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MACHINE DRILLED POLYETHYLENE FILM FOR MODIFIED ATMOSPHERE PACKING

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ABSTRACT

Modified atmosphere packing (MAP) is used to increase the shelf life of fruits and vegetables. Plastic films for MAP require perforations with diameters ranging between 50 and 200 µm. This drilling process requires an automatic machine for plastic film punching. A transmission-based cam was used so that hot needles perforated the film while it was stationary. The transmission disk allows the cam to rotate when the plastic film is moved horizontally. When the cam stops, film movement ceases and the plate with needles attached moves down punching holes in the film. In order to produce well-formed circular perforations it was found that optimum needle temperature was 90°C and that the plastic film tension should be maintained at 80 N. When the machine is required to process several bag sizes, the cam transmission is replaced by an electronic controlled clutch system. Two clutches are used in order to synchronize the roller movement and the plate punching. Only one clutch operates at a time and the clutches are activated by an encoder signal.

KEYWORDS : modified atmosphere packing, drilling, needles, machine control

INTRODUCTION

Modified atmospheres inside containers are determined by the total area of micro-drilled perforations in the film (50-200µm in diameter) [1]. Modified atmosphere packing (MAP) of fresh fruit and vegetables is based on the management of O2 and CO2 levels in the atmosphere within a sealed package. MAP works by reducing the respiration rates, ethylene production, physiological changes, inhibiting enzymatic chemistry and microbiological mechanisms that decompose fresh products. It provides an alternative, in some instances, to freezing, dehydration and sterilization. [2, 3]. The atmosphere inside a package requires a fine balance for effective product conservation. Changes to the atmosphere within a package are influenced by the size and number of perforations in the polymer film as well as film permeability.

The objective of this work was to design a machine that was capable of drilling precise perforations in polymer film using a roll-roll system at low speed and heated needles. The accuracy of the drilled holes, as a function of the needle temperature, was also analyzed.

MACHINE DESIGN AND OPERATION

Polypropylene film is inserted in roller A of the machine, (Fig. 1). The plastic film passes through the machine and winds up on motorized roller (F). Rollers (B) and (E) tighten the polypropylene film, while rollers (C) and (D) flatten the film flat in preparation for drilling. A stainless steel plate (D) with holes moves vertically controlled by a cam transmission system. The plate holds the needles using a LEGO system for easy interchange and installation. Depending on the size of the bag, some bags may require 5 perforations while others may require 15 perforations, not always in the same place.

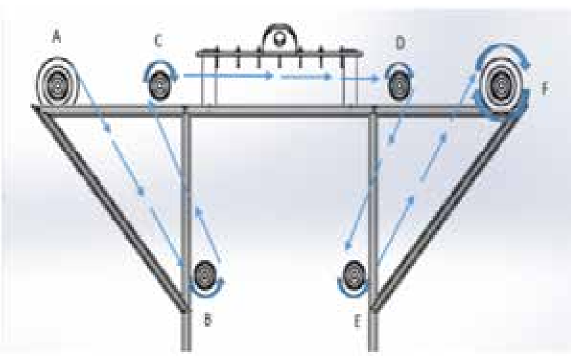


Figure 1: machine design.

Each of the rollers has two circular limit spacers so that the plastic remains correctly aligned during the process. Rollers (A) and (B) run without any traction.

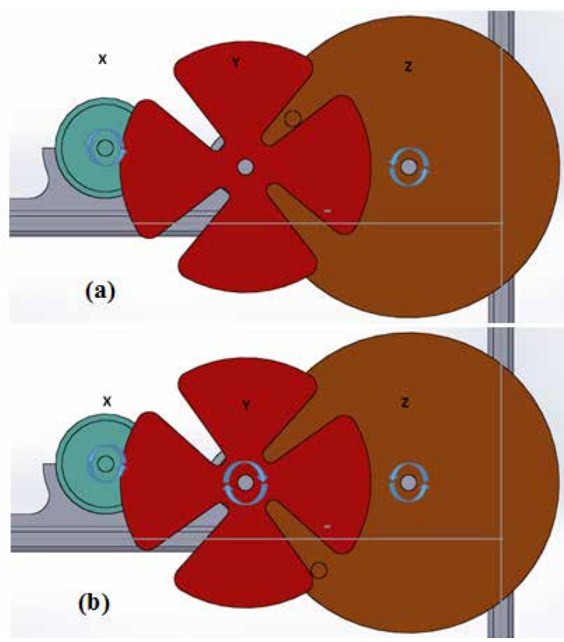


Figure 2: Motor, cam and disk (a) before cam turns and (b) after cam turns.

The machine´s motor (X) is connected via sprockets and a chain to the transmission disk (Z) which drives the machine via control chains. A rod in the transmission disk moves the cam, Fig. 2a. The cam is clover-shaped and contains four slots. The transmission disk turns continuously and the cam turns on periodically, (Fig. 2b). The cam is moved when the transmission disk rod enters the slot.

The timing of the machine is essential for effective function. When the plate moves, the traction roller (F) must be motionless. When the cam (Y) is stationary, the connecting rod (G) transfers? motion to the plate (H) making the perforations in the plastic film, (Fig. 3).

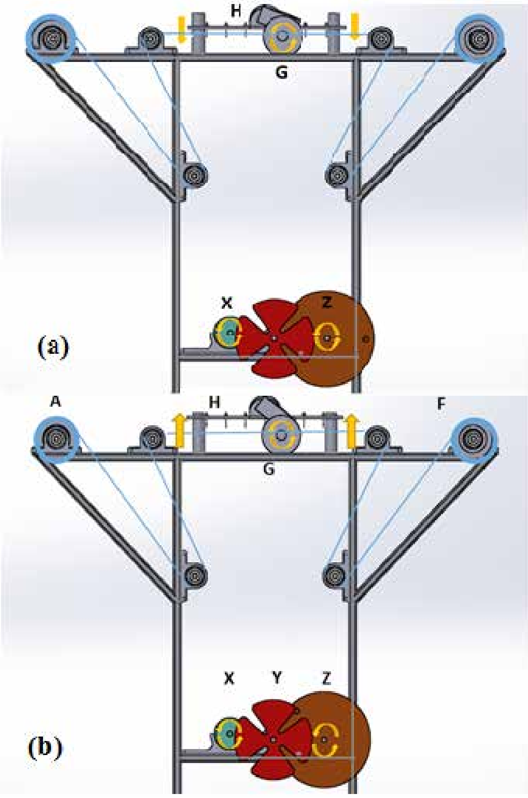


Figure 3: Movement of the plate (a) down and (b) up during film perforation.

Once the film has been drilled, the plate containing the needles rises (Fig. 3b); the motorized roller (F) starts turning and pulls the perforated film. At this point, the cam turns and moves roller (F) via a sprocket and chain transmission

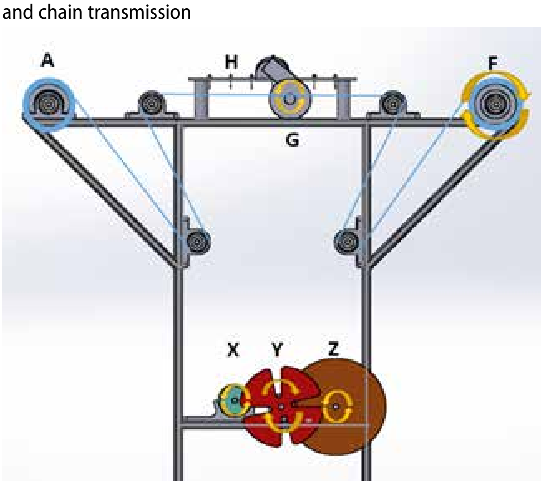


Figure 1: rolling of the film in the motorized rollers.

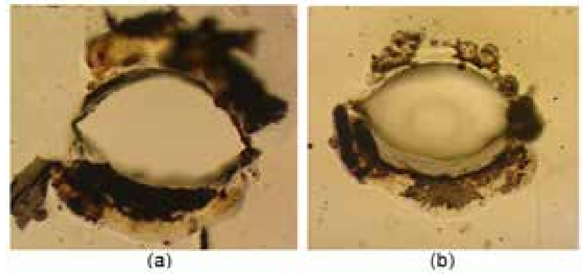
NEEDLE TYPE & TEMPERATURE

Needles from insulin syringes (0.3mm diameter) as well as tailors' needles were used in testing. A small heating wire (resistance) was fixed to the needles and connected to a power supply so that the needles heat by conduction. Before the plate shifts vertically the needles should be at the required temperature which is maintained by an Autonic TC4S PID temperature controller.

RESULTS

Holes punched by tailor's needles gave better results [4], based on observations of their circularity using a X100 digital microscope. A temperature of 90°C produced the most accurate perforations in the film. The tension of the film is important for obtaining circular holes.

Figure 3: orifice (a) after needle insertion and (b) without insertion.



When the heated needle pierces the film a hole is formed (Fig. 3a), leaving burnt plastic burrs on both sides of the film. A pair of plain aluminum sheets 5 mm thick and 20 mm wide were placed just outside the moving plate, one beneath and one over the plastic film, to remove the remaining of this residue (burr). Without these aluminum sheets, the hot burrs cause damage in other film sections. This problem was solved by using the pair of aluminum sheets.

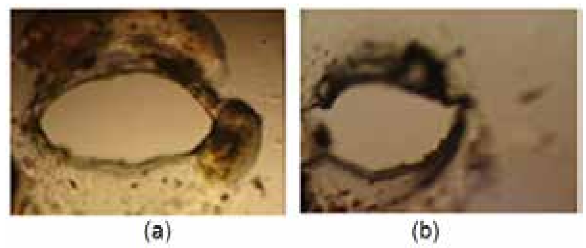


Figure 4: orifice with film tension of (a) 60 N and (b) 80 N.

When the plastic tension is maintained close to 80 N, the hole remains circular; however if the tension decreases an ellipse-shaped hole is formed. A micro switch was used to retain the tension close to 80 N. The speed of the traction roller did not affect cavity punching. If a larger bag is required the cam has to be changed, or an electronic control implemented. Using this method it was found that the permeability of the controlled atmosphere bag operated satisfactorily [4].

NEEDLE PERFORATION CONTROL

In order to accommodate different film lengths (for different sized bags), two motors with respective drives are required. The first motor drives the film movement, while the second moves the plate vertically. In order to avoid continuous motor stops a clutch is used to stop each motor motion.

As the film roller rotates and the plastic unwinds, a rotary encoder sensor detects film advance and the limit switch indicates if the tension is correct. Each bag size can be programmed and corresponds to an encoder increment. As the film advances the encoder value increases and when it reaches the set point fixed for the proper bag size it activates the clutch. The clutch isolates the driving sprocket from the motorized roller (F), stopping film movement. One second later, the second motor is powered up, after the clutch is deactivated, causing the plate to move down and punch the film. After an additional second, the needles go up leaving the plastic film free. At this point the perforations have been made and the traction roller requires turning again. This action repeats continuously until the orifices of the entire film roll have been completed.

It is very important to maintain the needle temperature within the range of 88°C to 92°C for optimum orifice formation.

CONCLUSIONS

A machine was built to continuously precision-drill microscopic perforations in plastic film. The motor remained running while a cam synchronized the film rolling with the needle punching. When punching takes place, the motorized roller is stopped to produce circular holes. The plastic tension has to be maintained at 80 N, while the needle temperature should be close to 90°C.

This system is very simple but only works for one bag size. If several bag sizes have to be drilled an electronic controlled system based on a rotary encoder is used. The control activates two clutches, which ensure that only one movement takes place at a time, even though the motor runs continuously.

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