

Electro-Pneumatic Portable Packaging Machine

^[1] Renis D Thumar, ^[2] Rinkesh M Soni, ^[3] Kalpak I Patel, ^[4] Hardik A Mistry, ^[5] Ravi Dabla
^{[1], [2], [3], [4]} Mechanical Engineering Students, ^[5] Assistant Professor
^{[1], [2], [3], [4], [5]} Mechanical Engineering Department
^{[1], [2], [3], [4], [5]} Institute of Technology and Management Universe, Vadodara, Gujarat, India

Abstract: This paper introduces a packaging machine using electro-pneumatic system in small scale industry. The main aim of the paper is to design and fabricate a simple and small packaging system which can seal the plastic bags. For automation, we will use pneumatic system for fast response. In last few years, many sealing machines were developed. These machines are highly automated, which have very high cost. So, these machines are not affordable by small scale industries. SO, they are using impulse heat sealer machine. But, there are losses of plastic packaging material due to manually press. To overcome these problems, we will design a machine, which is semi-automatic, less laborious and have less initial cost. We are using major components like Air compressor, Double acting cylinder, Air storage tank, 5/2 Direction control valve, SMPS(Switch Mode Power Supply), a foot operated push button switch, a heat sealer, and tubes for air supply. Unskilled or semi-skilled operators can operate this machine, hence required less labour cost. Also, due to fast response, production per day is increased. Perfect sealing can be obtained due to applying required exact pressure on the plastic material.

Keywords- Electro-pneumatic, Packaging, Portable, Automatic, Direction control valve, SMPS, Compressor

I. INTRODUCTION

In recent development, packaging is a very important factor in most of the fields. Every industrial product requires packaging for its protection from environment, like foods, doughy products, washing powder, etc. In most of the small scale industries, sealing is done by conventional method, i.e. by using candles, stapler, manually sealing machine, etc., which is time consuming and laborious. Many manufacturers of sealing machine are available in the market. They manufacture the automated and fast machines. But these machines are very high costlier, they are not affordable by small scale industries. A sealing machine should reduce the labour cost and time. Also, it should increase the rate of production, which improves the profit for the benefit of small scale manufacturers. And also it should increase the quality of the sealing.

Heat sealing is the process of sealing one thermoplastic to another similar thermoplastic using heat and pressure. It can join two similar materials or can join dissimilar materials, one of which has thermoplastic layer. Plastic bags are mostly used for packaging of foods, powders, chemicals, doughy products, etc. In heat sealing, a sealing bar is used to apply heat to seal the two thermoplastic layers together. Heat sealing is used in many fields like, bio-engineering, food industries, etc. It is also used in manufacturing of film for filling the blood.

Sealing quality depends on the accurate parameters like Time, Temperature and Pressure. By applying accurate pressure on the sealing bar, with accurate time and temperature as per the thickness of the plastic bag, we can seal it perfectly. Sealing quality can be tested by a simple pull to determine the bond between the two layer.



Figure-1 Impulse Heat Sealer Machine

An impulse heat sealer machine is shown in figure 1. In impulse heat sealer machine, a heating element of Nichrome is provided as the source of heat. An energy pulse is applied to the area of sealing, immediately followed by the process of cooling. Thus, there is no requirement of warm up period. It requires power consumption when only the sealing bar is lowered. These machines are used to seal any thermoplastic materials, like polythene or polypropylene. These materials require lower temperatures for sealing compared to other materials.

This heat sealer is manually operated used in small scale industries. In this machine, a plastic bag is placed between the sealing bar and heating pad. And then, sealing bar is pressed manually. When the sealing occurs, there is an indication of beeping sound, which is set as per the material of the bags. Due to manual press, sometimes more than required time, sealing bar was pressed. Hence, more heating applied on the polythene bag, which damaged the sealing material. Hence, it will consume more time to fill that product (like food, powder, etc.) in that damaged polythene bag to another.

To overcome that problem, we have design and fabricate a semi-automatic packaging machine, which seals the polythene bag with increased sealing quality without any damage to it. We are using electric and pneumatic system for fabrication of this machine. As we have requirement of increasing the production rate, we have used pneumatic system due to its fast response. In the setup, how we have used the pneumatic system and components is shown in figure 2.

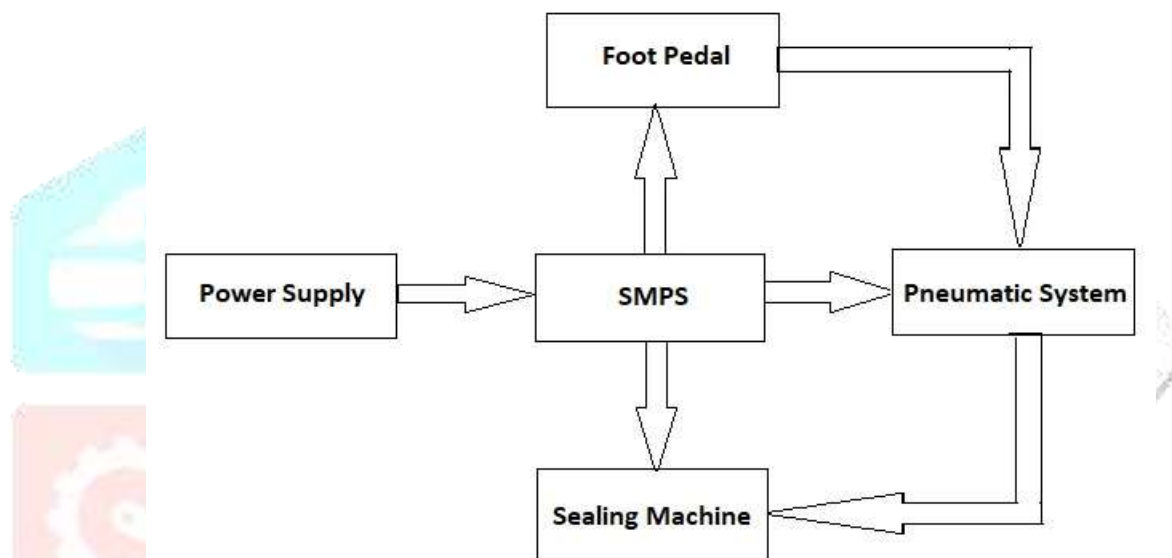


Figure-2 System Diagram

III. LITERATURE REVIEW

C.S. Yuan**et al*(2007) analyzed the effect of sealing parameter(Pressure) on OPP(Oriented Polypropylene) and MCPP(Metallic Cast Polypropylene) heat seal strength. OPP and MCPP are the one type of thermoplastic materials. Heat seal strength can be defined as the maximum force per unit width required to separate the heat seal. To obtain the value of heat sealing strength, they did a peeling test after the seal is cooled at the room temperature. In this test, failure modes at each pulled was examined to identify the acceptance level of each heat seals. After the test, it was found that failure of sealing of OPP/MCPP material occurred in three stages:

1. In peeling mode failure, when sealing made lower than the temperature of melting point of the sealing material, all tests are failed.
2. In delaminating mode failure, which involves the tensile break of the sealing material and separation of interlaminar bond.
3. In tearing mode failure, when the strength of the laminate structure is less than the strength of the heat seal and the interlaminar bond.

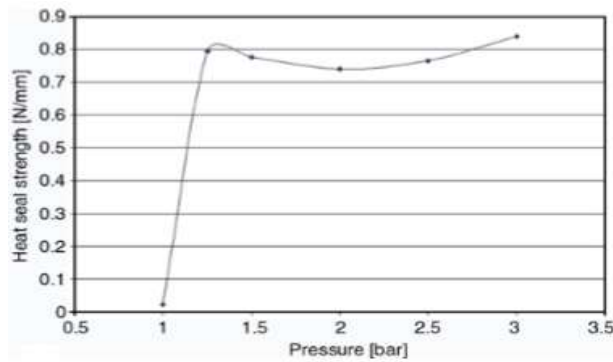


Figure-3 Plot of Heat Seal Strength versus Pressure

Figure 3 shows the effect of pressure on heat seal strength. As shown in figure 4, no sealing occurs at one bar pressure. At pressure 1.25 bars, sealing began. After 1.25 bar pressure, with increase in pressure, there is no significant changes occur in the heat seal strength. Hence, pressure level should be minimum 1.25 bars for proper sealing.

Venkatesa Prabhu* et al (2017) studied about selecting the proper method for position control of pneumatic actuator. The different methods analyzed in this paper for position control are Pulse Width Modulation (PWM) technique, Solenoid Valve, servo-pneumatic actuator system, PID controller. All the methods above given, Solenoid Valve is better for position control, because the position control was successfully implemented using solenoid valves instead in expensive servo valves. Hence, a fast, accurate and inexpensive pneumatic position control system of pneumatic actuator can be developed. So, this paper is helps in selecting the position control method in our design.

Shengzhi Chen* et al (2014) –This is about consumption of air and transmission (reaching time), which depends on pressure of compressed air in pneumatic system. In pneumatic systems, it is not easy to measure the air power flow due to its characteristic of compressibility of pneumatic system. In this paper, they were used air power meter (APM) to measure the energy consumption in pneumatic actuators. They are using meter-in circuit (forward stroke controlled) and meter-out circuit (reverse stroke control) for this research.

The effect of supplied pressure on transmission (reaching time) and energy consumption is given below:

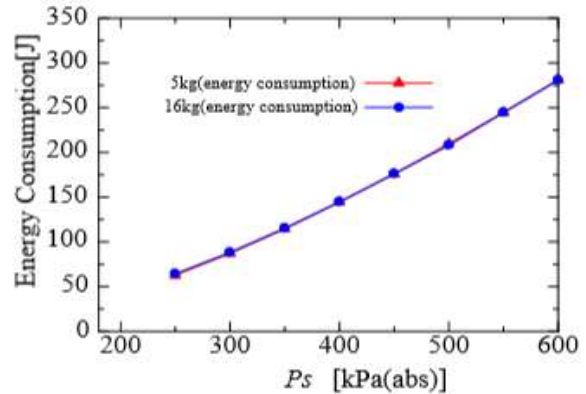
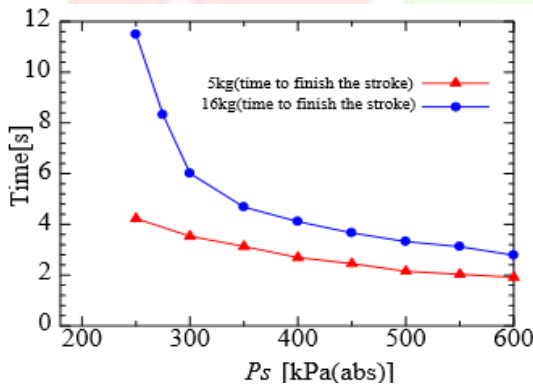


Figure-4 Relationship between supply pressure and reaching time

Figure-5 Relationship between supply pressure and energy consumption

As shown in figure 4, reaching time decreases with increase in supplied pressure. Hence, for fast approach, high pressure required. But, energy consumption is major function instead of reaching time.

As shown in figure 5, energy consumption increases with supplied pressure. Hence, supplied pressure should be given only required for our work. Hence, this paper is to be useful for energy saving research.

Christysofi M *et al (2016) - designed a packaging machine by using pneumatic system for the purpose of filling oil and seal the bag. They had used limit switches for pneumatic control. By using pneumatics, it is easy to find the problem and also achieved the fast response. This gives us the idea about to use pneumatic system instead of gear mechanism to reduce the friction. With the help of pneumatic automation, we can control the position of accumulators/cylinders easily. Also, due to fast response, it will increase the productivity.

Akinnuli B O *et al (2013) - designed a packaging machine by using charcoal as the source of the heat for sealing purpose. The machine consists of a heat chamber, supported by four mild steel angle iron stands. It has two jaws, in which one is fixed and one is movable with two coiled springs. Movable jaw was controlled by foot pedal. They did an experiment on this charcoal fuel operated packaging machine. As per the experiment, they have concluded that the efficiency of this machine is 85.6%. As the charcoal is available at cheapest rate, it is useful in rural as well as urban areas. But its disadvantage is that its relative efficiency with electrical sealing machine is 67.20%, which is very low due to human errors and heat loss.

Omar Lengerke *et al (2008) - designed and fabricated a low cost packaging machine for doughy products. It has feeding system, dosing system, packaging system and pneumatic system. Doughy products from the container filled in the film through dosing system. After filling, sealing process starts by actuating pneumatic system using pedal. The machine has two types of systems, electrical and pneumatic. The electrical system actuates the pneumatic system and controls the temperature of the sealing. The pneumatic system actuates the dosing valve and sealing process.

Charles Mbohwa (2015) – designed a small scale cereal packaging machine. It has a hopper from which the products to be packaged are poured through. The quantity of the product is controlled by the rotating weight meter below the hopper. The weight meter weights the product and its rotation provides the path to the product in the plastic film. Roller pair below the weight meter forms sealing between two thermoplastic layers and completes the sealing process. The other roller pair cuts the package from meshes. The package then slides by gravity through outer passage.

Nitin R. Deshmukh *et al (2017) – designed and fabricated a pouch filling machine using PLC. It has control processing unit for all control operations, data transfer and data manipulation. The machine uses the pneumatic cylinder to produce a force for filling which is controlled by PLC. Hence, by using PLC, entire process is automated by feeding the required data into it. And as per the developed system, all processes take place and filling and sealing of pouches are done accurately.

IV. CONCLUSION

This designed and fabricated packaging machine is produced and utilized satisfactorily in small scale industries and in shops. The machine has less initial cost compared to highly automated machines, which can be affordable by small manufacturers. For sealing, pressure of 1.25 bars or above is required. By using pneumatic for automation, due to its fast response, the production rate can be increased. Hence, customer satisfaction can be achieved. Due to automation, labour work can be decreased. There are less chances of burning plastic material compared to conventional methods of packaging. There is no skilled person required to operate this machine, hence less labour cost required. Also in pneumatic system, there is less chances of damaging of components. By using SMPS, which have low cost, it reduces the high cost of transformers. We have used 5/2 direction control valve instead of 4/2 direction control valve due to its advantage of low cost, dual exhaust and also due to dual supply port in it, use of different pressure for cylinder movement can be obtained. Hence, a fast, accurate and simple packaging machine for sealing the plastic bags is developed.

REFERENCES

- [1] C.S. Yuan, A Hassan “Effect of Bar Sealing Parameters on OPP/MCPP Heat Seal Strength” EXPRESS Polymers Letters Volume 1 No. 11 (2007) 773-779
- [2] D. Venkatesa Prabhu, A Sathishkumar, C Manibalaji, T Shakthivel, V Robin “Accurate Position control of Pneumatic Actuator Using On/Off Solenoid Valve” International Journal of Scientific Research in Science and Technology (www.ijrst.com) Volume 3 | Issue 1 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
- [3] Shengzhi Chen, Chongho Youn, Toshiharu Kagawa, Maolin Cai “Transmission and Consumption of Air Power in Pneumatic System” Energy and Power Engineering, 2014, 6,487-495

- [4] Christysofi M, Murugeswari M, Gurubalan R, Balasubramanani P, Maheswari M “Automatic Oil Packaging Machine Using Pneumatic System” Imperial Journal of Interdisciplina Research Volume-2, Issue-6, 2016 ISSN: 2454-1362
- [5] Akinnuli B O, Abadariki S O, Fasan J O “Design, Fabrication and Testing of a Charcoal Fueled Sealing Machine” Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 4(1): 89-93 © Scholarlink Research Institute Journals, 2013 (ISSN: 2141-7016)
- [6] Omar Lengerke, Carol Viviana Martinez “Mechatronics Design of a Low-Cost Packaging Machine for Doughy Products” ABCM Symposium Series in Mechatronics – Vol. 3 – pp.717-725
- [7] Charles Mbohwa “Design of a Small Scale Cereal Packaging Machine Suitable for Developing Countries” International Conference on Operations Excellence and Service Engineering Orlando, Florida, USA, September 10-11, 2015
- [8] Nitin R. Deshmukh, Prafull K. Patil, Akshay G. Shelar, Dnyaneshwar P. Jadhav, Pooja S. Gangurde “Design and Manufacturing of Shape Pouch Filling Machine” International Journal for Scientific Research & Development| Vol. 5, Issue 01, 2017 | ISSN (online): 2321-0613
- [9] Peter R N Childs “Mechanical Design Engineering Handbook” Chapter-18 Pneumatics and Hydraulics Butterworth-Heinemann is an imprint of Elsevier the Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, UK
- [10] Andrew Parr “Hydraulics and Pneumatics- A Technician’s and Engineer’s Guide” Third Edition (2011) Elsevier Retrieved from www.knovel.com
- [11] S R Majumdar “Pneumatic Systems- Principles and Maintenance” Mc Graw Hill Education ISBN-13: 978-0-07-460231-7 www.mheducation.co.in

