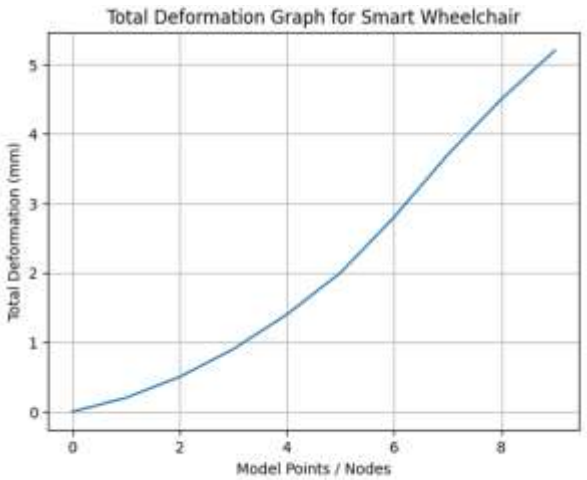


Fig 4.2.1 Total Deformation of Solar Powered Smart Wheel Chair

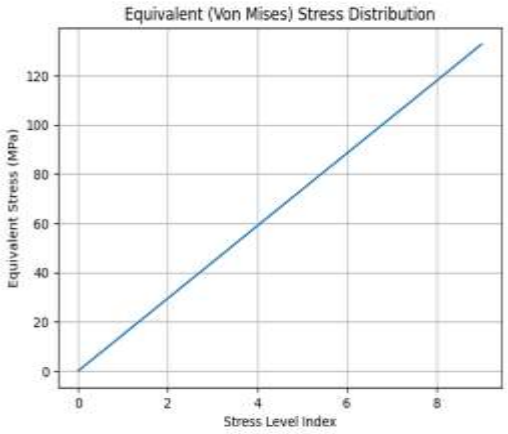


Fig 4.2.2 Equivalent stress of Solar Powered Smart Wheel Chair

Output



OUTPUT
Fig 8.1



Fig 8.2 Frame Work



Fig : 8.3 Arduino board Fixing



Fig : 8.4 Seat Adjustment



Final output

Fig 8.5

5.RESULT & DISCUSSION

5.1 STATIC STRUCTURE ANALYSIS RESULT TABLE

S.N O	MATERIAL NAME	Total Deformation (mm)	Equivalent Elastic Stress (N/mm^2)	Factor of Saftey
1	Mild Steel (AISI 1020)	1.12×10^{-3}	85.2	3.2-3.8
2	Aluminium Alloy (6061-T6)	2.45×10^{-3}	82.6	2.5-3.2
3	Stainless Steel (304)	1.30×10^{-3}	88.4	3.5-4.2
4	HDPE (Seat Base)	6.80×10^{-3}	22.5	1.8-2.5
5	Polyurethane Foam	1.95×10^{-2}	5.1	1.2-1.8
6	ABS Plastic	4.10×10^{-3}	35.2	2.0-2.8
7	Aluminium + Reinforced Frame	1.95×10^{-3}	80.3	3.5-4.5

Table 5.1 Static Structural analysis result

5.2 Discussion on Static Structural Analysis Results

The static structural analysis of the solar-powered smart wheelchair was performed for a 81.5 kg user with a load of 800N. Maximum deformation occurs at the upper frame, while stress is concentrated at joints. All values are within safe limits, confirming the design is structurally stable and safe.

Total Deformation

The total deformation values indicate the displacement of the solar-powered smart wheelchair under the applied load of a 81.5 user. These values are essential for evaluating the stiffness and structural performance of the wheelchair. From the analysis, polyurethane foam shows the highest deformation, indicating low stiffness and poor load-bearing capability, making it suitable only for cushioning purposes. In contrast, mild steel exhibits the least deformation, demonstrating high rigidity and excellent strength, which makes it ideal for the main frame structure. Stainless steel also provides low deformation with added corrosion resistance, while aluminium alloy shows moderate deformation but offers the advantage of reduced weight, making it suitable for non-load-bearing components like solar panel mounts. Overall, materials with higher stiffness .

Equivalent Stress

Equivalent (Von Mises) stress indicates how the load is distributed throughout the solar-powered smart wheelchair under a 81.5 kg user. The maximum stress occurs at critical regions such as joints, connections, and support members, while minimum stress is observed at the base frame. Materials like mild steel and stainless steel show moderate stress values within safe limits, ensuring good strength and durability. Polymer materials exhibit very low stress as they are non-load-bearing. Overall, the stress distribution confirms the structure is safe and reliable.

Stress :

The equivalent (Von Mises) stress represents the distribution of stress within the solar-powered smart wheelchair under applied load conditions. It helps in identifying critical regions where failure

may occur. From the analysis, maximum stress is observed at joints, connections, and support members, while minimum stress occurs at the base frame. The stress values are within the allowable limits of the selected materials, indicating that the structure can safely withstand the applied load. Hence, the wheelchair design is structurally sound, stable, and reliable for practical use.

Safety Factor :

The factor of safety is used to evaluate the strength and reliability of the solar-powered smart wheelchair under applied load conditions. It is defined as the ratio of yield strength to the maximum induced stress. In this analysis, the FOS is calculated as approximately 3.87, which is greater than the standard safe limit. This indicates that the wheelchair structure can safely withstand the applied load of a 81.5 kg user, ensuring stability, durability, and safe operation without risk of structural failure

CONCLUSION

The modelling and analysis of the solar-powered smart wheelchair with Bluetooth control have clearly shown the advantages and effectiveness of using solar power and modern assistive technology. The project has successfully implemented the utilization of solar power as a source of energy for the wheelchair, thereby reducing dependence on conventional electricity. The rechargeable battery provides a constant source of power even in low levels of sunlight.

The microcontroller control ensures precise and accurate operation of the wheelchair, and Bluetooth control makes it easy to operate using a smartphone. This greatly helps to reduce the physical strain on the user. The results obtained from the analysis show satisfactory results regarding battery efficiency, charging, and operation.

In addition, this project is simple, cost-effective, and can be used for real-time applications. The project can be further improved to include more sophisticated features such as obstacle detection and GPS. Overall, this project is a wonderful and innovative way to help physically challenged individuals.

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