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Design and Manufacturing of Automatic Pouch Packing Machine.

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Abstract - *This paper presents the design and development of an automated pouch filling and sealing machine for small-scale food businesses. Manual packing of liquid food items is time-consuming and costly due to labour charges, and hence, there is a need for a cost-effective solution to improve efficiency and reduce human efforts. The proposed machine aims to automatically fill and pack pouches of specific weight, thereby streamlining the packaging process.*

The machine consists of various components, including a hopper, forming shoulder, forming tube, solenoid valves, sealers, actuators, and motors. The fluid to be packed is stored in the hopper, equipped with a stirrer assembly to prevent blockage caused by settling particles. An astable multivibrator using a 555 IC is employed to control the opening and closing of solenoid valves, regulating the flow of fluid into the pouches.

The proposed machine offers several advantages, including reduced labour costs, increased production speed, and improved accuracy. It eliminates the need for manual weighing by using the volume of the cylindrical filling tube to determine the weight of the fluid. The cost-effective design and automation features make it suitable for small food businesses, enabling them to enhance their packaging efficiency and overall net margin.

Through a comprehensive review of related literature, this paper highlights the significance of automated packaging machines in the food industry. It also compares the proposed machine with existing solutions, emphasizing its cost-effectiveness and performance. The experimental results demonstrate the feasibility and effectiveness of the developed machine, paving the way for its implementation in small food businesses seeking to optimize their packaging processes.

Key Words: Automatic pouch packing machine, Sealer mechanism, Cost effective design, small food businesses, Astable Multivibrator.

1.INTRODUCTION

Small-scale food businesses often face challenges in packaging liquid food items, as the process of manual packing and sealing can be time-consuming, costly, and labor-intensive. The need for a more efficient and cost-effective solution has led to the development of automatic pouch packing machines. However, the high cost of these machines poses a significant barrier for small businesses, limiting their ability to adopt automation. Therefore, there is a growing demand for the development of low-cost automatic pouch packing machines that can cater specifically to the needs of small-scale food businesses.

This paper aims to present the design and development of a low-cost automatic pouch packing machine (APM) that addresses the challenges faced by small food businesses. The machine is designed to automate the process of filling and packing pouches with specific weights, thereby reducing manual effort and time consumption required for sealing. By implementing this machine, small food businesses can reduce their dependency on manual labor and increase their overall net margin.

The physical design of the APM is compared to the traditional manual pack and seal machine to highlight its advantages and improvements. The machine comprises various parts such as:

I. Hopper
II. Plastic film roll
III. Forming shoulder
IV. Filling tube and Forming tube
V. Solenoid valve
VI. Astable Multivibrator
VII. Horizontal Sealer
VIII. Vertical Sealer
IX. DC Motor
X. Actuators

1.1 Working of Automatic Pouch Packing Machine:

The workflow of the APM involves several key processes. Firstly, the liquid food product is stored in a hopper, which is equipped with a stirrer assembly to prevent settling of heavy particles that may block the fluid flow. The fluid then passes through solenoid valves, which regulate the flow into the forming tube. The plastic film roll is fed from tension rods to the forming shoulder, where it is shaped into a cylindrical form. Simultaneously, the fluid flows from the filling tube into the forming tube, filling the pouch directly.

Vertical sealing is achieved with vertical sealers that contain cylindrical blocks and heating elements. The height of the blocks is designed to be equal to or greater than the pouch length, ensuring a complete seal and preventing any leakage. Horizontal sealing is accomplished by pulling the plastic film down with the help of actuators, followed by the sealing and cutting processes. The sealing mechanisms incorporate motors, cam systems, and tension springs to ensure efficient and accurate sealing.

2. LITERATURE REVIEW

Prof. S. B. Mandlik, Patole et. Al [1] titled as 'Automatic Packing Machine'. This invention concerns developing a machine which automatically weighs and packs food with the help of sensors and microcontroller. The idea is to place the bag manually and automatically weighing, filling, and packaging is carried out. The electrical DC motors are used as actuators for the entire process to move the upper and lower conveyor belt, and sensors are used to feed the conveyor system by system information. The control system for the hardware project is to be controlled by Arduino. They developed an automation technique using Arduino uno board which increases speed and accuracy of the process of production. The purpose of the project is to reduce time for manually packing and reduce human efforts.

M. R. Saraf et. Al [2] titled 'Design and Development of Cost-Effective Automatic Machine for Powder Packaging '. The paper presents a low-cost pouch filling machine which has a weighing and pouring mechanism to increase accuracy of the system. The low-cost automated system uses simple pneumatic, mechanical and electric systems. A mechatronics system is developed for the machine which takes feedback from sensors and controls the manipulator. Additional weighing and pouring mechanism is added to increase accuracy. Also, a cost comparison is presented between conventional machine and the one developed. The project aims to develop Low-cost Automated Pouch Packing Machine for small industries or enterprises.

Prajakta Hambir et. Al [3] titled 'Automatic Weighing and Packing Machine'. The project aims to develop a machine which automatically weighs and packs food with the help of microcontroller and sensors. The idea is to manually place the bag and then automatic weighing, filling, and packaging is done. It can wrap 10-100 grams of pouches, sachets, and bags. The sealing is based on the drawbar mechanism or belt drawdown mechanism. The entire weighing and packaging process is done with the help of electro pneumatics and motors. The control for hardware is done by programmable logic controllers. Weight calculation is done using a load cell sensor. The purpose of the project is to reduce human efforts and time consumption.

Md. Mosfiqur Rahaman et. Al [4] titled 'Analysis and Design of Different Astable Multivibrator Circuits for Various Applications in Communication Circuits '. The aim of the paper is to design and implement astable multivibrator in many applications of communication systems. Here the multivibrator circuit design is done by using different IC such as IC timer 555, V741 as an optional amplifier. Different software packages such as PSPICE, SIMetrix, Tina Pro are used to develop and harmonize the concept of IC 555. The circuits were tested using the softwares whose values resembled the theoretical value. Thus, the simulation results can be used to test different circuits to decide whether they can be implemented in the real world.

3. PROPOSED WORKFLOW OF MACHINE

The fluid stored in the hopper is directed through the first solenoid valve, filling the filling tube. It then flows through the second solenoid valve, passing through the forming tube. At the same time, the plastic film, positioned on a roller, moves over the forming shoulder, where it undergoes a transformation, taking on a cylindrical shape.

Subsequently, the plastic film on the outer side of the forming tube is vertically sealed, ensuring the contents are securely enclosed within the pouch. Additionally, horizontal bottom sealing takes place. The plastic film is pulled with the assistance of actuators equipped with nylon wheels.

Once the sealing processes are completed, the fluid is poured into the pouch. Horizontal top sealing is then performed, followed by cutting, ultimately completing the formation of the pouch.

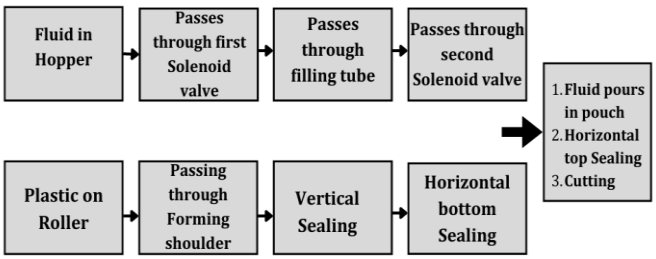

Fig-1: Process Flow

The following section comprises of various mechanism used in packing machine and synchronization of the mechanism with each other.

I. Hopper Assembly:

The fluid is stored in the hopper for a long time, this may cause heavy particles in the fluid to settle down and block the flow of fluid further. Therefore, the hopper is equipped with a stirrer assembly. It consists of a paddle/anchor agitator and a motor.

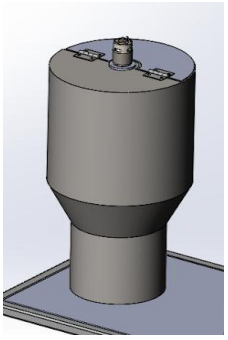

Fig-2: Hopper

II. Astable Multivibrator:

Automatic technique was developed using the Astable multivibrator which was accurate, reliable , simple in design , easy to construct and low cost. They can remain functional for an extraordinary time.

Astable multivibrator is also called a Free Running Multivibrator and uses 555 IC. It has no stable states and continuously switches between the two states without application of any external trigger.

The on time and duty cycle should be specified on that note resistance and capacitance value can be determined using following formulas:

D= TON/T
D = R1/ (R1 + R2)
TON = 0.693 * R1 * C
TOFF = 0.693 * R2 * C

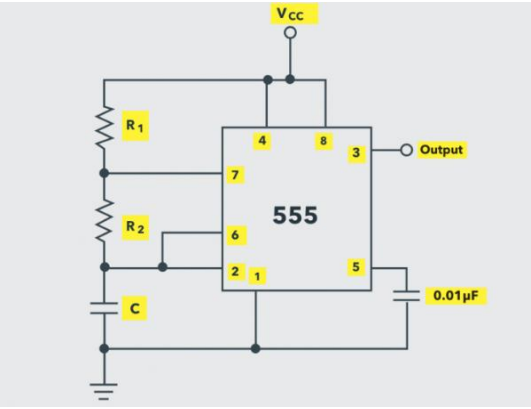

Fig-3: Astable Multivibrator

This logic is applied to solenoid valve 1, and equal but opposite logic is applied to solenoid valve 2. This ensures alternate on and off valve which eventually regulates the flow of the fluid. Let,

Ton1=time for which solenoid valve 1 is open.
Toff1 = time for which solenoid valve 1 is closed.
Ton2 = time for which solenoid valve 2 is open
Toff2 = time for which solenoid valve is closed

The one end of solenoid valve 1 is connected to the hopper nozzle and the other to the filling tube. Similarly, one end of solenoid valve 2 is connected to filling tube and other end to forming tube. The volume of cylindrical shaped filling tube has volume equal to that of volume of fluid filled in pouch. Thus there is no need to install weight measuring system for cost reduction.

Mass Flow rate = (r*A*V) * Nd

(Mass flow rate=given,
r=density(given),
A = area=pi*R*R (R=nozzle radius)
V = sqrt(2gH))

From the above equation we get R

Nozzle diameter = pipe diameter

Based on the volume of the cylinder, the height of the filling tube can be calculated.

Volume of cylinder = pi*R*R*h

III. Forming Shoulder and tube:

Plastic from plastic roll goes over tension rods to the forming shoulder. Forming shoulder helps in making rectangular plastic sheet into cylindrical shape. The plastic flows on outer side of the forming tube and fluid flows from filling tube on inner side of forming tube. The fluid pours into pouch directly from forming tube.

Fig-4: Forming Shoulder

IV. Vertical Sealing:

The vertical sealing takes place with the help of vertical sealers. The sealers contain cylindrical blocks and heating element connected to blocks. The height of blocks should ideally be equal or more than the pouch length. This ensures that there is no section of plastic unsealed and avoids any leakage if possible.

Vertical sealing mechanism:

Vertical sealers are driven by motors instead of pneumatic cylinders which offers reduced cost as well as reduced accuracy.

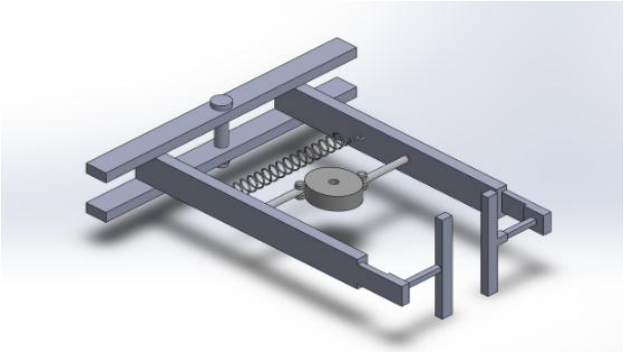

Fig-5: Vertical Sealing Mechanism

The motor is connected to shaft which further connects to cam. Type of cam used is elliptical cam. The follower following the cam are connected to cuboidal blocks which are further connected to sealers. These blocks are connected to each other by tension springs. When the follower is at vertex point the sealers are away from each other and sealing phenomenon does not take place at this position. Springs have maximum potential energy at this point. When follower travels from vertex to co-vertex, spring helps in bringing back the blocks. At co-vertex point the sealers come in contact and sealing phenomenon takes place.

V. Horizontal Sealing:

After vertical sealing plastic is pulled down with the help of actuators and further horizontal sealing takes place. All these processes of vertical sealing, rolling and horizontal sealing takes place at Ton1 . Margin: vertical and horizontal sealing takes place simultaneously. The rolling process are actuated by 2 different motors which actuate at specific interval with specific rpm in opposite direction. Motors actuating at specific interval avoids crippling of plastic. Therefore, sealing and rolling does not take place simultaneously but takes place one after other in a cycle. Horizontal sealers are connected with cutter to cut the pouch.

Horizontal Sealing Mechanism:

The outer frame is fixed and inner sealer is movable. The shaft which drives vertical sealer the very same shaft is extended further and is connected to radial type cam. The follower which follows the cam is connected to movable part of sealer. The sealers seal at nose point of the cam, after this point as the followers follow at the heel part of cam the tension springs which are connected to the fixed part and movable part of the sealer pulls movable part , at this point sealers are away from each other.

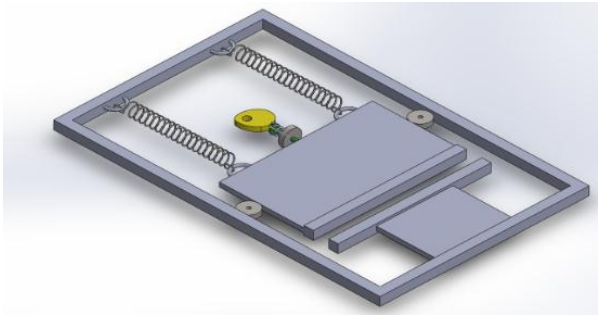

Fig-6: Horizontal Sealing Mechanism

4. RESULT AND DISCUSSION-

The following section shows that the problem statement was analysed and solved successfully. The table-1 shows time taken by worker to fill specific amount of fluid in comparison with the packing machine. Table has 10 readings which shows that the mean time taken by worker is more than packing machine.

Sr no.	Time taken by Manual labour(sec)	Time taken by Packing machine(sec)
1.	11	6
2.	11	5
3.	10	6
4.	9	8
5.	9	5
6	10	4
7.	9	5
8.	10	6
9.	8	5
10.	8	6
mean	**9.5**	**5.6**

Table-1:time comparison

4.1 COST ESTIMATION

Sr no.	Component	Cost in Rs.
1.	Materials	16000
2.	Labour	3000
3.	Micro-controller	19000
4.	Other electronic components	12000
5.	Commission and Installation	12000
6.	Transport	4000
	Total	**66000/-**

Table-2 cost estimtion

5. CONCLUSIONS

This paper presents the design and development of an automatic pouch packing machine for small-scale food businesses. Firstly, it reduces labor costs as it eliminates the need for manual weighing and filling of pouches. Instead, the machine uses the volume of the filling tube to determine the weight of the fluid, ensuring accuracy and consistency. Secondly, it increases production speed by automating the packaging process, allowing businesses to meet higher demand and enhance overall efficiency. Additionally, the machine is cost-effective, making it suitable for small food businesses with limited resources.

The significance of automated packaging machines in the food industry is emphasized through a comprehensive review of related literature. A comparison with existing solutions highlights the cost-effectiveness and performance of the proposed machine. Experimental results demonstrate its feasibility and effectiveness, providing evidence for its implementation in small food businesses.

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