ISSN 2250-3153

Design of Automated Low Cost String Hopper Machine for Medium Scale Industry

B D N Mendis, Nimali T Medagedara, D C Wijewardene

The Open University of Sri Lanka

***Abstract*- C**urrently, many types of string hopper machines are available in Sri Lanka. One is a rotary type and the other one is the lever type string hopper machine. Rotary type machine which is available in the local market has a main drawback of having to remove the cylinder for each batch of 100 string hoppers [1]. For this task handle should be rotated until the rack comes to its uppermost position which makes the operator fatigued and consumes more time.

Another one is the lever type string hopper machine which is operated by a lever mechanism connected to a piston. Disadvantage of this machine is for each 15 hoppers, the cylinder should be refilled.

This paper discusses the design of an automated low cost string hopper machine to be used in medium scale industry.

The designed new machine has an ability to stop the string hopper mold rotator at the required position, ease of feeding, and better accessibility for cleaning. The proposed machine is also is affordable in price, particularly for the small and medium scale string hopper manufacturers.

***Index Terms*-** Design, Automated, Low cost, String Hopper Machine

I. INTRODUCTION

String hoppers are a traditional meal in Kerala, Tamil Nadu and Sri Lanka consisting of rice flour pressed into noodle form and then steamed.

Before making string hoppers we have to pass several steps. Normally this is a manual process. In Sri Lanka there are a lot of individuals involved in string hopper manufacturing industry, using the traditional string hopper press or with the modern hand operated lever type press. It is a very tedious and time consuming process.

In string hopper manufacturing industry, the flour mixture is formed into strings using extrusion process. In the extrusion process a material is pushed through a die of the desired cross-section. It is a very common application in food processing.

The main parameters required for automating the string hopper making process has been taken into consideration when designing the machine.

First the flour mixture should be feed into the machine. Then the empty molds should be placed at the proper place where the flour strings are forming. When the machine is switched on, the flour mixture should be extruded to form the flour strings. While the strings are forming, the mold should be rotated. When the mold is filled up to the required amount, further forming of the strings should be stopped. Then the mold with the string hopper is shifted away from the extruding unit.

II. DESIGN AND CALCULATIONS

2.1 Design for the extruder

This machine is designed to be used for batch production process. Due to this, material (flour mixture) is loaded to the machine in batches manually. A piston extruder is selected to extrude the flour mixture as it is easy to clean when compared with the single or twin screw extruder.

2.2 Design of the cylinder

The "cylinder" is the vessel in which the flour mixture is compressed by a piston. Bottom of the cylinder has the extruding die. After daily production, the cylinder should be washed and cleaned. Therefore the cylinder is made out of stainless steel. The cylinder capacity of the design is considered to be 100 string hoppers, totaling up to 1.5kg flour mixture.

The density of the flour mixture is found experimentally as $1072 kgm^{-2.}$ Therefore the dimensions of the cylinder are calculated as 6cm diameter and a height of 50 cm.

2.3 Extruding die

The string hoppers available in the market have a 5-7cm diameter approximately. Change in the 5cm diameter of the extruding die may affect the appearance of the string hopper which is produced from the proposed design. Therefore the diameter of the extruder die was selected as 5cm. Cylinder die is fixed to the cylinder from a threaded end cap.

2.4 Design of the piston

A piston is used to compress the flour mixture in the cylinder which makes the flour mixture to squeeze through the tiny holes in the extruding die. Piston contacts directly the flour mixture. Therefore piston should have hygienic conditions. Plastic materials such as HDPE or LDPE which are hygienic have a low strength [2]. Due to this stainless steel was selected, which has a high strength and hygienic qualities.

When the piston compresses the flour mixture, the mixture can squeeze through the piston clearance. To eliminate this, a rubber seal was fixed to the piston. This NBR-food grade rubber has hygienic conditions and it has a lower price when compared with the other material.

2.4.1 Design of the piston driving system

The rack and a pinion mechanism, is used to drive the piston as it has a higher overall efficiency.

2.4.2 Piston force calculation

Piston force is required the piston to compress the flour mixture through the extruder die. For this, the speed or the time of the strings falling from the extruding die was experimentally detected and it was about 5s.

2.5 Motor selection

The actual required power of the piston was calculated for the design and a 4 Pole induction motor[3] with a 1400 rpm was selected. Rated power of the selected motor is 0.18kW.

2.6 Power transmission system

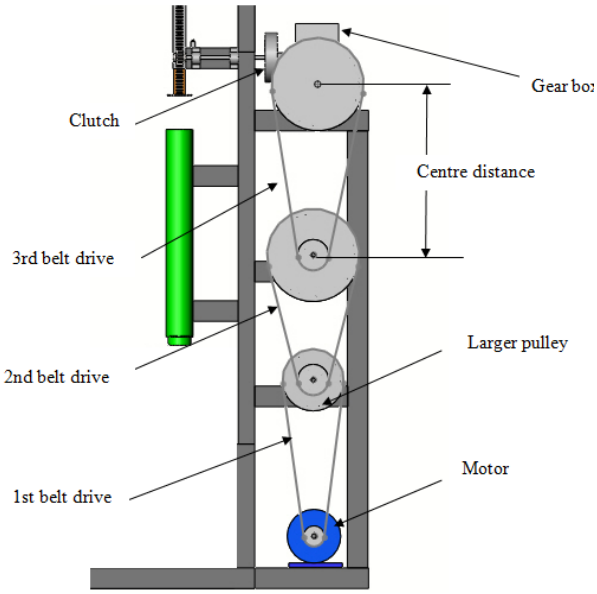

Fig.1.0 Configuration of the power transmission system

Fig.1.0 shows the method used to transmit power to the pinion. Power of the motor is transmitted to the pinion through belt drives, worm gearbox, speed reducer and an electromagnetic clutch.

2.7 Pneumatic system

A pneumatic system can be used instead of the mechanical piston driving system. Pneumatic system consists mainly with a pneumatic cylinder, air compressor and a pressure regulator[4]. Pneumatic cylinder is operated from compressed air. But when the cost is considered mechanical piston driving system is favorable to drive the piston as the total amount for the pneumatic system is approximately 50,000 rupees including the compressor.

2.8 Mold rotator

Fig.2.0- Mold rotator

Mold rotator which shows in Fig.2.0 is a disc which rotates around its centre under the extruding die. Mold rotator consists of a mold holder, limit switch, disc and a driven wheel. Mold holder is a plastic disc fixed to the limit switch and the limit switch is fixed to the disc which is connected to the driven wheel. Before producing a string hopper, an empty mold should be kept on the mold holder manually.

2.8.1 Cutting unit

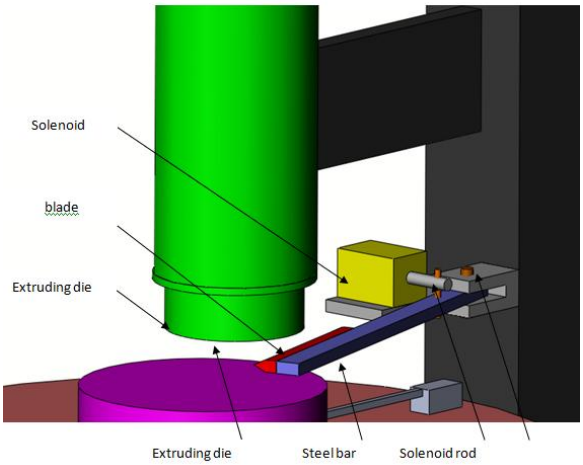

Fig.2.0- Cutting unit

Fig.2.0 is an image of the cutting unit. The cutting unit cut the strings which are linked between the mold and the die. This unit consists mainly with a solenoid actuator[5] and a blade. Solenoid energizing and de-energizing is controlled by the electronic control unit.

To operate the devices, relay switches were used. The relay switches for the solenoids must have a 5V input voltage and 12V output voltage and for the clutch and the motor have a 5V input voltage and 24V output voltage. Therefore the final relay switch was selected according to the requirements of the clutch.

III. CONCLUSION

1. In this project, a new automated low cost string hopper machine was designed and was avoided several problems which was identified in existing machines in local market.
2. In this design making the mold shift away from the extruding die the problem of inability to stop the mold rotator was eliminated. Also at the end of the daily production, the cylinder and the extruding die can be dissembled from the machine for cleaning purposes. To avoid the problem of trapping the flour mixture inside the cylinder a die was designed to before compress it by piston.
3. It can be concluded that the new designed string hopper machine has made the string hopper manufacturing an easy task for medium scale industry.

REFERENCES

[1] International Journal of Food Science and Technology 1999

[2] Polything product and market guide

[3] Motor selection Guide http://www.phidgets.com/docs/Motor_Selection_Guide

[4] http://www.anaheimautomation.com/products/brush/dc-gearmotor-item.php

[5] IMA Industrial Machine Automatic https://iscmp.mit.edu/white-papers/white-paper-2

AUTHORS

First Author – B D N Mendis, The Open University of Sri Lanka

Second Author – Nimali T Medagedara, The Open University of Sri Lanka

Third Author – D C Wijewardene, The Open University of Sri Lanka