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Original Research Article

Design and Fabrication of a Polyethylene Sealing Machine for Packaging Unripe Plantain Flour

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ABSTRACT

Heat sealing is one of the most commonly used methods for sealing polyethylene of either a high density or a low density. Local farmers either expose their products without sealing or use sealing machines that do not achieve a perfect seal. To prevent this problem, an affordable heat-sealing machine was designed and fabricated using locally available materials. The polyethylene sealing machine designed and fabricated could seal a package within 10 secs.

1. INTRODUCTION

Nowadays, the commercialization of food is not conceived, without the use of any type of packing that contains and protects it from its primary production until it reaches the consumer (Tijskens et al., 2001). Packages have many functions like containing specifications, preservation and protection role, to inform the consumer, to sell the product and to reduce losses, damage and waste for distributor and customer and to facilitate storage, handling and other commercial operations (Weber, 2000). Packaging has progressed from the functional to the expressive as a result of some factors: to motivate customers to buy the product and to convey a suitable product image for selling (Maroulis and Saravacos, 2003).

It is very common to find products packed manually without any type of sanitary control, neglecting completely the quality of the product. This frequent situation makes the consumer the main victim. Few farmers know the advantages of applying technology to the packing process of their products (quality and economy), since at glance the raised costs offered in the market are not reachable to many of the possible consumers that do not have enough resources (EHEDG, 2001).

Heat sealing is a process of performing sealing operations with the use of heat to melt the substance or in this case the polyethylene, with the application of little amount of pressure to make a seal. The major mechanics of this concept involves the concept of heat transfer, as heat is transferred from the heating element in the sealing machine to the polyethylene, which melts a little and with the application of a little pressure, sealing takes place (Hishinuma, 2009).

Unripe plantain flour produced by our local farmers has gain usefulness in Nigeria today. One cannot but sight the way in which this flour is packaged locally by these farmers. Some of these farmers expose their products allowing it to attract different types of bacterial and germs others use local bags with ropes as a means to seal (Tawanda and Charles, 2015). Some of the heat sealing methods available to the local farmers have varying problems like the burning of part of the polyethylene they are meant to seal, hands as well as the local farmer's body are exposed to fire burns while some take longer time to seal (Tawanda and Charles, 2015). This work sought to design, fabricate and test an affordable polyethylene sealing machine that can hold 5kg of unripe plantain flour using locally available material.

2. MATERIALS AND METHODS

2.1. Material Selection

Mild steel was the basic material used for this design, because of its availability and ease of fabrication.

2.1.1. Selection of heating element

Heating elements are made of Nichrome. They usually come in flat or round shapes. When it comes to heat sealing polyethylene bags, the heating element typically used are flat wires. Round wires are typically meant to be used to cut and seal on shrink bags (Callister and Rethwisch, 2012). For heating elements to function properly, there must be no hot spots; this is so to help avoid breakage. Heat is generated only when there is a flow of electric current through the element, which then generates heat due to the resistance it offers to the flow of electricity (Callister and Rethwisch, 2012). In this design however, the flat wire type of heating element was selected.

2.2. Basic Design

Polyethylene generally has a melting point of about 115 ^{o}C – 135 ^{o}C. When polyethylene is heated to a temperature that is slightly below or equal to this range, with the application of slight pressure sealing can be attained when the material is cooled (Bergman et al., 2011).

2.2.1. Design calculations

Polyethylene has a melting temperature, T 115 ^{o}C to 135 ^{o}C

Maximum seal length of polyethylene, L = 200 mm

Maximum seal width of polyethylene, W = 2 mm to 5 mm

Power of the heating transformer, P = 600 W

Voltage, V = 240 V (indigenous voltage supply in Nigeria)

From the relation P = IV

$$I = \frac{P}{V} = \frac{600}{240} = 2.5A$$

Where, P is the power of the transformer, I is the current and V is the voltage supply

Calculating for resistance of the heating element (R):

From Ohm's law:

$$V = IR \tag{1}$$

$$R = \frac{V}{I} = \frac{240}{2.5} = 96\Omega$$

2.3. Manufacturing Process

The manufacturing process utilized in this design and fabrication was (Kalpakjian and Schmid 2006):

- Measurement
- Welding
- Painting

Measurement was applied to get the length and width of the machine. Arc welding process was used for the assembling of the body to get the desired shape. Painting was used for surface finishing to beautify the work.

2.4. Principle of Operation of the Polyethylene Sealer

Two film layers were placed between two jaws, a seal bar (2) and a counter jaw (3), which press them together. The heating element (4) was provided with a thermal and electrical insulation on the support's side and a non-stick coating (5) on the film's side. The counter jaw was also thermally and electrically insulated. An impulse of electrical current was passed through the heating element causing it and the film layers beneath it to heat. The heat causes the film layers to plastify, fusing them firmly together, which equals sealing. The most important influencing variables for the sealing process are pressure, temperature and time.

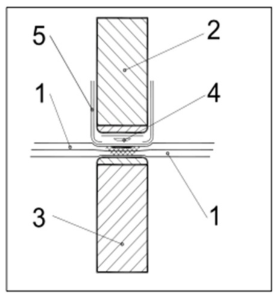

Figure 1: Cross-section of a polyethylene sealing machine

The sealing process is generally followed by a cooling time during which the plasticized material is allowed to cure to its full strength. The most important factor is the strength of the seal achieved by using this method. An electronic temperature control was used to produce sealing seam in a constant quality. The use of a temperature control is advantageous, especially when working with thick film materials, as the temperature can be kept constant over a pre-set time.

3. RESULT AND DISCUSSION

Figure 2 is the designed and fabricated polyethylene sealing machine. The performance of this machine was evaluated simply by supplying an alternating current of 240 V to the machine through the connection plug been connected to the mains or socket. A low density polyethylene was slotted in between the sealing elements of the machine, and the temperature control switch was set to the required sealing temperature (115 ºC – 135 ºC). It was observed that as the upper handle of the machine made contact with the lower handle and impulse current was generated it resulted in the heating up of the element and with seconds, sealing was achieved. It was observed that the machine could seal 6 – 15 packages per minute, meaning an average of 10 seconds for the designed machine to seal one package.

(a) (b)

Figure 2: (a) and (b): the polyethylene sealing machine designed and fabricated

4. CONCLUSION

The heat sealing machine has been designed, fabricated and performance evaluation has been carried out. The design was based on low density polyethylene, hence, it should not be used for high density polyethylene sealing. The machine has the capability of sealing one packet which weighs 5 kg every ten (10) seconds.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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