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Development of an Automated Sealing System for Polythene Bag

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Abstract

The blessings of technology have sky rocketed in recent era and everything that is witnessed in the surroundings are the contribution of technology. Therefore, being up to date with the technology is the demand of modern science. The more automated the processes are, the better up to date is the technology. This paper presents the design and construction of a low cost yet flexible and secure automation based polythene bag sealer. This paper will investigate automation function, sealing mechanism as well as integration of automated filler, robotic hand and conveyor over the system. The purpose of this system is to supply polythene bags through vacuum grippers and seal these bags automatically and hence it is called an automated sealer. The parts that have been used in this system are working according to plan and the strength of sealing has been determined by hanging dead weight with the polythene bag. If there is enough capital and investment made behind this whole process, then it will be possible to construct the desired machine and make it eligible to use in the industry.

Keyword: *Automation, Sealing, Flexible and secure operation, low cost*

INTRODUCTION

Automation in the light of modern era, while most things are put to the effect automatically rather than manually on a regular basis, beginning from the usual practice of switching lights on and off to controlling the entire work cycle, it is high time people around the globe get a palpable concept about automation and run with the fast changing modern civilization. Before it gets too late, before others take control over you, before you run fully behind the modern world, this is the time that one should be starting having a grip over automation to control everything they see in the surrounding. Automation though does not entirely eliminate the human involvement in a work, but it reduces the human judgment to the lowest possible degree. Therefore, the accuracy of the output too takes the upward graph [1]. The fields over which the blessings of automation have showered are limitless. There are hardly any sectors left where the footsteps of automation haven't been found. Starting from manufacturing to facility operation, defense to utilities, transportation everywhere there are applications of automation. Manufacturing includes food, chemical, pharmaceutical and petroleum, paper and pulp. Transportation includes automotive, rail and aerospace. Utilities include wastewater and water, gas and oil, telecommunication and electric energy. There are ample of more sectors like environmental control, safety, energy management, security, other building operation etc.

Heat sealing involves sealing one thermoplastic with another same kind of thermoplastic by means of heat and pressure. The direct contact procedure of heat sealing uses either a sealing bar or a constantly heated die for the purpose of applying heat over a specific path or contact area to weld or seal the thermoplastics together. Heat sealing has several applications, including thermally activated adhesives, heat seal connectors, plastic ports, film media or foil sealing. The automated polythene bag sealer is however made in such a way where the sealing process is automated and rendering

of polythene bags carried out via a vacuum gripper, followed by a robotic hand facilitates the pouring of objects down to the polythene bags. The filler too is automated and a conveyor belt assists the polythene bag to carry to the sealing machine. All these procedures are analyzed incisively in the paper. With literally low cost and at the same time increase in the sealing rate really makes this sealer machine desirable. The apparatus required for making this machine are all readily available in our surrounding which result in its low cost. This machine has a great scope for working in future; hence it is preferable to industries.

Bhairavi N. Savant addressed a process that can hold and carry any types of polythene bags and papers automatically[2]. The process had the ability to control the speed of automation and observe the output. For automating the process, he used microcontroller and DC motor and instead of PLCs and servo motors. R.A.R.C Gopura in his paper discussed the bottlenecks of polythene bag manufacturing in which the sealing methodology of the bag was also dwelled upon[3]. He focused on the accuracy of sealing system and subsequently carried out some other processes such as printing, cutting, packing, quality checking. R. Callies wrote a paper in which they elaborated the limit of vacuum grippers to control an object for instance polythene bags or plastic[4]. He reached his envisioned object by reducing the contact surface between the load and the gripper. Tsujii tetsuya in his paper developed a process in which the temperature of impulse heat sealing has been compared with that of manual heat sealing and how it reduced the power loss[5]. A. K. Jaiswal and B. Kumar in their paper talked about the vacuum gripper that can grip and load several objects beginning from pallets, bags, sacks to any kinds of material. They emphasized on variety of material that can be lifted by vacuum gripper[6]. Their main concern was about improving quality of end effectors that can certainly increase the lifting and gripping quality. L. Brainbridge discussed the problems regarding automation and how to deal with it. The problems including the inability of making instant decision by the automation process, inability to handle abnormal condition.[7] Raja Parasuman researched about how human misuse or overuse the automation technology causing several problems in the field of decision making and monitoring. He also discussed the underutilization or negligence of automation where it should have been used.[8]T.B Sheridan in his book put light on the importance of automation and robotics in the upcoming era. It says every ins and outs of automation and how it is linked to robotics.[9]. Karen Slinkard compared between manual and automated procedure for analyzing total phenols in wine and other plant extracts.[10] He took 40 samples per hour in singleton-rosy method. He counted the coefficient of variation in manual, semi-automated and automated system using replicate analysis. T.B Sheridan identified the relationship between human and automation in the sector of system design and analysis. He even developed the general principles of human automation interaction.[11] Pm. Taylor drew attention on the importance of handling limp material (cotton, leather) in the industry and how it is less prone to error than manual handling.[12] F. Erzincanli talked about using suitable end effectors for handling non rigid material. As there is a scarcity of convenient end effector for moving and gripping non rigid material, it is important to design such end effector and he did exactly that.[13] F. Erzincanli developed a method of packaging food products and classification system for the robotic handling which is discussed in terms of automated packaging cell.[14] R. Kolluru described in his paper an analytical model of a robotic gripper whose surface is flat and designed to automate the process which will be reliable, distortion-free and rapid limp material handling system.[15] The gripper prototype is incorporated with an industrial robot manipulator. N.B Sarter demonstrated the amount of uncertainties and surprises imposed by automation to human worker.[16] The automation has a

propensity to surprise human worker by its unpredictable nature which precipitate machine breakdown or work breakdown.

From the above literature review, it is cleared that automation is of utmost necessity in our daily life. Therefore, in this study an automated polythene bag sealer is designed and developed. The automation process is carried out by means of vacuum gripper, robotic hand, automated filler and conveyor belt that feature time control and pressure control. It also aims to evaluate performance of this system.

Materials and Methods

Working Principle

Each part of the entire work follows a certain mechanism. Initially the polythene bag is lifted by the vacuum gripper and followed by the second gripper attached to the opposite side of the polythene bag that suck the surface air of the polythene bag and opens up the bag to be filled by automated filler. The robotic hand holds the bag under the filler. The robotic hand moves after a specific period of time following the instruction of a servo motor. For industrial use, it would be run by the gear mechanism. The hand releases the bag over the conveyor and it carries the bag to the sealing machine where the sealing is done. After holding the polythene bag for a specific period of time, the hand releases the object on the conveyor where Pulley loops over material continually by endless procession of rubber belt. During sealing the conveyor keeps stationary which is done by Conveyor protection switch control movement of conveyor, and then the conveyor moves again. The entire working principle of the sealing system is shown in figure 1.

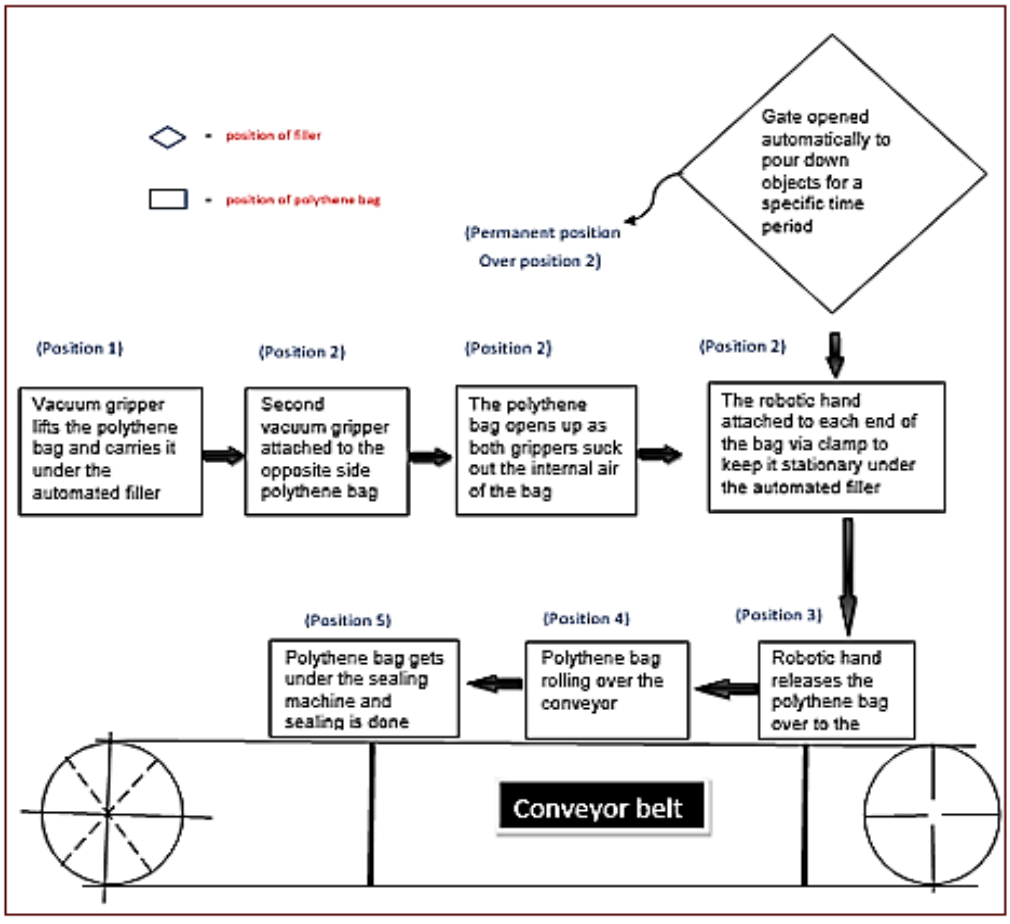


***Figure 1**: Working principle of automated sealing process*

Components of Sealing System

The different component used in this sealing system is sown in figure 2.

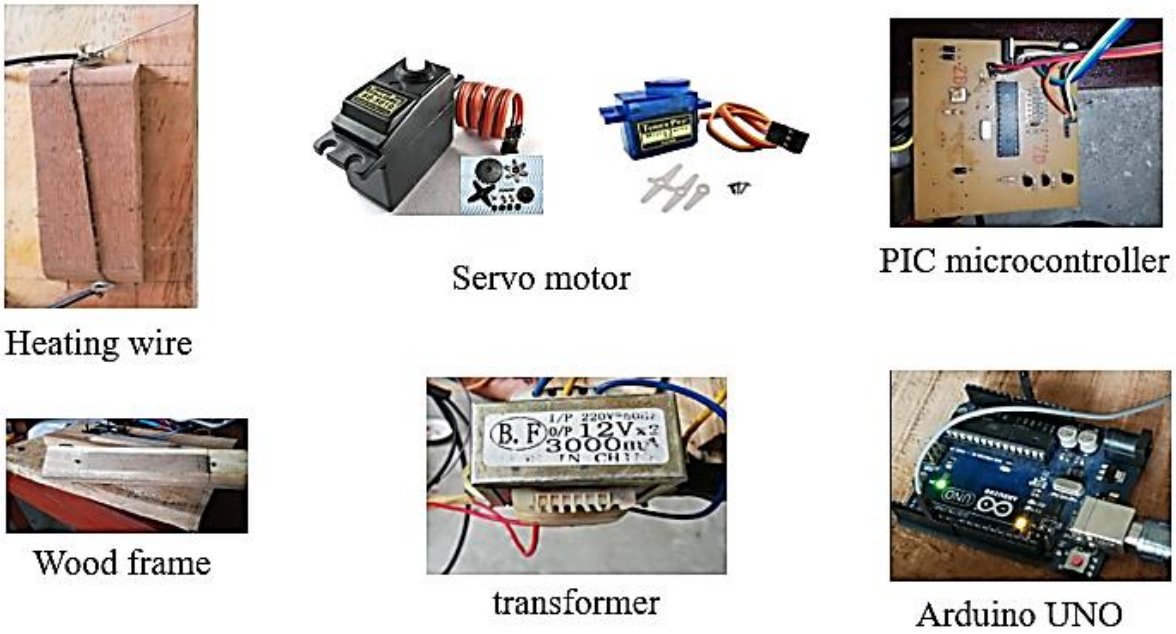


***Figure 2**: Different components used to construct the sealing system*

Vacuum grippers: Vacuum grippers can pickup and drop-off products that are different in shape and size. Vacuum grippers are customarily used to grip and lift bags, plates, boxes, products, stackers, barrels, and reels. In this paper, the procedures of lifting polythene bags using vacuum grippers are discussed. The vacuum gripper is programmed to move up and down and sideways as well and it is possible to rotate the polythene bags.

Robotic hand: The robotic hand is controlled by a servo motor. The motor can be operated at desired angle and desired time, and the coding of this servo motor is implemented via an Arduino.

Belt Conveyor: Conveyor is material handling equipment. It is used in mechanical sector for moving material from one place to another place. In this project, cotton belt is used because it is of low cost and more flexible.

Automated filler: An automated filler machine is the way to carry out the filling process automatically. Unlike manual filling methods which are followed traditionally, an automated filler machine is developed with a view to reducing human usage and enhances efficiency.

Wood frame: Two separate wood frames have been used to conduct the sealing operation. In the first wood frame, one of those two wood pieces is attached permanently with a wood board. The dimension of this wood piece is 6" ×75" ×1". Over this wood piece, another small wood piece is glued over which the product to be sealed would be placed. The dimension of this small wood piece is 4" ×.25" ×.5". The second wood frame is controlled by a servo motor which eventually carries out the sealing operation. The motor is made fixed at the end of one of the two wood pieces of this wood frame. The dimension of this wood piece is 8" ×.75" ×1". With this wood piece another small wood piece is glued over which a heating wire is tied up with two screws

Heating wire: A "Nichrome25" wire was used as a heating wire which was attached

with two screws with the wood frame. This Very wire was selected as it has high resistance and thus it can be heated without being torn.

Transformer: A transformer is used in this project to supply power to the heating wire so that it can seal the desired product. Transformers are generally used to either increase or decrease the alternative voltages in electric power application.

Microcontroller: A sophisticated microcontroller is required to operate the servo motor. The controller used in this project is Arduino and PIC microcontroller. The Arduino that has been used in this project is placed on the wood board and controls the movement of servo motor via programming.

Servo motor: The servo motor is used to make the sealing process automated. It can be operated at desired angle and desired time, and the coding of this servo motor is implemented via an Arduino. The high torque standard servo can rotate approximately 180 degrees (90 in each direction), and one can use any servo code, hardware or library to control these servos.

Sealing strength test procedure

To measure the strength of the polythene bag, we have hung a dead weight manually under the sealed bag with a rope as showed in the figure 3. Then we had increased weight incrementally till the sealed part torn. The experiment proves that the strength of the sealing is stronger than the strength of the polythene itself. So it can be concluded that, the sealing is strong enough.

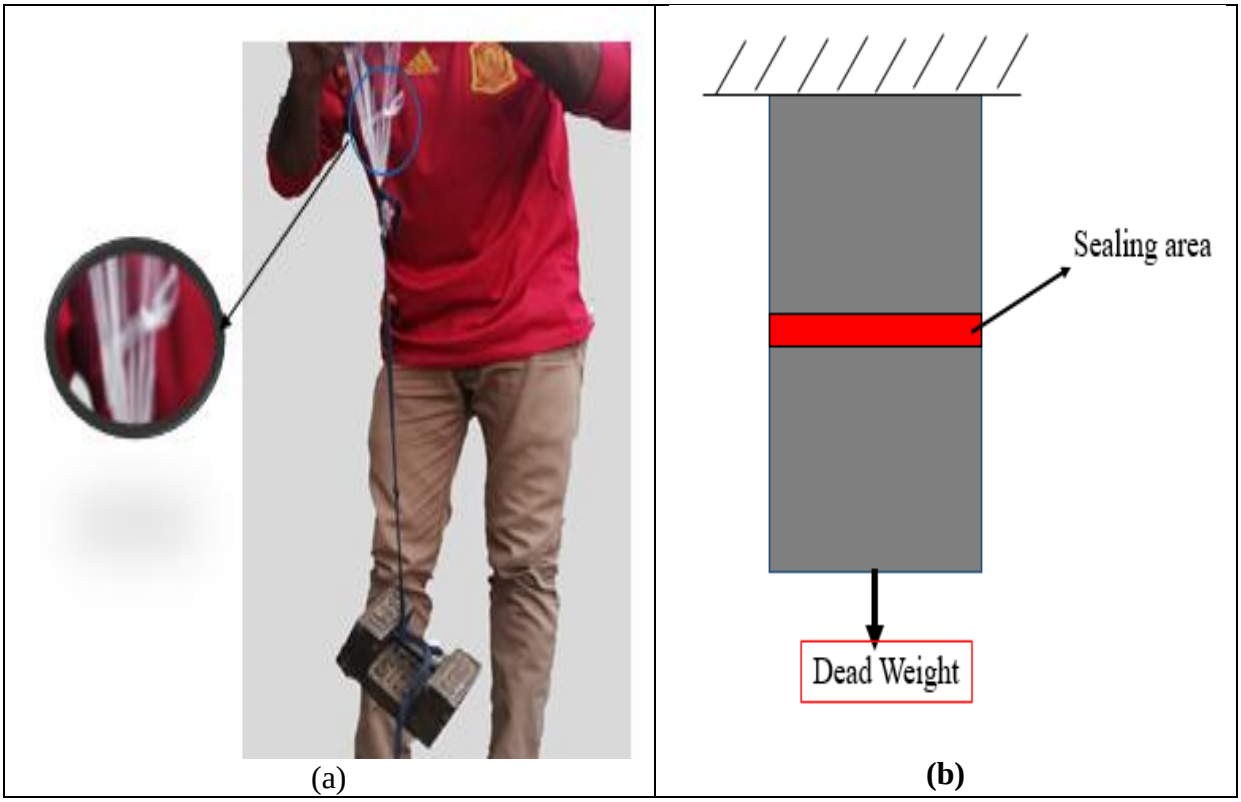
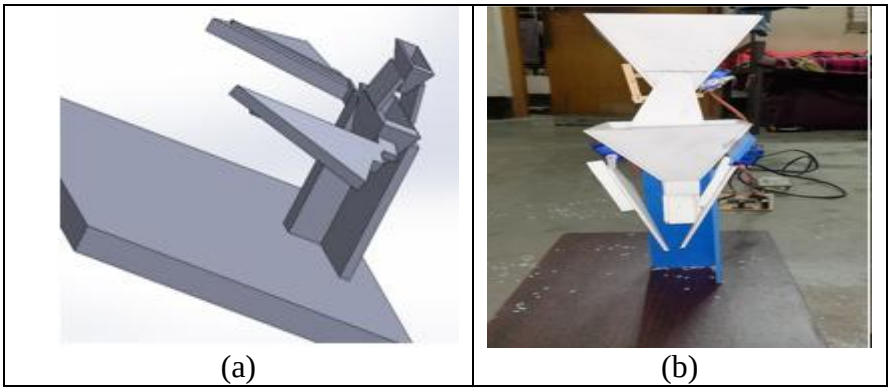


***Figure 3**: Strength test procedure **(a)** Original view **(b)** Schematic view*

RESULTS AND DISCUSSIONS

In this study, automated filler part and sealing part are constructed separately. After successful construction, these two parts are assembled together with conveyer belt. Performance results show that the all parts of this sealing system are working as desired. Also it can seal any type of polythene bag. Automated filler and sealing part are shown in figure 4 and figure 5 respectively.



(a) (b)

***Figure 4**: Automated filler part of this sealing system **(a)** CAD design **(b)** constructed view*

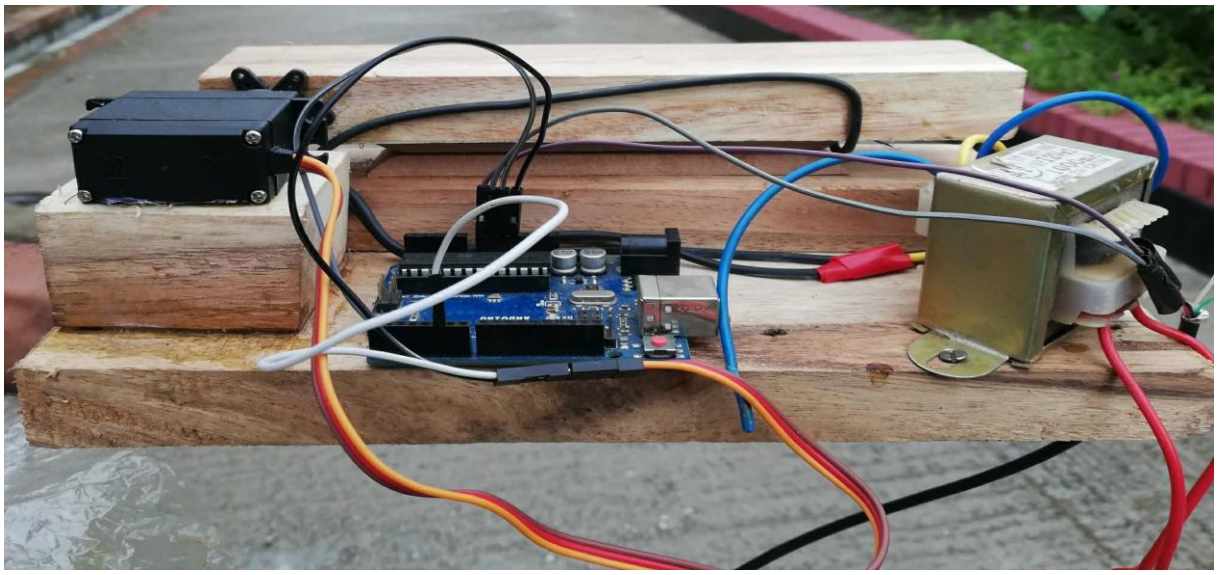


***Figure 5**: Final construction of sealing system*

Strength of the seal

***Table 1**: Sealing strength analysis results*

Weight	Condition of sealing area
1 kg	No significance damage
2 kg	No significance damage
3 kg	No significance damage
4 kg	No significance damage
5 kg	Observed little damage without tear

Sealing strength results have been shown in Table 1. From this table it can be seen that, the sealing can bear load up to 5kg, in which load, the polythene bag gets torn but the sealing area remain unchanged. So this system can be used for sealing any polythene materials for packaging.

Power Consumption per seal

For cost analysis, we have to determine the cost for each seal.

Here, current flow, $I = 3amp$; resistance of the $wire = 6000\,\Omega$; time $t = 1\,hour$.

Power, $P = I^2Rt = \frac{9\times6000\times1}{1000} = 54$ kw/h

Each seal requires 2.6s. So seal/hour $= \frac{3600}{2.6} = 1385$ piece

Power consumption per seal $= 54/1385 = 0.038\,kW$.

The experimental results clearly show the massive gap between manual and automated process. The initial setup cost

might be more in terms of automation system, but in the long run it is more cost effective as it eliminates the labor cost permanently. The payback period too is not long and the setup cost will soon be recovered.

CONCLUSION

The automated Polythene bag sealer process has been successfully developed which is eligible for industrial use and also has a high sealing rate. Though this process is best Suited for small bags, large bags can also be sealed. With power consumption on a higher side of 0.038 kW/seal in industry, it does have some room for improvement. The automated polythene bag sealer has a great application in many packaging industries like different food production industry, limp material industry (cotton), small packaging industry and many more. For its limitless application, the demand of this product will only follow an upward graph.

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