DESIGN AND FABRICATION OF PADDY FILLING MACHINE FOR BAGS FILLING

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ABSTRACT

In modern agriculture, efficient packaging systems are essential for reducing labor cost and increasing productivity. This paper presents the design and fabrication of an automated paddy bag filling machine developed to improve speed, accuracy, and hygiene in grain packaging operations. Conventional manual filling methods are slow, labor-intensive, and often result in weight variation, grain spillage, and contamination. To address these limitations; the proposed machine combines vacuum conveying, controlled grain discharge, sensor-based filling, and automatic sealing in a compact and user-friendly unit. A vacuum pump transfers paddy from storage to the hopper through a flexible suction line, minimizing manual handling and material loss. The hopper discharge is regulated through a control valve, while sensors and a programmable control unit ensure accurate bag filling through dual outlet nozzles. An automatic sealing mechanism completes the packaging cycle efficiently. The fabricated prototype was tested under practical conditions and showed reduced filling time, improved weight consistency, lower spillage, and decreased labor dependency compared with traditional methods. The machine offers an economical, scalable, and efficient solution for farms, rice mills, and small packaging industries, thereby supporting agricultural mechanization and modern post-harvest processing.

Keywords: *Paddy Filling Machine, Vacuum Conveying, Automated Bag Filling, Grain Packaging, Weight Accuracy, Spillage Reduction, Agricultural Mechanization, Post-Harvest Processing*

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1. Introduction

Agriculture plays an important role in economic development, and efficient post-harvest grain handling is essential to reduce losses and maintain product quality [17], [18]. Paddy requires proper collection, filling, and packaging for safe storage and transportation. However, many small and medium-scale agricultural units still depend on manual bag filling, which causes high labor demand, slow processing, inconsistent bag weights, grain spillage, and worker fatigue [6], [7]. These issues highlight the need for affordable mechanized systems to improve productivity and filling accuracy. Recent advancements in agricultural engineering have led to semi-automatic and automatic grain handling systems such as bag filling machines, collectors, and pneumatic conveying units [8], [9], [13]. Studies show that controlled grain flow, pneumatic transfer, and automation can improve speed, hygiene, and operational efficiency [10], [11].

Vacuum conveying systems are especially effective in reducing contamination and material losses [16].

Based on these needs, the present work focuses on the design and fabrication of an automatic vacuum-based paddy bag filling machine. The system combines vacuum conveying, hopper storage, controlled discharge, weighing, and sealing mechanisms in a single unit. It is designed to reduce labor effort, improve filling consistency, minimize grain loss, and increase packaging efficiency, offering a practical solution for farmers, rice mills, and small packaging industries [12], [14], [19], [20].

2. Earlier Investigations

Many researchers have worked on mechanized grain handling and bag filling systems to reduce labor and improve efficiency. Kumar et al. [6] developed a grain collector machine that improved collection performance. Kumar et al. [7] proposed a semi-automatic cereal bag filling machine that increased packaging speed and reduced operator effort. Thete et al. [8] introduced a vacuum-assisted grain collector, showing reduced contamination and grain loss. Saravanan et al.
[9] designed a portable grain collector suitable for rural use, while Aquino et al. [10] developed a mobile pneumatic paddy collector for field applications. Sathish et al. [11] designed a paddy seed bagging machine with better filling accuracy and reduced wastage. Jayavahini and Dharmasena
[12] proposed a paddy collecting and bagging system that lowered manual effort. Dhaxith et al.
[13] reviewed grain collector technologies and emphasized economical, efficient, and low-maintenance machines. Dale et al. [14] developed a grain packing machine that improved productivity. Gupta and Nott [15] studied granular flow in conveyor systems, providing useful guidance for hopper and discharge design. Studies on pneumatic conveying and post-harvest efficiency [16], [17], along with review papers on agricultural mechanization [18], [19], highlighted the growing need for low-cost automated grain packaging systems. From the literature, most systems focus separately on grain collection, conveying, or bag filling. Very few combine vacuum conveying, accurate filling, and sealing in a single unit. Hence, the present work aims to develop an automatic vacuum-based paddy filling machine with improved packaging efficiency and operational performance.

3. Methodology and experimentation

The methodology adopted in this project involved problem identification, conceptual design, engineering calculations, material selection, fabrication, assembly, and testing of a paddy filling machine for bagging applications. Manual grain filling methods were studied and found to cause low productivity, uneven bag weights, grain spillage, and high labor dependency [6], [7], [18]. Based on these issues, a compact and economical machine was designed to improve filling efficiency with minimum wastage [12], [14]. The machine consisted of a hopper, mild steel frame, flow control valve, motor drive, discharge nozzle, and bag holding arrangement. The hopper was designed for smooth gravity flow, while proper outlet dimensions prevented clogging and ensured uniform discharge [15]. A control valve regulated grain flow to maintain consistent bag weight. Fabrication was carried out using cutting, drilling, welding, grinding, and finishing processes. After assembly, performance testing was conducted using paddy grains under practical conditions. Parameters such as filling time, bag weight variation, spillage, and hourly output were evaluated. Results showed faster filling, improved weight accuracy, reduced wastage, and lower manual effort compared with conventional methods [10], [11]. Overall, the developed machine proved to be an economical and practical solution for post-harvest grain packaging, with scope for future automation through sensors, sealing units, and conveyors [16], [19], [20].

Specifications

S. No.	Parameter	Specification
1	Machine Type	Vacuum-based Paddy Filling Machine
2	Bag Filling Capacity	1 bag (50 kg) per minute
3	Mass Flow Rate	0.833 kg/s
4	Bulk Density of Paddy	560 kg/m^3
5	Volumetric Flow Rate	0.00149 m^3/s
6	Minimum Air Velocity	18 m/s
7	Theoretical Pipe Diameter	10 mm
8	Selected Suction Pipe Diameter	25 mm
9	Prime Mover	Electric Motor
10	Motor Power	0.25 HP
11	Hopper Capacity	100 kg (2 bags)
12	Hopper Volume	0.178 m^3
13	Total Design Load	150 kg
14	Factor of Safety	2 to 3
15	Motor Speed	1440 rpm
16	Required Torque	1.33 Nm
17	Frame Material	Mild Steel

18	Operating Features	Compact, durable, energy-efficient
19	Application	Paddy bag filling for farms, rice mills, small industries

4. Fabrication Process

- The fabrication of the paddy filling machine began by converting the finalized design into a working prototype with the objective of developing a strong, economical, and efficient bag filling system using vacuum-assisted grain handling.
- Material selection was the first stage of fabrication. Mild steel was chosen for the main frame because of its strength, durability, easy weldability, and local availability, while sheet metal was selected for the hopper and flexible PVC pipes or rubber hoses were chosen for the suction line.

  Cutting operations were then carried out according to the required dimensions. Mild steel angles, rods, and flats were cut for frame construction, and sheet metal plates were cut into suitable shapes for hopper fabrication. Pipes were also cut to the necessary lengths for suction and discharge connections.

- Machining processes such as drilling were performed on structural members to provide holes for bolting, mounting, and fastening of components during assembly.
- Hopper sheets were bent into trapezoidal or pyramidal shapes to ensure smooth downward movement of paddy grains under gravity and to avoid clogging during discharge. Proper dimensional accuracy was maintained throughout the shaping process.
- Welding operations were conducted using arc welding to assemble the frame and hopper structure. Strong and permanent joints were obtained while maintaining alignment, rigidity, and smooth internal hopper surfaces for efficient grain flow.
- After frame fabrication, the vacuum system was installed. A vacuum cleaner unit or suction motor was securely mounted on the frame, and the suction hose was connected to the inlet side. A separator or filter chamber was fitted between the suction line and hopper.
- The discharge mechanism was then attached below the hopper outlet. A sliding gate or control valve was provided to regulate paddy flow into bags, ensuring controlled filling, reduced wastage, and improved bag weight consistency.
- Electrical wiring was completed for the motor-operated system using a switchboard, insulated wires, and safety arrangements. Surface finishing was also carried out by removing sharp edges, cleaning weld zones, and applying anti-corrosion paint for better durability and appearance.

- Finally, the complete machine was assembled and tested under working conditions. Paddy grains were passed through the system, and suction efficiency, grain flow, discharge rate, and filling performance were checked. Necessary adjustments were made, and the fabricated machine proved to be a practical solution for reducing labor effort and improving paddy bagging productivity.

5. System Integration

The assembly procedure of the paddy filling machine involved the systematic installation and integration of all fabricated components to obtain a fully functional unit. Initially, the mild steel frame was placed on a level surface and checked for balance, alignment, and stability, while rubber pads were provided to reduce vibration. The vacuum unit or suction motor was then securely mounted on the frame using bolts and clamps, ensuring correct inlet and outlet alignment for efficient airflow. A flexible PVC or rubber suction pipe was connected to the vacuum inlet with proper sealing materials to prevent air leakage. The separator or filter chamber was fitted between the suction line and hopper to separate paddy grains from the air stream and protects the motor from dust. The hopper was mounted at a suitable height to allow gravity flow, and a sliding gate or control valve was fixed at its outlet to regulate grain discharge. A nozzle or chute with bag holding support was attached below the hopper outlet to ensure accurate filling with minimum spillage. After mechanical assembly, electrical wiring was completed through switches, fuse, and insulated connections for safe operation. All components were then inspected for alignment, tightness, and leakage, while moving parts were checked for smooth functioning. Finally, a trial run was conducted using paddy grains to evaluate suction efficiency, grain flow, filling speed, and bag weight accuracy. Necessary adjustments were made wherever required. Overall, proper assembly ensured efficient performance, reduced grain loss, and reliable operation of the machine for agricultural bag filling applications.

6. Testing and validation

Testing and validation were conducted to evaluate the performance, reliability, and practical suitability of the fabricated paddy filling machine under working conditions. The objective was to confirm whether the machine achieved accurate filling, reduced labor effort, lower grain loss, and improved productivity [6], [7], [18]. Initially, the structural frame and mechanical assembly were inspected for rigidity, stability, and load-carrying capacity. Welded joints, fasteners, and supports were checked to ensure safe operation without excessive vibration or deformation [1], [3], [5].The vacuum conveying system was then tested for suction efficiency. The suction motor successfully lifted and transferred paddy grains through the flexible pipe. Air leakage and pressure losses were checked, as proper sealing is essential for efficient conveying performance [8], [16]. The separator or filter chamber effectively separated grains from the air stream before entering the hopper, preventing grain escape and protecting the vacuum unit from dust accumulation [10], [16]. The hopper and flow control valve were tested for smooth discharge into bags. Continuous grain flow was achieved without blockage or overflow, confirming the importance of proper outlet design and controlled discharge [11], [15]. Bag filling accuracy was verified by filling multiple bags and measuring their weights. Minimal variation between bags indicated good filling consistency, which is essential for commercial packaging standards [7], [12].Productivity was evaluated by measuring filling time and hourly output. The machine filled bags faster than conventional manual methods while reducing operator fatigue [9], [14], [19]. Grain spillage was significantly reduced due to controlled suction transfer, correct nozzle positioning, and stable bag holding. This improved material utilization and maintained cleaner working conditions [17]. Energy consumption of the vacuum motor remained within acceptable limits, making the system economically suitable for small and medium-scale users [4], [18]. Safety and ease of operation were also confirmed through proper guarding, insulated wiring, and simple controls [13], [20].

Overall, the machine successfully achieved improved filling speed, better bag weight consistency, reduced labor dependency, and lower grain losses. The testing results confirmed that the developed paddy filling machine is an efficient, reliable, and economical solution for post-harvest grain packaging operations [6], [17], [19].

7. Results and Discussion

The results obtained from the design and fabrication of the paddy filling machine confirmed that the developed system effectively improved the efficiency of grain bagging operations. The fabricated prototype successfully performed vacuum-based grain collection, separation, and controlled filling of paddy into bags. Machine performance was evaluated on the basis of filling speed, bag weight accuracy, grain loss, energy usage, and ease of operation [6], [7], [18]. During testing, the vacuum conveying system demonstrated satisfactory suction performance. Paddy grains were lifted and transferred through the suction pipe without major obstruction under normal operating conditions. The airflow generated by the vacuum motor was sufficient to maintain continuous grain movement, while the separator chamber effectively separated paddy grains from the air stream before entering the hopper. This ensured smooth conveying operation and prevented grain damage during transfer [8], [10], [16].

A noticeable improvement was observed in bag filling speed when compared with conventional manual methods. The machine was capable of filling a standard 50 kg bag in a shorter time, thereby increasing hourly output capacity. This improvement in productivity makes the developed system suitable for small and medium-scale farms, rice mills, and storage units where rapid packaging is required during peak seasons [9], [14], [19]. In terms of filling accuracy, the machine produced good consistency in bag weight when the hopper outlet gate was properly adjusted. The variation in bag weight between repeated trials was minimal, indicating reliable control over grain discharge. This is a major advantage over manual filling methods, where significant weight variation often occurs due to operator error. Accurate filling is important for commercial transactions, storage management, and standard packaging practices [11], [12]. Grain spillage was considerably reduced because of controlled suction transfer, proper hopper discharge, and correct alignment of the bag holding arrangement. Only minor losses were observed during the initial setup and adjustment stage. After optimization, the system maintained a cleaner working area and minimized wastage, contributing to better material utilization and improved hygiene [17].

The results also showed that the vacuum-based mechanism played an important role in simplifying machine construction. Unlike complex conveyor systems, the vacuum unit provided a compact and economical means of transferring grains. This reduced the number of moving components, lowered maintenance requirements, and improved portability of the machine. Such characteristics are valuable for rural and small-scale users with limited resources [13], [20]. However, certain operational limitations were observed during experimentation. The conveying efficiency depended on motor power, pipe diameter, and suction line sealing. Any air leakage reduced system performance. Occasional clogging occurred when grains with higher moisture content were used, indicating that the machine performs best with properly dried paddy. Continuous long-duration operation also caused slight heating of the vacuum motor, suggesting the need for periodic rest intervals or improved cooling arrangements [15], [16].

Despite these limitations, the overall performance of the machine was satisfactory. The developed system achieved its primary objectives of reducing labor dependency, increasing filling speed, improving bag weight consistency, and lowering grain losses. In addition, the simple design enabled easy operation and maintenance, making the machine practical for users with limited technical knowledge [18], [19]. The discussion of results indicates that the proposed machine offers an effective balance between cost, efficiency, and usability. By using locally available materials and a simple vacuum-assisted mechanism, the system provides an economical alternative to expensive commercial grain filling equipment. Future improvements such as automatic weighing sensors, improved suction control, and sealing integration can further enhance machine capability. The results and discussion verified that the fabricated paddy filling machine is a practical and efficient solution for agricultural bagging operations. With minor design enhancements, the system can be adopted widely for post-harvest grain packaging in farms, rice mills, and small processing industries [6], [17], [20].

8. Cost analysis

- The cost analysis of the developed paddy filling machine was carried out to evaluate its economic feasibility for farmers, rice mills, and small packaging units. The objective was to achieve a low-cost system without compromising performance and durability.
- The total fabrication cost mainly depends on raw materials, purchased components, labor charges, machining operations, and miscellaneous expenses related to transport and installation.
- Structural materials such as mild steel sections, sheet metal for the hopper, PVC suction pipes, fasteners, and protective paint formed the basic material cost, estimated between **₹4,800 and ₹7,400**.
- Major purchased components included the vacuum cleaner or suction motor, electrical accessories, flow control valve, and bag holding arrangement. The estimated component cost ranged from **₹4,200 to ₹8,500**.

- Fabrication expenses such as cutting, welding, drilling, machining, assembly, and finishing contributed an additional **₹3,000 to ₹5,000** depending on workshop charges and labor availability.
- Miscellaneous costs such as transportation of materials, handling charges, and unforeseen expenses were estimated between **₹1,000 and ₹2,000**.
- Based on the above estimates, the total project cost was found to be approximately **₹13,000 to ₹22,900**, making the machine economically suitable for small and medium-scale users.
- Compared with commercially available automatic grain bagging machines, the proposed system is considerably less expensive while still offering improved filling speed, reduced labor effort, and better bagging accuracy.
- The use of locally available materials and standard components further lowers maintenance cost, since spare parts such as hoses, valves, and electrical items can be replaced easily when required.
- Overall, the cost analysis confirms that the developed paddy filling machine is an affordable and practical solution for agricultural packaging applications, offering a good balance between investment cost, operational efficiency, and long-term usability.

9. Conclusion

The design and fabrication of the paddy filling machine for bag filling applications was successfully completed, and the developed system proved to be an efficient, economical, and practical solution for post-harvest grain packaging operations. The machine effectively reduced manual labor involvement, improved filling speed, maintained better consistency in bag weight, and minimized grain spillage when compared with conventional manual methods. The integration of a vacuum-based conveying mechanism simplified grain handling and provided a cleaner working environment with reduced material losses. The fabricated structure was compact, durable, and suitable for small and medium-scale farms, rice mills, and packaging units. Experimental testing confirmed reliable operation, satisfactory productivity, and ease of use under practical conditions. In addition, the overall cost of the machine was significantly lower than many commercial automated systems, making it accessible for rural users and small enterprises. Therefore, the developed paddy filling machine can be considered a valuable contribution toward agricultural mechanization by enhancing efficiency, reducing operational costs, and improving packaging quality. With future improvements such as automatic weighing, sealing, and advanced control systems, the machine can be further upgraded for wider industrial applications.

10. Future Scope of Work

- An intelligent weighing arrangement with sensors can be incorporated in future versions to improve quantity precision and reduce operator intervention during filling.
- A fully automatic sealing section may be added so that filling and packaging can be completed in a single continuous process with higher output.
- The suction and conveying mechanism can be redesigned with improved airflow control and larger capacity motors to process greater volumes of paddy and similar grains.
- Mobility features such as wheels, compact modular construction, or renewable power options can be introduced to make the machine more suitable for field and rural applications.
- Digital control systems using PLCs or microcontrollers can be implemented for automated operation, performance monitoring, and easy adjustment for different bag sizes or grain varieties.

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