



## **Design of A Pedal–Operated Sealing Machine for Plastic Packaging Application**

*Ifeyinwa Faith Ogbodo<sup>1</sup>, Onyenanu Chukwunonso Nnanyelum<sup>2</sup>, Munachimso Obioha Onye-Ndimele<sup>3</sup>, Ogbodo Emmamuel Utochukwu<sup>4</sup>*

Department of Industrial & Production Engineering<sup>1,3</sup> Department of Chemical Engineering<sup>2</sup>, Department of Electronics & Computer Engineering<sup>4</sup>  
<sup>1,2,3,4</sup>Nnamdi Azikiwe University, Awka.

Email: [if.ogbodo@unizik.edu.ng](mailto:if.ogbodo@unizik.edu.ng), [cn.onyenanu@unizik.edu.ng](mailto:cn.onyenanu@unizik.edu.ng), [mo.onye-ndimele@unizik.edu.ng](mailto:mo.onye-ndimele@unizik.edu.ng), [emma.ogbodo@unizik.edu.ng](mailto:emma.ogbodo@unizik.edu.ng).

### **ABSTRACT**

This paper reports the development of a low-cost, portable, Pedal sealing machine for plastic application. The major components of the machine include: 24–30 volts transformer, heating element, electrical cables, plywood, tape (paper, Teflon, black) lever machine, Micro Regulator switch and on/off indication bulb. The project started with a thorough review of plastic materials, and Low-Density polyethylene was the material of focus and various methods of heat-sealing film packages. The machine can be used in sealing low, medium and high-density polyethylene. The product has a heating element, which converts electrical energy to heat energy, which is utilized in the sealing of the Material. It has high efficiency with a reasonable degree of accuracy. The machine was relatively cheap compared to imported types of the same capacity. It was tested and confirmed. The method employed involves the selection of appropriate materials, fabrication, design and assembly of the various components of the machine parts, industries are recommended to research into improvement of the machine.

Keywords: Sealing Machine, Plastic Packaging, Polyethylene, Machine.

### **1. INTRODUCTION**

Sealing and cutting machine is a machine that is used simultaneously to seal and cut polythene into different sizes depending on the required dimension. The portable sealing machine is one of the most important fabrications of engineers of 20<sup>th</sup> century, the achievements led to sweet relieve for Agriculturist, industrialist, marketers etc. For this purpose, the production of Agricultural and industrial goods which need appropriate attention for packaging and storage has been on the increase. Packaging is an important element of a product that is marketed in the market and ensures product safety. Consumers also play a role in determining the appropriate packaging method for the product. Product packaging method is one of the elements that need to be emphasized in planning the production of a product, especially for food products. This is because; they are products that are of daily necessity to consumers. In addition, the packaging method also reflects the quality of the product and the identity of the company that manufactures the product.

Product packaging methods include how the product is packaged, materials used in packaging, the features and specifications of the packaging. The process of selecting the best packaging method should be done so that the product produced easily gets a place in the market and can be marketed well. The best product packaging method is packaging that meets the needs of customers and can attract consumers to buy marketed products. This machine helps to speed up the process of polythene, plastic or aluminum foil packaging. Before the existence of this machine, the methods used to seal or preserve food, fruits, etc. are flame method sealing, the use of wax method, etc. the methods are less practical, and the result is less neat. Small entrepreneurs can use this machine because it can cover food packaging well and neatly. In addition, it can help to maintain the quality of food to avoid bacteria and air that can damage the quality of food. This machine has a very neat finish and can make food last longer. Not only dry food industries can use sealer machine, but wet food industries also use it. These sealing and cutting machine are widely sold in the market but many machines are sold in large sizes and the cost is also expensive. Also, this operates under low power supply. In the case of this project, we will be making use of polythene bag for the sealing and cutting operation. Polythene is a type of synthetic rubber widely used often as transparent sheets for waterproof packaging. Traders in the market require polythene bags in packaging commodities for their customer. The same material can be made in various shapes as long as packaging of goods is concerned. Previously, the packaging system was done using paper, clothing material, etc. Polythene or polyethylene is the most common plastic in use today. It is a polymer which is primarily used for packaging. Polyethylene is produced from ethylene, and although ethylene can be produced from renewable resources, it is mainly obtained from petroleum or natural gas transparency. This polythene can be obtained by the process of polymerization of organic compounds. Polyethylene (PE), despite having the simplest basic structure of any polymer (a repetition of CH<sub>2</sub> units), is the largest tonnage plastic material...The main attractive features of PE are its low price, excellent electrical insulation over a wide range of frequencies, very good chemical resistance, good process ability, toughness, flexibility, and-in thin films of certain grades-transparency (Ronca, 2017). Polythene sealing machine is a machine that uses the mechanism of light, heating materials or element to seal two impressed surfaces or even more impressed surfaces depending on the

usage and application of the polythene. The machine can be used to seal both low, medium, and higher density polythene. The use of polythene cannot be overemphasized, and food packaging is done for hygienic reasons technology of cellophane permits raw materials of textile industries to be carried with sealed polyethylene the finished products that are either marketed or exported with polyethylene packaging. Most utensils are packaged with polyethylene. Special polyethylene materials have been invented of recent that have shock absorber which gives protection to the breakable material. Since this packaging came up, there had been a safer conveyance of glass and ceramics materials, especially for transportation and exportation of finished goods. The use of a polythene sealing machine will produce a more attractive finished product (Grover, Gupta, Chandra, Kumari & Khurana 2015). There is obvious need for diversification of the Nigerian economy. We can start by producing some simple machine so that scarce of foreign exchange can be conserved for more need and essential goods. It will also enable Nigerian manufacturers to expand their industries there by making price of products relatively cheaper and affordable to majority of Nigerians compared with the imported ones. Developed countries like Japan started by producing simple machine using the abundant local raw material for the manufacture of goods that can also be exported in order to earn foreign exchange rather than exporting the raw material. There is great need to improve on the technological advancement in the country since, she is blessed with abundant material and human resources which needs to be tapped for useful purposes. This is the reason behind the modification of the simple machine (polythene bag sealing and cutting machine) to make it up to standard so it can be used in various industries, and this shows that this machine is one that is indispensable. The following indicates possible areas of improvement in the existing machine based on observed shortcomings and the perceived proactive alternatives. A pedal operated sealing and cutting machine is a type of equipment used to seal plastic bags or pouches by applying heat to the pedal-controlled sealing jaw. These machines are commonly used in packaging industries, retail stores, and food processing units to seal bags containing various products such as food, cosmetics, pharmaceuticals, and more. The machine is designed with a sealing jaw that heats up and fuses the plastic together, creating an airtight seal. The sealing jaw is controlled by a pedal, allowing the operator to keep both hands free to load and unload the bags. This feature enhances the efficiency of the packaging process. Overall, plastic pedal sealing machines are an essential piece of equipment in the packaging industry, providing a quick and efficient way to seal plastic bags and pouches. The packaging process was previously done by the use of paper bags but as time went on, this method changed to plastic packaging system and till date, it has been growing. With the invention or introduction of technology have made package and sealing important.

### **1.2 Statement of Problem**

Most Available Sealing Machine are Made Specially for Different Packaging Materials, also they are always expensive, the cost-effective ones needs Stabilizer to regulate the power, Also Some of the Available Machines require skilled Operators to operate them. This paper seeks to design a sealing Machine that can seal different materials, and also cost effective which do not need any Stabilizer to regulate it, as it will have its inbuilt Transformer, and will not require skilled operators as it will be made easy to use with low Maintenance and Operating Cost.

### **1.3 Aim and Objectives**

To design and construct a pedal operated sealing machine for plastic packaging application with less power consumption. The objectives are;

- To construct a machine that can efficiently and effectively seal plastic bags or pouches for packaging and transportation purposes.
- To provide the machine at a relatively cheap cost from locally gathered materials, thus, reducing the cost of production of sealing machine.
- To create a tool that can help businesses improve their packaging processes, increase productivity, reduce waste, and enhance the overall quality of their products.

---

## **2. LITERATURE REVIEW**

The history of plastic dates back to the mid-19th century when the first synthetic polymer was invented. The material was made from cellulose and was used as a substitute for ivory in billiard balls, buttons, and other items. However, this early plastic was not very durable and had limited applications. In 1907, Leo Baekeland invented Bakelite, the first synthetic plastic made from a combination of phenol and formaldehyde. Bakelite was a durable and heat-resistant material that was widely used in electrical and mechanical applications, such as telephone cases and electrical insulators. In the 1970s, environmental concerns about plastic waste and pollution began to emerge. The development of recycling technologies and biodegradable plastics was pursued as a solution to the growing environmental impact of plastic waste. Since then, plastic has continued to evolve, with new materials and technologies being developed to address environmental concerns and improve the sustainability of plastic production and use. Today, plastic is a ubiquitous material used in a vast array of products and applications, from packaging and construction to medical devices and electronics (Grover et al, 2015). 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 (Cantwell et al, 2015). Sealing machines close and seal an individual package or provide a long continuous horizontal or vertical seal. There are many different types of sealers. Sealing machinery that combines form, fill, and seal functions is also available. Some sealing machines transport the plastic film horizontally, while others transport vertically (Dudbridge, 2016). Seal equipment wraps or secures products but does not form packages or fill them. Semi-automatic sealers help with both packaging and placement, allowing a single operator to perform several activities with greater speed and accuracy. Fully automatic sealing equipment requires limited operator intervention. Typically, operators need only replenish packaging components by loading supply hoppers or removing completed cartons. One of the main differences between semi-automatic and fully

automatic sealers close all of the flaps, including the leading, trailing, and side flaps before taping, while semi-automatic sealers tape only the top and bottom (Ronca, S. 2017)). This paper seeks to understand the Low-density polyethylene type of plastic packaging materials and its properties like Melting point that affect the sealing process, choose the Hot-bar Sealing method which is an effective method for sealing LDPE materials due to its ability to precisely control the heat and pressure applied, its efficiency and cleanliness, and its flexibility in sealing complex shapes and designs; and Produce a Sealing Machine that can operate Efficiently even at the lowest power.

### 3. MATERIALS AND METHODS

A mild steel was used for major part of the Plastic sealing machine, for constructing the square pipe and in making the pedal mechanism part of the machine owing of some desirable (appreciable) properties of mild steel. These desirable qualities of mild steel in constructing Pedal sealing machine include the following among others:

#### 3.1 Heating Element

The main function of the heating element into heat energy for easy sealing of the Plastic. The heating element has rotating power of about 200 watts. For much conversion of electrical energy into heat energy, the element must have a very high resistance to the flow of current. The current passes through it from the current source and it gets heated thereby doing the sealing. On and off indicating bulb: It contributes greatly to the proper functioning of the machine. It serves as a controller which shows whether electrical current is entering the machine or not, hence the bulb will be on, showing red light but if it is not entering, the bulb will be off. Tension spring: The smaller tension spring is needed to provide accommodation for the expansion and contraction of the heating element when heated during the sealing operation. The larger tension spring is used for controlling of the mechanism part of the machine. A tension spring is considered suitable because of its high elasticity. Bolt and nut: Bolt and nut made of mild steel is need for the coupling of the parts of the machine. Micro switch and regulator: The micro switch is necessary for bridging and breaking of electrical circuit. it is used to regulate the temperature of the sealing element. Materials and Methods

A mild steel was used for major part of the Plastic sealing machine, for constructing the square pipe and in making the pedal mechanism part of the machine owing of some desirable (appreciable) properties of mild steel

#### 3.2 Machine Description

The machine consists of a number of units namely: the cutting and sealing unit, drive mechanism, frame and electrical system. As shown in Figure 1 the cutting and sealing unit is made up of a heating element and foam that aids uniform distribution of pressure. The length of the heating element which is the same with that of the foam strip is 62 cm. This length was chosen due to the fact that no single package length could be more than this. The foam is overlaid with a heat resistant material called Teflon. This is to avoid the burning of the foam under intense heat from the heating element. As the element is heated by the passage of current, its temperature rises therefore making it to expand and sag. This can lead to uneven cutting and sealing operation. It can equally cause the rupturing of the element. To check this, a switch regulator is connected within the circuit as shown in Figure 1. This limits the time in which current passes through the element. With this measure, only the heat required for cutting and sealing is generated and the unwanted sagging effect is reduced to the barest minimum. Thus, the switch regulator helps to save energy and to prolong the life of the heating element which is an improvement on what is already in existence. The drive mechanism consists of the pedal, the twine and the arm on which the heating element is connected. As shown in Figure 1, the pedal is connected to the arm by a twine and the position of the arm is controlled with a rubber band.

Underneath the arm is a heat resistant material called asbestos which protects the arm from being burnt by the heating element when red hot. The pedal measures 72 cm and runs through the length of the sealing table to aid operation from any sitting position on the sealing table.

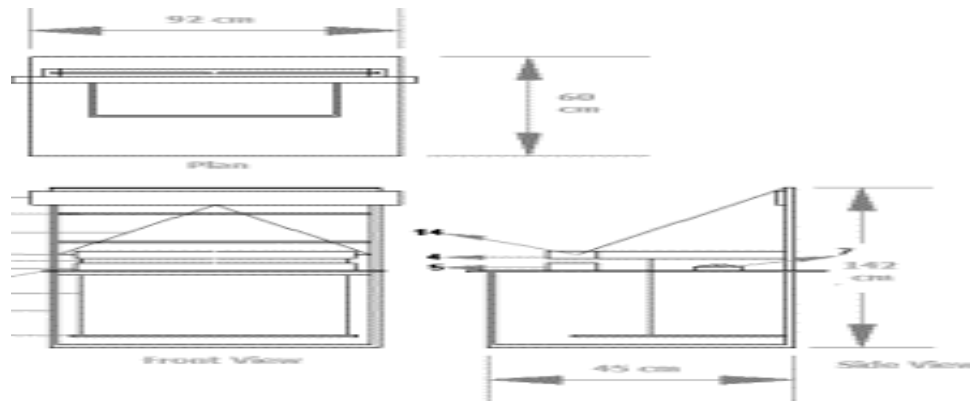


Figure 3.1: Pedal Twine to the Hand of the Machine.

In any engineering design and construction work, it is usually necessary to state the steps taken in producing the desired product. Thus, in the construction of a portable Plastic sealing machines the following steps were involved.

Transformer is made from two bar magnets which possess North and South poles was brought in separate cores and were bounded together 800 turns of 0.03mm diameter of copperwire was wound round the core to form the primary part of the transformer and 150 turn of 0.25mm diameter of copper insulating the primary to form the secondary part of the transformer.

- $E_p \propto N_p$
- $E_p =$  primary voltage = 30V
- $E_s =$  secondary voltage =25V.
- $N_p =$  number of primary turns
- $N_s =$  number of secondary turns
- $t =$  turns ratio

After all this, it was tested with an induced voltage at 25 – 30 volts. Ensuring that the transformer

**The calculation:**

### 3.2 Transformer Design

The transformer is a static electronic device consisting of two closely coupled coils(primary and secondary). Its job is to either step up or step down the AC supply to its primary side through induction to the secondary side stepped up/down. An ideal transformer has the following characteristics (See Appendix)

- 1 Sealing temperature: The sealing temperature is an important parameter that affects the strength and quality of the seal. The temperature is usually determined based on the melting point of the Plastic material. The melting point of Plastic is around 130-170°C, so the sealing temperature.
- 2 Sealing time: The sealing time refers to the duration for which the heat is applied to the Plastic material to create the seal. The sealing time depends on the thickness of the Plastic material and the sealing temperature. Typically, the sealing time is in the range of 1-3 seconds. We Calculate the approximate sealing time based on the thickness of the Plastic material and the sealing temperature. A general rule of thumb is to use a sealing time of 1-3 seconds per 0.01mm of Plastic thickness. For example, if the Plastic material is 0.02mm thick and the sealing temperature is 180°C, the sealingtime can be calculated as follows: Sealing time = 2 x 1-3 seconds per 0.01mm x 1.5 (factor for hightemperature) = 3-9 seconds.
- 3 Sealing pressure: The sealing pressure is the force applied to the Plastic material to create the seal. The sealing pressure depends on the thickness and type of the Plastic material, as well as the size and shape of the object being sealed. Typically, the sealing pressure is in the range of 1-5 kg/cm<sup>2</sup>.
- 4 Conveyor speed: The conveyor speed refers to the speed at which the object being sealed moves through the sealing machine. The conveyor speed needsto be set based on the desired production rate and the sealing time. If the conveyor speed is too fast, the sealing may not be strong enough, while if it is too slow, the production rate will be low.
- 5 Power consumption: The power consumption of the sealing machine depends on the size of the machine, the sealing temperature, and the sealing time. Typically, the power consumption of a Plastic sealing machine ranges from 10-300W.

## 4. RESULT AND DISCUSSION

The portable Plastic sealer is found to be highly efficient after its modification. The machine has a metal frame coated with paint to avoid rusting and plywood, thick enough to withstand any load to avoid damage. The density of Plastic material ranges from high, medium and low-density types each of these class of Plastic has a peculiar product or process that it is utilized. The filament (element) is a good conductor of heat and electricity and can therefore easily convert electrical energy to heat energy. This makes it possible for the filament if heated, it expands and if it is continuously used to seal Plastic, distortion is likely to occur on the product. To avoid this, the bolts used for holding the filament were inclined away from the filament. Also, a spring was attached to the bolts at the ends of the filament to increase tension and give a straight cutting and sealing.

There exists various Plastic cutting and sealing methods. They include mechanical sealing, high frequency heating, ultrasonic sealing, heat sealing, use of adhesives etc. The choice of a particular method depends on a number of factors including the sealing characteristics required, the nature of the film to be sealed, production speed and the cost effectiveness of the materials of construction and power sources. The effectiveness of a sealed Plastic can be ascertained by inflating with water or air and then exerting pressure on the bag, any leakage will be manifested by escape of air or water from the bag. The heat-sealing method is efficient because of its fast production speed, effective and less energy consumption, the ease of fabrication, and low cost of

the materials of construction. Heat sealing method can be in the form of heated wheels for band seals, high frequency heat sealing, flame sealing hot wire sealing, etc. The one adopted for this paper is the hot wire sealing due to its ability and ease to cut and seal effectively and simultaneously.

The result shows that this portable Plastic sealing machine has a capacity of 7200 sealed bag per hour at 50 milliseconds Per bag, With no downtime, at 50 milliseconds per bag, an average of 8 working hours per day gives 57,600 sealed bags (from the table 4.1 below). However, the machine can work for 24 – 48 hours depending on the need of production before maintenance.

The Machine can be used to seal different range of plastic bags and pouches and other materials too.

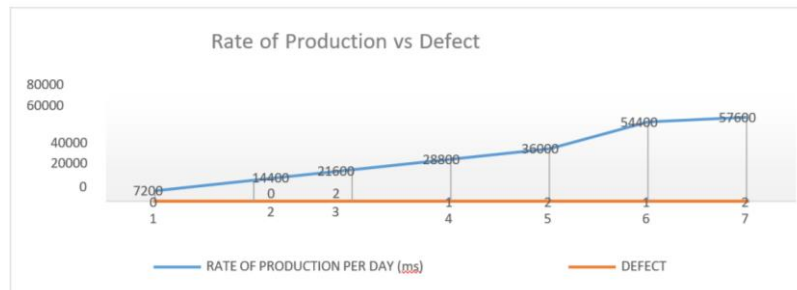


Figure 4.1: Chart of Rate of Production Versus Defect for Sample Week

Table 4.1: Defect Versus Rate of Production for a Sample Week

Defect	Rate of Production (ms) Per day
0	7200
0	14400
2	21600
1	28800
2	36000
1	50400
2	57600

## 5. CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion and Recommendation

In conclusion, it is vital to conclude that engineering materials such as mild steel, heating elements, transformer, plywood, Formica, Foam, Indicator LED, switch and others can be successfully assembled into a fine and portable Plastic sealing machine that is available and relatively cheap. The hot bar sealing method used is preferable to other sealing methods because of its cheapness, leakage proof, less prone to fire hazards or over loading/overheating and its good sealing quality. It is recommended, that, locally manufactured Plastic sealing machine should be used in industries; because of its low cost of fabrication and operation. As well as its low power consumption and simplicity of its mode of operation together with its portability.

### REFERENCES

- Cantwell, M., Cantwell, M., Davison, B., & Gonyea, C. (2015). *Heat Sealing Fundamentals, Testing, and Numerical Modeling*. <https://digital.wpi.edu/downloads/f7623f11j>
- Dudbridge, M. (2016). Handbook of Seal Integrity in the Food Industry. *Handbook of Seal Integrity in the Food Industry*. <https://doi.org/10.1002/9781118904619>
- Grover, A., Chandra, S., Paul Khurana, S., Gupta, A., & Kumari, A. (2015). Polythene and Environment IPA-Under Creative Commons license 3.0 Polythene and environment. *Article in Environmental Sciences: An International Journal of Environmental Physiology and Toxicology*, 5(6). <https://doi.org/10.6088/ijes.2014050100103>
- Ronca, S. (2017). Polyethylene. In *Brydson's Plastics Materials: Eighth Edition* (pp. 247–278). Elsevier Inc. <https://doi.org/10.1016/B978-0-323-35824-8.00010-4>.