iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71587

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Arduino Based Solar Powered Mini Forklift

Shaurya Veer Sharma[1], Nikhil Gupta[2], Anuj Ram Tripathi[3], Pawan Yadav[4], Rahul Srivastav[5]
[1, 2, 3, 4]Students, [5]Assistant Professor, Bachelor of Technology (Mechanical Engineering), Buddha Institute of Technology, Gorakhpur, U.P., India

Abstract: Forklifts are used in a wide variety of applications, such as manufacturing, construction, retail, meat and poultry processing, lumber and building supplies, trades, agriculture, and a variety of warehouse operations. This project presents the design and development of solar powered mini forklift utilizing Arduino as control system. The primary objective is to create an eco-friendly, cost effective, and efficient material handling solution for small-scale industries. In this system, five DC motors, Arduino UNO, Bluetooth module are used. Four DC motors are used for moving and one DC motor is used for lifting. Arduino UNO is mainly used to control the overall system. Arduino UNO will determine whether the motors have to rotate forward or backward. Motor directions are implemented by Arduino programming management. Bluetooth module facilitates communication between mini forklift and a smartphone app which allows the users to execute commands such as forward/reverse, left/right and lift movements. The mini forklift is equipped with solar panels to harness renewable energy, reducing dependence on fossil fuels and minimizing carbon emissions to keep the environment pollution free. Therefore, the system will be a foundation in implementing of the industrial forklift.
Keywords: Arduino UNO, Bluetooth module, Solar-powered, Mini forklift, Material handling, Renewable energy, Eco-friendly.

I. INTRODUCTION

Material handling is a critical aspect of industrial operations, directly impacting productivity, safety, and operational costs. Efficient material handling can maintain smooth workflow, reduce delays, and ensures that products reach their intended destinations safely and on time. With increased emphasis on sustainable practices, industries are seeking automated and semi-automated technologies to improve efficiency and reduce environmental impact. Devices such as the Arduino UNO microcontroller and energy-efficient solutions can easily be integrated into material handling equipment, including forklifts, to enhance their functionality and operational performance. Additionally, the adoption of solar panels as a renewable energy source will become more common, allowing forklifts and other equipment to operate using clean energy, further reducing reliance on conventional power sources and supporting sustainable industrial operations. By combining automation with solar power, modern material handling systems achieve greater energy efficiency, lower emissions, and improved productivity.

II. PROJECT OUTLINE

Our project “Arduino-based solar powered mini forklift” is an innovative material handling device designed to combine automation, energy efficiency, and sustainability. This system utilizes an Arduino Uno microcontroller to control the forklift’s movement and lifting mechanisms, while solar panels provide a renewable energy source for operation. The mini forklift is equipped with DC motors for driving and lifting, all managed by the Arduino Uno, which processes inputs from various sensors and user commands. The solar panel charges the onboard battery, ensuring that the forklift can operate independently of the electrical grid and reducing its carbon footprint.

Fig.1. Actual image of project (Arduino-based Solar powered Mini Forklift)

III. PROBLEM STATEMENT

Traditional forklifts used in warehouses and small industries are often powered by fossil fuels or rely on expensive, non-renewable electricity sources, leading to increased operational costs and environmental concerns. Additionally, many conventional forklifts lack automation and remote-control features, limiting their adaptability and efficiency in modern, technology-driven environments. This project aims to design and develop a compact forklift system that utilizes solar energy as its primary power source, thereby reducing dependency on non-renewable energy and minimizing carbon emissions. By integrating an Arduino microcontroller, the system aims to enable precise control, remote operation, and enhanced safety features. The project seeks to deliver a cost-effective, eco-friendly, and user-friendly solution for material handling tasks in small-scale warehouses, educational settings, and similar applications.

IV. METHODOLOGY

The approach adopted for the Arduino-based solar-powered mini forklift project involves a step-by-step process covering the planning, construction, assembly, and evaluation of a functional prototype. The central objective is to engineer a compact forklift that utilizes solar energy as its main power source, operates under the supervision of an Arduino microcontroller, and is designed to handle the lifting and movement of light materials in a safe and effective manner.

The several steps involved are given below as following:

- Project Planning and Requirement Analysis
- Component Selection and Procurement
- Design & Mechanical Fabrication
- Arduino Programming and Control Logic
- Electrical System Integration
- System Assembly and Integration
- Testing and Evaluation
- Documentation and Reporting

V. CONCEPTUAL DESIGN ANALYSIS

A. *Conceptual Design*

The design of chassis and other parts of Arduino-based solar-powered mini forklift was carried out using SolidWorks which is a very user-friendly software that ensures accuracy, efficiency, and reliability. The software's robust features support the creation of a well-engineered, practical, and innovative solution for modern material handling needs.

All the dimensions specified for the chassis have been measured and represented in milli-meters to ensure precision and consistency throughout the design process. The chassis design consists of several different parts and structures which are mention below with their appropriate dimensions as following:

1) *Main Frame*: Main frame is the backbone and provides structural support for the whole Mini forklift. Isometric view of main frame with dimensions is shown below:

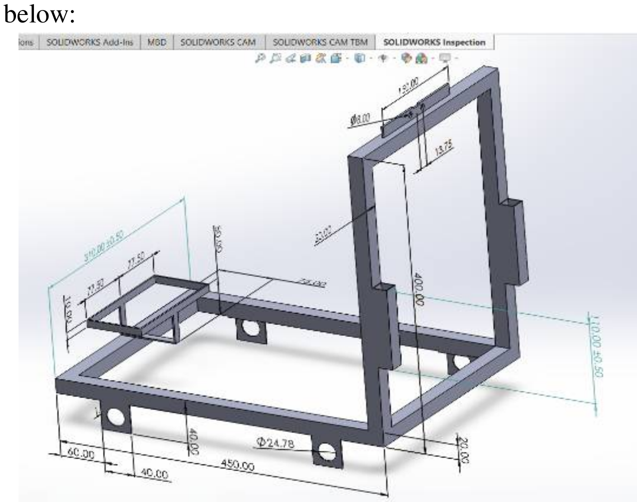

Fig.2. Isometric view of main frame with dimensions

2) *Lift & Fork structure:* Attached to the main frame is the fork and lift assembly, which is responsible for picking up and moving loads vertically. The isometric view of this component is shown below:

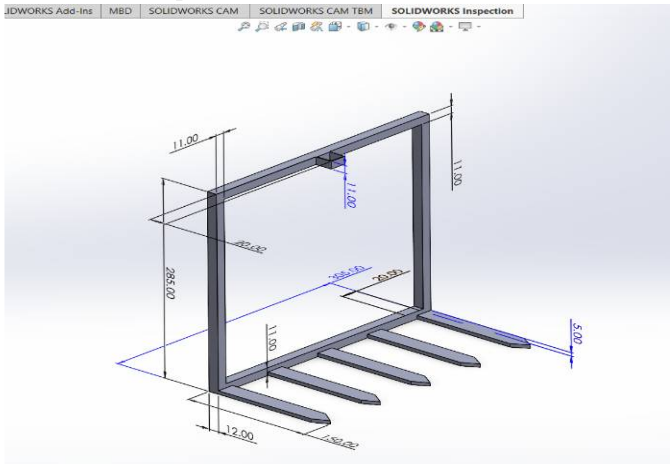

Fig.3. Isometric view of lift and fork structure with dimensions

3) *Pulley Wheel & Control Box:* The lifting mechanism often relies on a pulley system to raise and lower the forks smoothly and a control box is mounted on the chassis to house the Arduino board, power supply, and electronic controls that manage the forklift's operations. The isometric view of pulley wheel and control box is shown below:

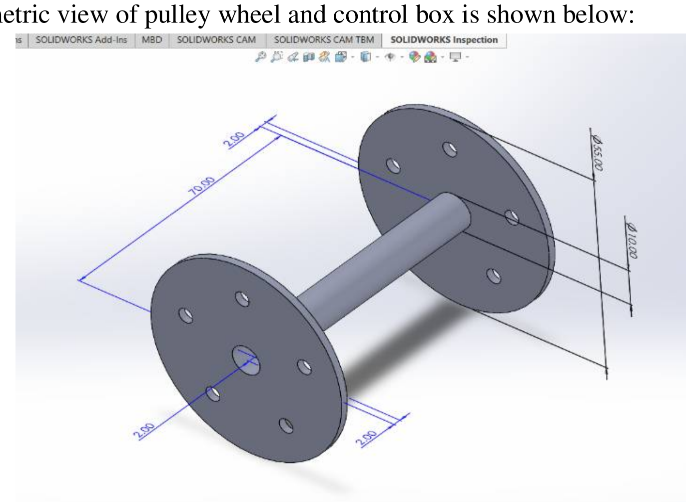

Fig.4. Isometric view of pulley wheel with dimensions

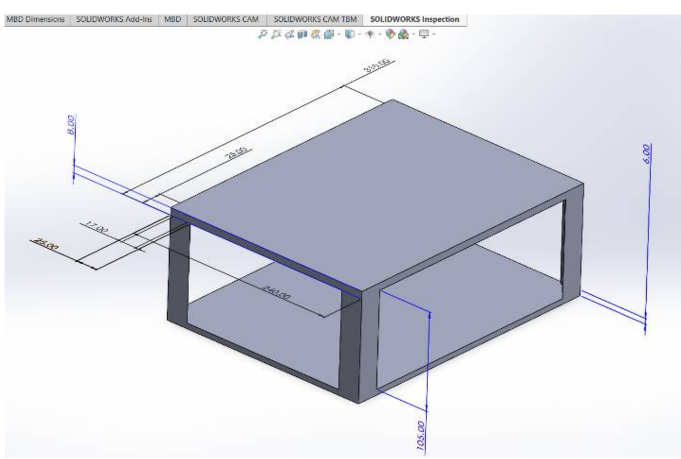

Fig.5. Isometric view of control box with dimensions

B. Selection of Material for Chassis

The material used to construct the chassis is EN 1.0301, also known as C10, is a mild, low-carbon steel widely used for components that require good machinability and weldability because of which EN 1.0301 is a versatile material for general engineering applications where moderate strength and good workability are required.

C. Selection of Four-Wheel Drive Motor

For the Arduino-based solar powered mini forklift, four 12V 100 RPM geared DC motors were chosen to drive the wheels and provide reliable movement. These motors are widely used in robotics and material handling projects due to their balanced combination of speed and torque.

D. Selection of Lift Motor

For the lifting mechanism of the Arduino-based solar powered mini forklift, a 12V 55 RPM wiper motor was selected due to its high torque output, robust construction, and reliable performance in demanding applications. Wiper motors are specifically designed for automotive use, where they must operate under continuous and intermittent loads, making them well-suited for material handling tasks that require both strength and durability.

VI. EXPERIMENTAL ANALYSIS & CALCULATIONS

A. Load bearing Capacity

To ensure the mini forklift can safely carry and transport the load without risk of tipping or structural failure, the combined weight of the chassis and the battery should be equal to or greater than the applied load. Together, these weights act as effective counterbalances against the load being lifted. Additionally, for the forklift to operate safely, the maximum bending stress experienced by its structure must remain below the yield strength of mild steel. This ensures that the material will not undergo permanent deformation during operations.

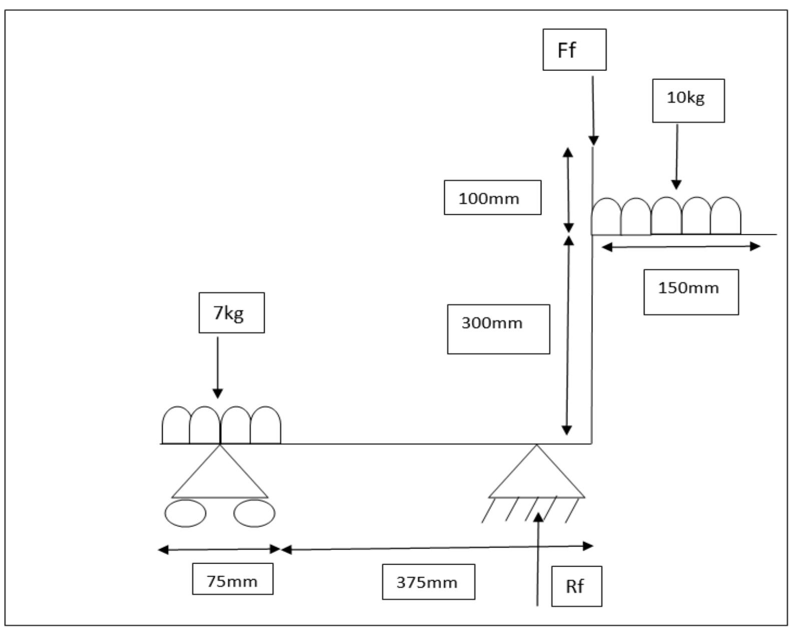

Fig.6. Mini forklift as beam under loading condition

Calculations:

Step 1: Understanding the Diagram and Data

- Load (W_1): 10 kg at the right end (force = 10 × 9.81 = 98.1 N)
- Counterweight (W_2): 7 kg at the left (force = 7 × 9.81 = 68.67 N)
- Frame weight (W_3): 3.5 kg (force = 3.5 × 9.81 = 34.34 N)

Step 2: Determining the Distances

- From left end to battery: 0 mm (battery at left end)
- From left end to pivot: 75 mm + 375 mm = 450 mm
- From pivot to load: 100 mm + 150 mm = 250 mm
- Total length: 75 + 375 + 100 + 150 = 700 mm
- All distances converted to meters for calculations.

Step 3: Free Body Diagram and Forces

- Let's define:

  A: Left end (where battery is)

  B: Pivot (375 mm from A)

  C: Front wheel (100 mm from B)

  D: Load (150 mm from C)
- Distances from Pivot (B):

  Battery (W_2): 75 mm left of B = -0.075 m

  Frame (W_3): Assume at B (pivot) for simplicity (0 m)

  Load (W_1): 100 mm + 150 mm = 0.25 m right of B

Step 4: Reaction Forces (Static Equilibrium)

- Let:

  Rf: Reaction at front wheel (C)

  Rr: Reaction at rear wheels (A)
- Sum of Vertical Forces:

  $Rf + Rr = W1 + W2 + W3 = 98.1 + 68.67 + 34.34 = 201.11N$
- Sum of Moments about Pivot (B):

  Take clockwise moments as positive:

  $\sum MB=0$

  $(W1\times0.25) - (W2\times0.075) - (Rf\times0.1) = 0$

  $(98.1\times0.25) - (68.67\times0.075) - (Rf\times0.1) = 0$

  $24.525 - 5.15 - 0.1Rf = 0$

  $19.375 = 0.1Rf$

  $Rf = 19.375/0.1 = 193.75$ N

  Now, substitute Rf into the sum of forces:

  $Rr = 201.11 - 193.75 = 7.36$ N

Step 5: Stress Calculations

- Assume a rectangular cross-section:

  Width (b) = 50 mm = 0.05 m

  Height (h) = 100 mm = 0.1 m
- Bending Stress (σ)

  $I = bh^3/12 = (0.05 \times 0.13)/12 = 4.167 \times 10^{-6}\ m^4$

  $c = h/2 = 0.05$ m

  $\sigma = (M max \cdot c) / I = (19.375 \times 0.05) / (4.167 \times 10^{-6}) = 0.232MPa$
- Shear Stress (τ)

  Area $A = b \times h = 0.05 \times 0.1 = 0.005\ m^2$

  $\tau = Vmax / A = 193.75 / 0.005 = 38{,}750$ Pa = 0.0388 MPa

Step 6: Factor of Safety

- Yield strength of mild steel:

  $\sigma_y = 250$ MPa

- Bending:
  Factor of Safety (bending) = 2500.232 ≈ 1077
- Shear:
  Factor of Safety (shear) = 2500.0388 ≈ 6443

Conclusion:

Both bending and shear stresses are much lower than the yield strength of mild steel. The mini forklift will NOT fail under a 10 kg load. The stresses are far below the yield strength of mild steel, and the factors of safety are extremely high. Your design is safe for the specified load.

B. Power Consumption of Wiper Motor & Geared Motors

The Wiper motor used is a 12V wiper motor rated at 55 RPM and 18 Nm torque and the four 12V Geared Motors used are rated at 100 RPM and 0.49 Nm torque.

To calculate mechanical power of Wiper motor:

Angular speed (omega) = (2 × pi × RPM) / 60 = (2 × pi × 55) / 60 ~ 5.76 rad/s

Mechanical power = Torque × Angular Speed = 18 Nm × 5.76 rad/s ~ 103.68 Watts

Assuming Wiper motor efficiency is around 70%, the electrical power required is:

Electrical power = 103.68 / 0.7 ~ 148 Watts

To calculate mechanical power of Geared Motors:

Angular speed (omega) = (2 × pi × RPM) / 60 = (2 × pi × 100) / 60 ~ 10.47 rad/s

Mechanical power per motor = Torque × Angular Speed = 0.49 Nm × 10.47rad/s ≈ 5.13W

Total Mechanical power = 4 × 5.13 ≈ 20.5W

Assuming per Geared motor efficiency is around 70%, the electrical power required is:

Electrical power per motor = 5.13 / 0.7 ≈ 7.33W

Total Electrical power = 4 × 7.33 ≈ 29.3W

C. Battery Backup Time

Lifting Motor Only:

Runtime = 96 W-h / 148 W ≈ 0.65 hours ≈ 39 minutes

Four Geared Motors Only:

Runtime = 96 W-h / 29.3 W ≈ 3.28 hours ≈ 197 minutes

All Motors Simultaneously:

Total Power=148 W+29.3 W=177.3 W

Runtime=96 Wh177.3 W≈0.54 hours≈32 minutes

Note: Actual run-time will be slightly lower when other components like the Arduino, Bluetooth Module, etc are also running.

D. Solar Panel Charging Time

A 12V solar panel is used. Assuming the panel is rated at 20W:

Charging Current = Power / Voltage = 20W / 12V ~ 1.67A

Charging Time = Battery Capacity / Charging Current = 8Ah / 1.67A ~ 4.8 hours (in full sunlight).

E. Overall Efficiency Considerations

- Motor driver efficiency: ~90%
- • Battery charging/discharging efficiency: ~85%
- • Solar panel efficiency: ~20% under optimal conditions
- • These values were considered to estimate real-world performance and energy losses during operation.

VII. FUTURE WORK & SCOPE

A. Future Work

Potential improvements for the mini forklift include:

- Optimizing the structural design and motor selection to handle heavier loads.
- Implementing wireless or autonomous navigation using sensors and IoT connectivity for improved mobility and safety.
- Integrating a more efficient solar charging system and battery management system to extend operating time.
- Developing a user-friendly smartphone app or remote for easier operation and monitoring.
- Adding emergency stop mechanisms, obstacle detection, and overload protection to enhance operational safety.

B. Future Scope

With ongoing advancements in renewable energy and automation, solar-powered mini forklifts have significant potential in various sectors:

- Adoption in eco-friendly warehouses and distribution centres aiming to reduce carbon emissions.
- Integration into smart factories where energy efficiency and automation are prioritized.
- In the future, these forklifts could be integrated into smart grid systems, allowing them to charge during periods of excess solar generation and contribute to grid stability
- The design can be tailored to meet the unique requirements of industries such as pharmaceuticals, food processing, or electronics, where clean and quiet operation is essential.

VIII. SUMMARY & CONCLUSION

A. Summary

The Arduino-based solar powered mini forklift project demonstrates the integration of renewable energy and embedded control systems in material handling equipment. Utilizing solar panels, the system charges an onboard battery, which powers the forklift's motors and lifting mechanism. An Arduino microcontroller serves as the central control unit, managing movement, lifting, and safety features. The project successfully showcases the forklift's ability to transport small loads efficiently while minimizing environmental impact through the use of clean energy. Performance tests indicate that the forklift can operate reliably for light-duty applications, making it suitable for small warehouses, workshops, or educational purposes.

B. Conclusion

1) The project successfully demonstrates the integration of solar energy and microcontroller-based control in a functional mini forklift.
2) Utilizing solar power reduces dependence on conventional electricity and promotes environmentally friendly operation.
3) The Arduino platform provides reliable and flexible control over the forklift's movement and lifting mechanisms.
4) The mini forklift is capable of safely handling small loads, making it suitable for light-duty applications and educational purposes.
5) The design offers a foundation for further enhancements, such as increased load capacity and advanced automation features.
6) This project highlights the potential of combining renewable energy with embedded systems to create sustainable solutions for material handling.
7) The experience gained from this project can be applied to larger-scale implementations and inspire further innovation in green logistics and automation.

REFERENCES

[1] FAN Jie, et al. (2015). "Design and Manufacture of an Electric Forklift."
[2] Kumar, et al. (2016). "Design and Fabrication of Mini Forklift."
[3] Jagtap, et al. (2017). "Portable Remote-Controlled Forklift for Small Industries."
[4] Salunke, et al. (2017). "Hydraulic Forklift Circuit Simulation."
[5] Shen, et al. (2017). "Optimal Steering System Design for Forklifts."
[6] Farah Abida Azman (2018). "Vision-Based Alignment and Control of Mini Forklift."
[7] Aditya Chawke, Lakhan Raut (2021). "Battery-Powered Remote Control Forklift Robot."
[8] Dr. K. Hema Latha, Mohd Ahmed Khan (2021). "Remotely Operated Mini Forklift for Lightweight Storage."
[9] Venugopal Kulkarni, Vishwas Gudlanur, Pradeep Patil, Adarsh Madiwalar, Anita Patil (2024). "Remote Controlled Mini Forklift Robot using Arduino Nano."
[10] ScienceDirect (Anonymous Authors) (2024). "Semi-Automated Smartphone Controlled Eco-Friendly Forklift."

[11] Manpreet Singh, Ankit Singh (2023). "Microcontroller-Based Mini Forklift for Industrial Applications."
[12] Jose Lima (2023). "FLOOR: Forklift Laser Omnidirectional Robot."
[13] Frontiers in Built Environment (Anonymous Authors) (2025). "Low-Cost Eco Friendly Forklift using ESP-32 and Conveyor System."
[14] Mohamad Mauz, Mohamad Hafiz, “Omni-Directional configuration and control approach on mini heavy loaded forklift autonomous guided vehicle” AiGEV in 2016.
[15] P. J. P. Amado, R. M. M. da Silva, and C. A. da Silva, "Energy consumption analysis of solar-powered forklift truck," Renewable Energy, vol. 124, pp. 585-595, 2018.
[16] P. J. P. Amado, R. M. M. da Silva, and C. A. da Silva, "Energy consumption analysis of solar-powered forklift truck," Renewable Energy, vol. 124, pp. 585-595, 2018.
[17] Smith., J., & Johnson, Journal of Industrial Sustainability, 2020.