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# Solar-Powered Grain Cleaning: Design And Analysis Of A Sustainable Riddle Machine

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***Abstract:*** The growing need for environment-friendly agriculture has brought into prominence the demand for energy-efficient and green machinery, especially in the countryside where electricity supply is scarce. The aim of this project is to design and develop a solar-driven riddle machine for enhancing the efficiency of post-harvest grain cleaning processes. The mechanism combines a 10W solar panel, a 12V DC wiper motor, and a lead-acid battery to provide constant operation even during changing sunlight conditions. Mechanical motion is employed to power a riddling mechanism to sift grains from impurities with great accuracy. SolidWorks CAD software was used for detailed structural design, while selection of materials with care ensured portability and ruggedness. Early trials showed considerable enhancement in cleaning effectiveness over manual processes, with considerable energy savings. This machine not only supports the use of renewable energy but is also a cost-saving mechanism designed for small and marginal farmers. The model developed is a step towards sustainable agricultural mechanization and indicates the scope for further use in rural farming communities.

***Keywords:*** Agriculture Machinery, Grain Cleaning, Renewable Energy, Solar-Powered Equipment, Sustainable Farming.

## 1.INTRODUCTION

Agriculture continues to be a vital industry in India and other developing countries where most people rely on agriculture as their means of survival. With rising food requirements and labor shortages, particularly in post-harvest operations like grain cleaning, there is an urgent need for automation by means of sustainable and cost-effective technologies. Conventional grain cleaning techniques like manual sieving and winnowing are labor-intensive, time-consuming, and inefficient. To address these issues, scholars are concentrating more on solar-powered farm equipment that can operate efficiently in rural and remote areas.

The application of solar energy to farm equipment not only lowers the cost of operation but also encourages the use of clean energy and resolves the issue of energy access in isolated farming regions. Various creative models and prototypes have been devised and tested to serve these purposes. For example, Mishra et al. [1] and Kumar & Singh [23] effectively designed solar-powered pneumatic seed cleaning systems that improved separation efficiency with air pressure mechanisms. Bhujbal et al. [2] proposed a solar-powered riddle machine that proved efficient to separate grains from impurities using a vibrating sieve.

Aradwad et al. [5] and Bhagat & Khandekar [13] developed solar-powered screen cleaners for small-scale farmers, and Muruganantham et al. [4] developed a gravity-driven grain separator to enhance dust removal in post-harvesting. Low-cost solar grain separator designs by Anonymous [3], [8] were focused on simple usage and low maintenance for rural use.

Energy-efficient drying is also a post-harvest issue covered by Vaishnavi et al. [6] and Gupta & Verma [22], who came up with automatic solar-powered dryers for grains that enhanced quality retention. On the same note, Mali & Patil [12] designed a solar seed cleaner ideal for rural regions, while Raskar & Bhosale [14] came up with a riddle machine intended for solar-powered filtration of grains meant for rural requirements.

Bazaluk [7] and Sánchez & González [18] were concerned with making grain cleaning technologies more energy-efficient using better design and optimization. Nerkar et al. [10] also presented a solar-powered cotton ginning machine, emphasizing the use of solar power in various agricultural processes.
Innovative solar-powered designs are still being developed. Sawant & Kale [11] and Zala & Patel [27] designed solar-powered grain separators with built-in mechanical sieving mechanisms that enhanced throughput among marginal farming communities. Dhokne & Nandurkar [15] and Yadav & Kumar [27] designed solar-powered winnowing machines and cleaning systems that enhanced the quality of grains and minimized human effort.
Kadam & More [16] delved into the overall design of solar farm equipment for small-scale application, while Chauhan & Sharma [26] presented multipurpose farm equipment driven by solar power. Pawar & Shinde [17] carried out an extensive review of solar-based farm inventions, describing the key advantages and technology gaps. Naik & Patil [32] complemented this by presenting progress in post-harvest smallholder farm machinery.
Ali et al. [9] and Sharma & Kaur [31] analyzed design tests and performance checks of solar-powered seed cleaning machines to maintain consistent use and purity of the grain. Singh & Chauhan [29] and Khan & Patel [30] analyzed renewable energy uses in agro-machinery, highlighting the environmental and economic benefits. Solis & Hines [20] talked about world opportunities and challenges for solar-powered farming equipment, whereas Mehta & Joshi [24] highlighted the role of solar energy in mechanizing Indian agriculture. Patel & Sharma [21] exhibited the flexibility of a multipurpose solar agriculture machine, and Kulkarni & Pawar [32] attempted reducing the cost of fabrication for grain cleaners to accommodate marginal farmers. Aluminum-silicon-magnesium alloy properties make it particularly suitable for lightweight, high-stress riddle machine and agricultural applications [24].The base of riddle machine serves as the basic foundation on which all the parts of a machine rest should be structurally sound in every way and support the body over the expected life of the riddle machine [34].
With this vast body of literature, it is apparent that solar riddle machines are a viable answer to grain cleaning in off-grid agricultural environments. Through consolidating current designs and innovations, this project under the title "Solar Powered Riddle Machine for Agriculture Use" seeks to provide a low-cost, energy-saving, and simple-to-operate machine specific to small-scale and rural farmers. The mechanism utilizes a solar-powered DC motor to produce oscillating movement in the sieve (riddle), efficiently sifting grains from chaff and impurities with little or no human intervention. This project not only supports sustainable development objectives but also holds promise of enhanced productivity, quality of grain, and rural farming community incomes.

## 2.EXPERIMENTAL SETUP

Experimental design for the Solar Powered Riddle Machine has been carefully done with a focus on simplicity, effectiveness, and cost. The machine uses solar power to drive a mechanical riddle sieving mechanism in separating unwanted particles and contaminants from harvested cereals. This section is divided into three sub-sections: Components and Methodology.

### 2.1 Methodology

The evolution of the riddle machine powered by the sun proceeded in an organized manner to solve the issue of ineffective cleaning of grain in rural localities. The issue of manual cleaning of grain and lack of power was first determined. A mechanism of riddling involving a motorized arm for moving the mesh plate was developed. The frame was made of metal and parts were fitted with accuracy. The main goals were established to ensure portability and effectiveness. Parts such as a DC wiper motor, solar panel, and mesh tray were chosen. A battery system was incorporated for energy storage as well as voltage regulation. Wiring was performed to connect the solar panel, motor, and battery. The solar panel was placed in a way that provides efficient sunlight collection. CAD software was utilized to create the machine as well as decide on the layout before final construction. The entire methodology flow is depicted in Figure 1.

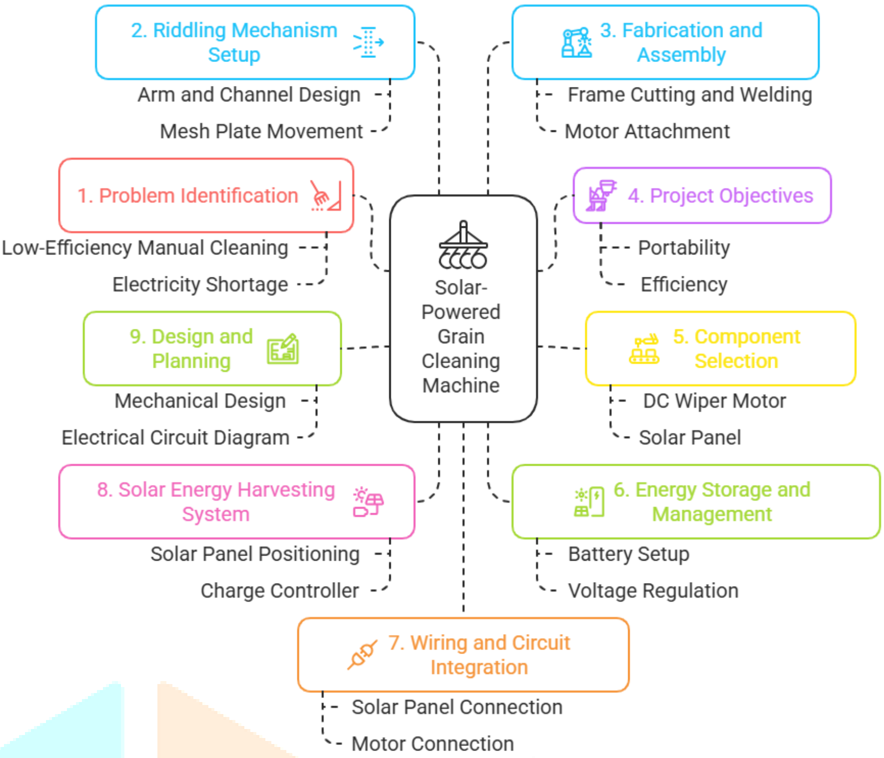



*Figure 1. Flowchart Showing Methodology adopted for development Solar-Powered Riddle Machine for Agriculture*

## 2.2 Components

The selection of components is critical to the success of the solar-powered riddle machine. Each part must work together efficiently and be suited for the task. Below are the key components selected for this project.

### 1. DC Wiper Motor (12V, 45RPM)

The DC wiper motor was chosen for its low power consumption and efficiency. With a speed of 45 RPM, this motor is ideal for driving the rotating mechanism of the machine. Its affordability and availability made it a perfect choice for this application, as it can provide the necessary rotational motion for the arm system.

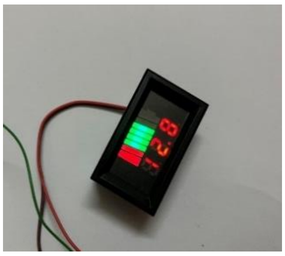
DC Wiper Motor (45 RPM)

- Operating Voltage: 12V
- Torque: 15-20 Nm
- Speed: 45 RPM
- Power Consumption: Approx. 30W

*Figure 2. DC Wiper Motor*

### 2. Voltmeter

The voltmeter is used to monitor the voltage level of the battery and the solar panel. It helps in checking whether the system is receiving enough solar energy and if the battery is charged properly. By showing the real-time voltage, the voltmeter allows users to quickly identify if the system is working well or if there's a problem. It plays an important role in maintaining the health of the battery and the overall performance of the machine.



Battery Power Indicator (Volt Meter)

- Operating Voltage: 5V-30V
- Accuracy: ±0.1V
- Function: Displays real-time battery voltage

*Figure 3. Voltmeter*

**3. Battery (12V)**

A 12V rechargeable battery was selected to store the solar energy. This battery ensures that the machine can continue operating even when there is no sunlight. It is sized to store enough energy to power the machine for several hours.


*Figure 4. Battery*

Battery (12V, 7Ah Lead Acid)

- Voltage Output: 12V
- Capacity: 7Ah
- Working Hours: Approx. 4-6 hours depending on load
- Charging Time: 6-8 hours

**4. Solar Panel (12V)**

The solar panel chosen for this project is a 12V model that can generate enough power to operate the DC motor and charge the battery. The panel is designed to work efficiently in various sunlight conditions, ensuring that the riddle machine operates even during cloudy days.

*Figure 5. Solar Panel*

Solar Panel (10W)

- Voltage Output: 12V
- Current Output: 0.83A
- Charging Time: 6-8 hours under full sunlight

**5. Mesh Plate (Stainless Steel)**

The mesh plate is made of stainless steel, which is durable and resistant to rust. The mesh's small holes allow smaller particles to pass through while larger grains remain on the surface. This component is vital for the filtration process. (3mm)

- Dimensions: 45×45 cm

*Figure 6. Mesh Plate*

**6. Sliding Channel**

The sliding channel is made from aluminum, which is lightweight and corrosion-resistant. The sliding mechanism ensures smooth motion of the secondary arm, facilitating the shaking and filtration of the grains.

- Dimensions: 18 inches

**7. Structural Frame (Mild Steel)**

The structural frame of the machine is made from mild steel and aluminum. The steel frame provides strength and stability, while the aluminum parts help reduce the overall weight of the machine. The combination of these materials ensures that the machine is both durable and lightweight, making it easy to transport and use in different agricultural settings.

Structural Frame

- Material: Mild Steel
- Dimensions: 3ft (L) × 1.5ft (B) × 2.5ft (H)
- Weight: Approx. 8-12 kg

### 2.3 CAD Design

The CAD modeling and drafting of the solar-powered riddle machine were done using SolidWorks software to visualize the overall structure before fabrication. A basic 3D assembly model was created to represent the approximate size, position, and motion of key parts like the frame, mesh, motor setup, and solar panel. This helped in understanding the overall layout and making initial design decisions. A sample 2D drawing was also prepared for reference, showing general dimensions and structure.

Figure 7(b) shows the isometric view of the final 3D CAD assembly of the machine.

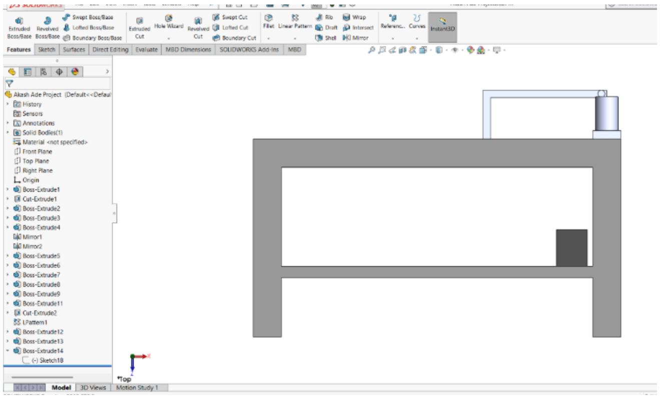


*Figure 7(a) Side view*

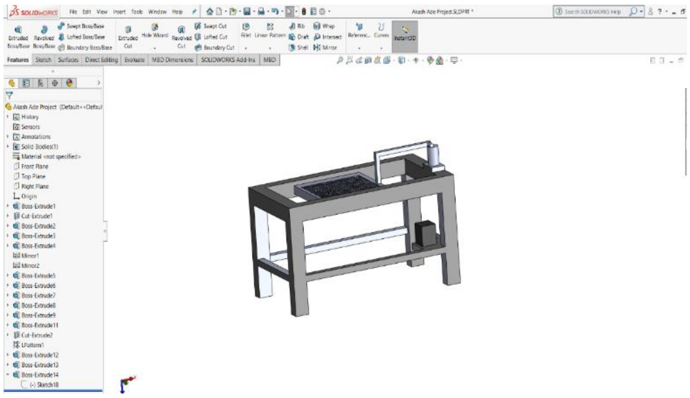


*Figure 7(b) isometric view*

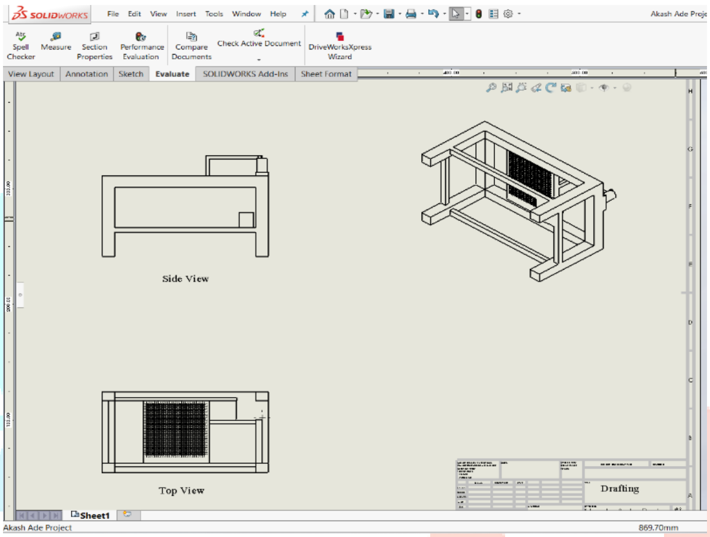



*Figure 8. Drafting*

## 2.4 Working

The solar-powered riddle machine operates using solar energy as the primary source of power. A solar panel is employed to power a 12V battery, which powers a DC motor. The motor powers a rotating arm specifically engineered to translate circular motion into reciprocating motion. This motion is transferred to a sliding tray that contains a wire mesh or a sieve. Farmers dump harvested grains blended with dust, small rocks, and other unwanted substances onto this tray. The tray oscillates back and forth, and the grains move through the mesh holes to fall into a collection tray below, while the larger waste particles are left on the mesh and can be scraped off effortlessly. This process effectively sieves clean grains from contaminants. The machine is light, portable, simple to use, and particularly convenient in rural communities where electricity might not be accessible. It is quietly operated and easy to maintain, a useful device for small farmers.

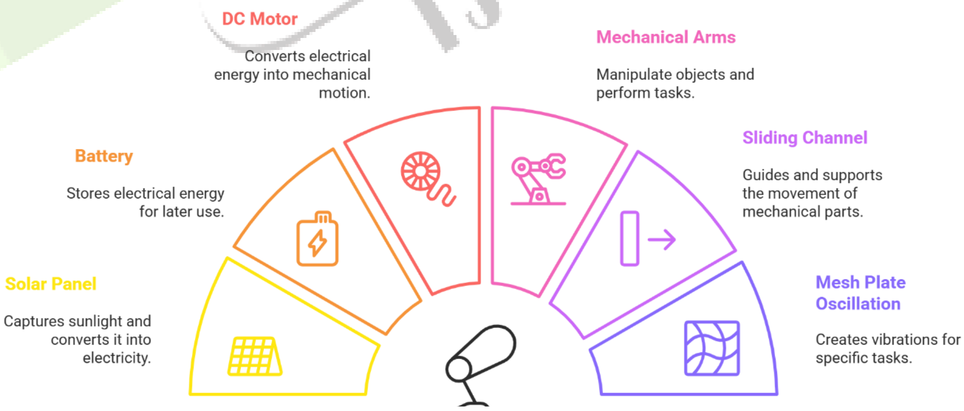



*Figure 9. working flowchart*

## 2.5 Final assembly

The final assembly of the solar-powered riddle machine involves combining all the individual components into one working system. First, the main frame of the machine was made using mild steel square pipes. These pipes were cut and welded together to form a strong rectangular base that can support all other parts of the machine.

After the frame was ready, the sliding mesh setup was fixed on top of the frame. This mesh is responsible for separating dust and small particles from the grains. A small arm was connected to the mesh, which helps it move back and forth. This arm is connected to another longer arm, which is fixed to the shaft of the DC motor. When the motor rotates, it creates a circular motion that gets converted into a side-to-side motion of the mesh through this arm mechanism.

Next, the DC motor was placed on the frame and properly tightened using clamps. The motor runs on power stored in a 12V battery. This battery is charged using a solar panel mounted on the top part of the machine. The solar panel is fixed with help of an adjustable metal frame to face sunlight properly.

The battery and wiring system were placed at the backside of the machine inside a small protective box. A switch was connected to easily turn the machine ON or OFF. All the wires were connected carefully using jumper wires and a breadboard, with proper insulation to avoid short circuits.

For safety and better operation, we also tested the machine at different speeds and adjusted the arm length to make sure the mesh moves properly and doesn't get stuck. After connecting everything, the machine was tested in real working conditions by pouring grains and checking how effectively it separates dust and stones. The results were good, and the machine worked smoothly with the help of solar power, without needing any external electricity.

The final machine is lightweight, portable, and easy to operate by farmers. It uses clean energy and helps in reducing manual labor required for grain cleaning.

*Figure 10. Working Model*

## 3. RESULT AND DISCUSSION

### 3.1 Result

The solar-powered riddle machine was tested under controlled conditions to evaluate its performance parameters. Table 1 summarizes the key technical specifications and operational data. The system includes a 12V, 7Ah lead-acid battery charged by a 10W monocrystalline solar panel. The battery requires 5–6 hours of optimal sunlight for a full charge. The machine's DC motor consumes 25W at 45 RPM, providing a grain sieving capacity of approximately 1 kg per minute, and an overall grain processing efficiency between 35-40 kg per hour.

*Table 1. Value and Details*

| **Parameter** | **Value and Details** |
|---|---|
| Battery Capacity | 12V, 7Ah (Lead Acid) |
| Solar Panel Output | 10W (Monocrystalline) |
| Time Required to Charge Battery | 5-6 hours under full sunlight (Optimal Conditions) |
| Power Consumption of DC Motor | 25W (2.1A at 12V) |
| Total Working Time on Full Charge | 1 to 1.5 hours (Without Solar Input) |
| Continuous Operation with Solar | 2.5 to 3 hours (Battery + Solar Panel Input) |
| Grain Sieving Capacity | 1 kg per minute |
| Grain Processing Efficiency | 35-40 kg per hour (Under Ideal Conditions) |
| Motor Speed | 45 RPM |
| Weight of Machine | 12 kg (Including Battery & Frame) |
| Durability | Estimated 5+ years with proper maintenance |

Operating time on a full charge range from 1 to 1.5 hours without solar input, which extends to 2.5 to 3 hours when solar power supplements battery usage. The entire machine weighs around 12 kg, making it portable for use in small farms and rural locations. Estimated durability with proper maintenance exceeds five years.

Table 2 presents detailed results on cleaning efficiency for various wheat varieties. Cleaning efficiencies ranged from 80% to 85% depending on the variety and the number of passes required. For example:

- **Sharbati** wheat achieved the highest cleaning efficiency at 85% with a single pass taking 2.5 minutes.
- **Lokwan (Lok-1)** and **Gold King** varieties showed 83% efficiency in one pass.
- Some varieties such as **Sona Moti** and **Ajit-11** required two passes, increasing total cleaning time but maintaining effective cleaning.

*Table 2. Time taken to clean different Variety*

| Sr. No. | Wheat Variety | Local Name | Grain Size (mm) | Cleaning Efficiency (%) | Passes Needed | Time per Pass (min) | Total Time (min) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Lok-1 | Lokwan | 5.2 – 5.8 | 83% | 1 | 2.5 | 2.5 | Most preferred in homes; soft and easy to clean |
| 2 | Shri Ram Super | Shri Ram Super | 5.4 – 5.9 | 82% | 1 | 2.5 | 2.5 | Slightly larger size, cleans well |
| 3 | Sona Moti | Sona Moti | 5.0 – 5.5 | 81% | 2 | 2.5 | 5.0 | Popular for taste; needs 2 passes |
| 4 | HD 2189 | 2189 | 5.1 – 5.6 | 80% | 2 | 3.0 | 6.0 | Common in rural areas, smaller grain traps more sand |
| 5 | HD 2496 | 2496 | 5.3 – 5.8 | 82% | 1 | 2.5 | 2.5 | High-yielding; widely used |
| 6 | Sharbati | Sharbati | 5.5 – 6.0 | 85% | 1 | 2.5 | 2.5 | Premium wheat; excellent cleaning |
| 7 | Ajit-11 | Ajit-11 | 5.0 – 5.4 | 80% | 2 | 2.5 | 5.0 | Used across Maharashtra; average sieving |
| 8 | Gold King | Gold King | 5.3 – 5.7 | 83% | 1 | 2.5 | 2.5 | Balanced size, fast cleaning |

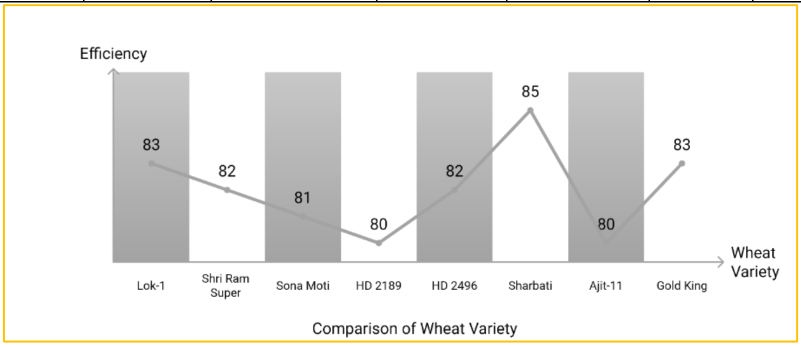



*Figure 11. Efficency of different Variety's of wheat*

### 3.2 Discussion

The results demonstrate that the solar-powered riddle machine significantly improves the grain cleaning process compared to traditional manual methods. Manual cleaning typically takes 4–5 hours for 50 kg of grain and requires considerable labor input. The developed machine reduces this time to 1–1.5 hours, with consistent and uniform cleaning results regardless of the operator's skill level.

Energy consumption and operating cost analysis further support the machine's effectiveness. While manual cleaning depends entirely on human labour with no direct monetary cost but high physical effort, the solar-powered machine uses clean, renewable solar energy, resulting in near-zero operating costs and minimal maintenance.

The portability and lightweight design of the machine (approximately 12 kg) make it highly suitable for small-scale farmers, especially in rural areas where access to electricity and skilled labour may be limited. The machine's performance across various wheat types indicates its versatility and practical utility.

However, some wheat varieties require two passes to achieve desired cleaning efficiency, indicating that mesh size or motor speed adjustments could further optimize performance. The durability of over five years ensures long-term usability, adding value for farmers investing in this technology.

Overall, the solar-powered riddle machine offers a sustainable, efficient, and labour-saving alternative for grain cleaning in agriculture, with strong potential for adoption in energy-scarce regions.

*Table 3. comparison Manual Method vs Solar-Powered Riddle Machine*

| Parameter | Manual Method | Solar-Powered Riddle Machine |
|---|---|---|
| Labor Requirement | High | Low |
| Time Consumption | Long (4–5 hrs/50 kg) | Short (1–1.5 hrs/50 kg) |
| Consistency | Varies with skill | Uniform and consistent |
| Energy Source | Human effort | Solar energy |
| Cost of Operation | No cost but high labor effort | Very low (free solar power) |
| Maintenance | Not applicable | Basic cleaning and inspection |

## 4. Conclusion And Future Scope

### 4.1 Conclusion

The solar-powered riddle machine developed in this project provides a simple, eco-friendly, and efficient solution for grain cleaning in agriculture. It significantly reduces the need for manual labor, which is often time-consuming and tiring, by using solar energy and basic automation through a DC motor and mechanical arms. The machine is compact, lightweight, and easy to use, making it ideal for rural areas with limited access to electricity and skilled labor.

Based on testing with various wheat varieties, it achieved a cleaning efficiency of up to 85% with minimal time and effort, especially for grains like Sharbati and Gold King. Varieties with smaller grain sizes needed more time and passes, but overall, the machine performed effectively across all types. Its low operating cost, clean energy use, and user-friendly design make it a promising tool for improving agricultural practices. With further development, it can benefit a larger number of farmers and support sustainable farming.

### 4.2 Future Scope

Although the current model of the solar-powered riddle machine is suitable for small-scale farming, it has good potential for future upgrades. With a few improvements, the machine can become more useful for larger farms and a wider range of agricultural applications. The following points explain how the machine can be scaled:

1. The size of the machine can be increased to handle a greater quantity of grains in one cycle, which will save time and improve efficiency during the harvest season.
2. A system can be added to allow changing the mesh based on the grain type, so the same machine can clean wheat, rice, or pulses by simply replacing the mesh.

3. To ensure smooth operation during cloudy weather or at night, a battery backup or an option to charge the battery using electricity can be included.
4. The frame of the machine can be redesigned in a way that makes it easier to fold or move, which will help farmers carry the machine to different locations without difficulty.

These changes will help the machine work better in various farming conditions and make it more practical for long-term use.

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