



Design and Development of an Energy Efficient Packing Machine for Small Scale Industries

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Abstract—

Small-scale industries play a vital role in the economic development of a country, especially in manufacturing and food processing sectors. However, these industries often struggle with high energy costs and inefficient machinery. Conventional packing machines consume excessive power due to continuous motor operation, inefficient sealing systems, and lack of intelligent control. This major project focuses on the design and development of an energy-efficient packing machine suitable for small-scale industries. The proposed system integrates optimized mechanical design, high-efficiency motors, load-cell-based weight control, and impulse heat sealing to significantly reduce energy consumption while maintaining packing accuracy and productivity. The machine is compact, affordable, and easy to operate, making it ideal for small manufacturers.

Keywords— Small-scale industries, Energy-efficient packing machine, Optimized mechanical design, High-efficiency motor, Load cell weight control, Impulse heat sealing



I. INTRODUCTION

All Packaging is an essential process in manufacturing and production industries. It helps protect products from damage, contamination, and environmental factors during storage and transportation. Proper packaging also improves the appearance of products and makes them easier to handle and distribute in the market. In modern industries, efficient packaging systems are necessary to maintain product quality, reduce waste, and increase productivity. Many industries use automatic packing machines to improve efficiency and maintain consistency. However, in many small-scale industries, packing operations are still carried out manually or with simple machines that are not energy efficient. Manual packing requires more labor, takes more time, and often results in inconsistent packaging. Workers may also experience fatigue when performing repetitive packing tasks for long periods. These issues reduce productivity and increase operational costs.

II. MATERIALS AND INSTRUMENT

Describe The design and development of the energy-efficient packing machine required several mechanical, electrical, and control components. These materials were selected based on their energy efficiency, durability, availability, and suitability for small-scale industrial applications.

The main structural framework of the packing machine was fabricated using mild steel sections to provide adequate strength, rigidity, and stability to support all mechanical components. The machine frame was designed in a compact structure to reduce space requirements and improve ease of operation for small-scale industries. A hopper was installed at the top section of the machine to store the raw material that needs to be packed.

The hopper allows a continuous and controlled supply of the material to the filling system. An auger screw mechanism was used to transfer the material from the hopper to the filling section. The auger helps in regulating the quantity of material being dispensed into each pouch, ensuring uniform packing.

A DC motor was used to drive the auger mechanism and other moving parts of the machine. The DC motor was selected because it consumes less electrical power and provides better speed control compared to conventional motors, thereby improving the overall energy efficiency of the packing machine.

For sealing the pouches, a heat sealing unit was incorporated into the system. The sealing unit ensures that the packaging film is properly sealed after filling, preventing leakage and maintaining product quality. An eye mark sensor was installed to detect the printed alignment mark on the packaging film, which helps in accurate positioning during cutting and sealing operations.

To automate the machine operation, a Programmable Logic Controller (PLC) was used as the main control unit. The PLC controls different processes such as material feeding, pouch filling, sealing, and cutting operations. A Human Machine Interface (HMI) was integrated with the PLC to allow the operator to monitor machine performance and adjust operating parameters easily.

The performance of the developed packing machine was evaluated through experimental trials by operating the system under different conditions. Parameters such as packing speed, sealing quality, and energy consumption were monitored to analyze the efficiency and suitability of the machine for small-scale industrial applications.

III. EXPERIMENTAL METHOD USED

The experimental method used in this study involves the product is poured into the hopper. When the start switch is pressed, the controller activates the dispensing motor. The auger rotates and dispenses material into the pouch. The load cell continuously monitors weight. Once the preset weight is reached, the controller stops the motor instantly. The sealing unit is then energized for a short duration to seal the pouch. After sealing, the system resets for the next cycle.

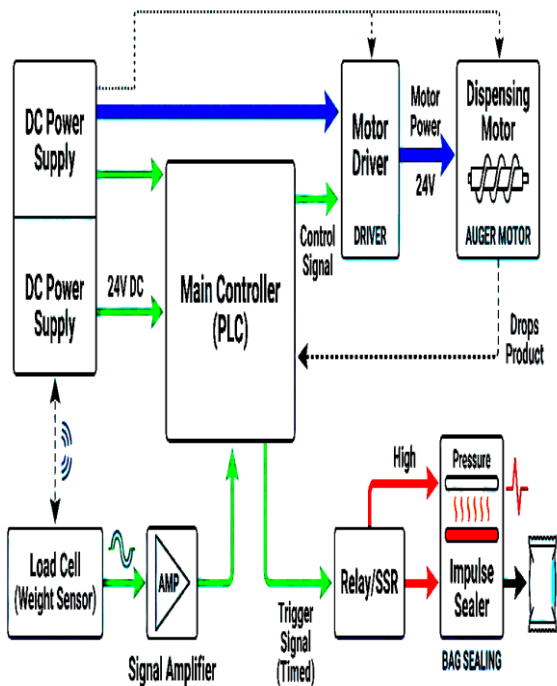
Sensors detect the presence of the packet and activate the sealing mechanism. The sealing unit uses controlled heat to seal the packet securely. After sealing, the packed product is moved out of the machine through a conveyor system for collection or further processing. The entire process is controlled by an electrical control system that coordinates the motor, sensors, and sealing unit to operate only when required, thereby reducing unnecessary energy consumption and improving overall efficiency.

After sealing, the packed packet is transferred out of the machine through a conveyor system or collection tray. The conveyor moves the finished packets smoothly to the output area for storage, inspection, or further distribution. The entire operation of the packing machine



is controlled by an electrical control system consisting of motors, switches, sensors, and controllers.

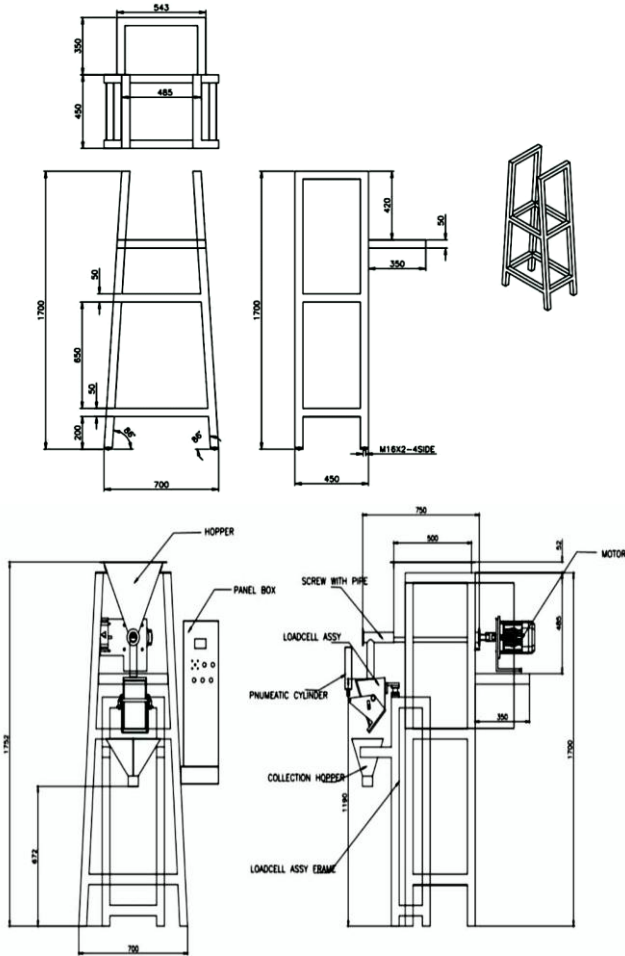
These components work together to coordinate the different stages of operation such as feeding, filling, sealing, and conveying. Energy efficiency is achieved by using efficient motors, proper control systems, and automation that allows the machine to operate only when required, thereby reducing unnecessary power consumption and improving overall productivity.



S. No	Material / Instrument	Purpose
1	Hopper	Store and supply materials to the packing machine
2	Auger	Transfer and measure materials accurately during the filling process
3	Sealing Unit	Seal the packed material in the pouch to prevent leakage and contamination
4	Eye Mark Sensor	Detect printed marks on the packaging film for accurate cutting and sealing position
5	DC Motor	Drive the machine components
6	Programmable Logic Controller	Control and automate the operation of the packing machine
7	Human Machine Interface	Allow the operator to monitor and control the machine easily



IV. FRAME DESIGN



V. POWER CALCULATION

Torque Calculation

Force required to move panel material (approx.):

$$F = 20 \text{ N}$$

$$\text{Torque (T)} = F \times r$$

$$T = 20 \times 0.025 = 0.5 \text{ N}\cdot\text{m}$$

Considering losses:

$$T_{\text{required}} = 0.5 / 0.85 = 0.59 \text{ N}\cdot\text{m}$$

Motor Power Calculation

Angular speed (ω):

$$\omega = 2\pi N / 60 = 2\pi \times 60 / 60 = 6.28 \text{ rad/s}$$

$$\text{Power (P)} = T \times \omega$$

$$P = 0.59 \times 6.28 \approx 3.7 \text{ W}$$

Selected motor power (with safety factor): 40–60 W
DC/BLDC motor

Sealing Power Calculation

Impulse sealer rating: 300 W

Sealing time per pouch: 2 seconds

Energy per seal:

$$E = P \times t = 300 \times 2 = 600 \text{ J}$$

Energy Savings Calculation

Parameter	Conventional Machining	Proposed Machine
Motor Power	400 W	60 W
Sealing Type	Continuous	Impulse
Avg. Energy/Hour	0.6 kWh	0.22 kWh

Energy saving \approx 63%

VI. RESULTS AND DISCUSSION

PACKAGING MACHINE PERFORMANCE

The developed energy-efficient packing machine was tested to evaluate its performance in terms of operation, reliability, and efficiency. During testing, the machine successfully carried out all the required packing operations including feeding, weighing, filling, and sealing of the packets. The hopper supplied the material continuously to the auger mechanism, which controlled the flow of the product into the packing unit

The dispensing motor rotated the auger screw to deliver the required quantity of material into the packet. The machine operated smoothly without sudden interruptions or mechanical failures. Proper coordination between the mechanical parts and electrical control system ensured that each stage of the packing process was carried out in the correct sequence. The frame structure provided good stability and reduced vibrations during operation. As a result, the overall machine performance was found to be satisfactory and suitable for use in small-scale industries.



Energy Consumption

Energy consumption was one of the major factors considered during the design and testing of the packing machine. The machine was designed using energy-efficient components such as efficient electric motors, impulse sealing units, and automated control systems. The results showed that the machine consumed less electrical energy compared to traditional manual or semi-automatic packing systems.

The impulse sealer generated heat only during the sealing process instead of maintaining continuous heating, which significantly reduced power consumption. The automatic control system also helped reduce energy wastage by operating the machine only when necessary. Sensors and controllers ensured that the motor and sealing units were activated only when a packet was present. These features helped minimize idle running and unnecessary energy loss, improving the overall energy efficiency of the system.

Packing Accuracy

Packing accuracy is an important factor in any packaging system because it ensures uniform product quantity in every packet. In this project, a load cell sensor was used to measure the weight of the product during the filling process. The load cell converted the weight into an electrical signal, which was amplified and sent to the controller. The controller continuously monitored the weight value and stopped the dispensing motor when the required quantity of product was reached.

Sealing Quality

The sealing quality of the packets was evaluated to ensure that the packaging was secure and reliable. The impulse sealing unit was used to seal the plastic packaging material after filling the product. The sealing jaws applied controlled heat and pressure to the packet, creating a strong and leak-proof seal. Since the impulse sealer heats the sealing element only for a short duration, it helps maintain consistent sealing temperature and prevents overheating. The sealed packets were inspected for leakage and structural strength, and the results showed that the seals were strong and uniform. Proper sealing ensures that the packed products are protected from moisture, dust, and contamination during storage and transportation.

Productivity Improvement

The packing machine significantly improved productivity compared to manual packing methods. Manual packing processes are time-consuming and require continuous human effort, which limits the production rate. In contrast, the automated packing machine can perform multiple operations quickly and continuously with minimal human intervention.

The integration of sensors, controllers, and automated feeding mechanisms allowed the machine to complete the packing cycle efficiently. As a result, the number of packets produced per unit time increased considerably. This improvement in productivity is highly beneficial for small-scale industries that aim to increase production while maintaining low operational costs.

Operational Reliability

Operational reliability refers to the ability of the machine to perform consistently over long periods without failure. During testing, the machine showed stable and reliable operation. The mechanical components such as the auger, bearings, and conveyor system were properly aligned and lubricated, which reduced friction and mechanical wear. The electrical components including the controller, sensors, motor driver, and impulse sealer worked together efficiently to maintain smooth machine operation. The system responded quickly to sensor signals and controlled the machine functions accurately. The machine also produced low vibration and noise levels, indicating stable mechanical performance. These results demonstrate that the packing machine is reliable and suitable for continuous operation.

Overall System Efficiency

The overall efficiency of the packing machine was evaluated by considering factors such as energy consumption, packing speed, accuracy, and operational reliability. The machine successfully achieved the objective of providing an energy-efficient and automated packing solution. The combination of efficient motors, low-friction mechanical components, impulse sealing technology, and automated control systems helped reduce energy consumption while maintaining high productivity. The machine was able to perform packing operations quickly and accurately with minimal energy loss.



VII . CONCLUSION

The design and development of an energy-efficient packing machine provide a practical and cost-effective solution for small-scale industries that require reliable and efficient packaging systems. Many small industries depend on manual or semi-automatic packing methods, which often lead to higher labor costs, slower production rates, and inconsistent packaging quality. By introducing an automated packing system with improved mechanical and electrical design, this project helps overcome these limitations and improves the overall efficiency of the packaging process. The machine integrates several important components such as the hopper, auger mechanism, load cell, sensors, motor, controller, and impulse sealing unit. These components work together in a coordinated manner to perform operations such as feeding, weighing, filling, and sealing of packets. The use of a load cell ensures accurate measurement of the product weight before filling, which helps maintain uniformity in every packet. At the same time, sensors and the control system help automate the process by activating machine operations only when required, thereby reducing unnecessary energy usage.

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