

Research Article

Application of microcontroller for accurate control and safety of SPM- A Case study on sweet making machine

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Abstract

Sweet product making companies have started to make a mark and succeed in Indian food industry over the few years by making use of automation. Traditional sweet making process works perfectly with human intervention but is unable to cope-up with the growing demand of the customers. During festivities, people often place a large order of sweets to the vendor and expect the delivery of the sweets to be as soon as possible. In order to complete the order within required time, the vendor has to put in additional manpower and at the same time, maintain the quality of the product. This can be achieved by using an automated SPM for large scale production for such demands. Sweet making machines are available for different varieties, capacities; grades etc. In order to full fill the demands in shorter time span, automation of sweet making machines using microcontroller can come in handy. A mechatronics system that is developed for sweet making machine, which takes feedback from sensors and controls the function has been introduced in this paper. The paper also describes project to automate the process for sweet making. The project aims to reduce the manpower and increase the profit by increasing the production rate and quality. It also aims to reduce the material wastage due to manual handling.

Keywords: Sweet making machine, Low Cost Automation, Microcontroller, PLC.

1. Introduction

In the current industrial atmosphere better quality, low cost with higher productivity are important factors for any enterprise to burgeon. To cope up with demanding market competition, low cost automation is the safest master plan. Low cost automation constitutes the use of standard components to mechanize machines, systems and processes. These automated machines can be operated by semi-skilled or unskilled labors as it requires very less human interpose. Providing optimum quality to the customers is one of the most important goals of any industry. The ability to manufacture high quality products is highly preferred in food industries as high quality products encourage customer loyalty and results in increasing market share. Quality assurance methods used in the food industry have traditionally involved human visual inspection and are tedious. So it is necessary for the food industry to employ automatic methods for quality assurance and quality control. In fact, this aspect of food manufacturing is one of the areas that have received the most attention in terms of automation. Also automation increases profit which not only adds to shareholder value but also allows management to

invest strategically in improving product quality and productivity as both of these contribute directly to improve profitability.

2. Need of automation

Sweet making machine involves tedious steps like input to feeder assembly, extrusion from feeder assembly, sensing the amount of feeder output, ensuring proper shape for required output, cutting the required amount of output and shaping the output for required final product. Performing all these processes manually is a tedious and time consuming job also the production rates will be low. In order to achieve optimal production rates use of automated machines is a necessity. Automated machines are time saving which gives the manufacturer a competitive edge over other. The quality of the work is better and always remains the same. An automated machine reduces the wastage of material which leads to proper utilization of the resources. Workers may suffer from fatigue which lowers the quality of job. Use of an automated machine lowers the labor dependency of a manufacturer. To achieve all of the above stated advantages low cost automation of sweet making machines using microcontroller is handy.

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3. Automation techniques

A sweet making machine has variants to automate it. The basic types of automation techniques which are quite renowned are programmable logic control (PLC), relay logic control and microcontroller technique. Relay logic control uses relays that are internally connected to each other by using wires which operates it. Relay logic control panels are big. The life expectancy of a relay is limited so some of them need to be replaced. In order to replace a relay the machine needs to be stopped which indirectly creates an impact on the production. It is also difficult and tedious to find an error as it is a very complex system. Electrician finding these errors needs to be skillful. Being a complex and inflexible control system changes cannot be done easily. Due to these implications, relay logic control is not a good choice for running the SPM's.

A programmable logic controller (PLC) is a digital computer employed for automating electromechanical processes. PLCs are used globally in lot of industries. The PLC's are designed for multiple inputs and output arrangements; immunity to electrical noise, extended temperature ranges resistance to vibration etc. Programs to control the machine operations are basically stored in a non-volatile memory. Microcontroller is a term used for a small computer running on a single chip, which contains the memory, microprocessor and few accessories. Microcontroller comes in reduced size and affordable price as compared to other devices. Microcontrollers can accommodate accessories like analog to digital converter, digital to analog converter, programmable timer, counter etc. Powerful and carefully chosen electronics embedded in the microcontrollers can run almost any system. PLC requires a computer to operate, programming software and a PLC control console but a microcontroller combined with some accessories can complete the job of automating a machine. The cost of PLC based controllers is more than that of microcontroller units. PLCs are flexible than microcontroller units but for automation of sweet making machine, flexibility criteria is very low in the requirements. Due to these reasons, the microcontroller technique is highly suitable to achieve automation of sweet making machine. Hence, in making sweet making machines microcontroller technique is optimal to go with.

4 Process flow and machine layout



Fig. 1 Block Diagram of the assembly

The machine is divided into 4 assemblies, namely

- 1) Feeding assembly
- 2) Die assembly
- 3) Cutting assembly
- 4) Shaping assembly

4.1 Feeding Assembly

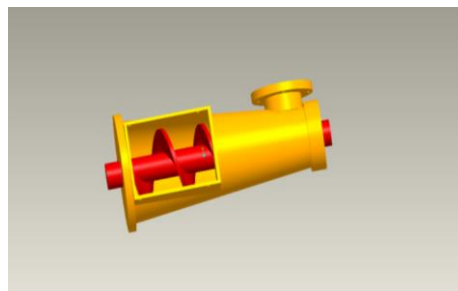


Fig 2 Feeder assembly

Motor coupled to a feed screw is to compress and push the material to desired consistency for further process. This part plays an important role as it carries the material forward with correct compression and speed. Accurate compression and speed are important parameters here because the material should not get dry in the hopper. It should be in proper consistency at the outlet of the feeder. If the above parameters do not satisfy the conditions then it will lead to undesirable results at the output. Continual smooth flow of material is necessary at the output for proper cutting of the fed material. The screw designed was such that a proper compression ratio should be maintained from the inlet to outlet of the feeder. The barrel design supports the feed screw functions. The screw is connected to the motor having sufficient power to overcome the forces and to provide the desired torque for pushing the material from inlet to outlet.

The hopper is attached to the feeder casing i.e. the barrel of the feed screw. The capacity of the barrel is kept optimum to maintain the moisture level of the feeding material. The hopper is detachable to make it handy for cleaning purpose.

4.2 Die plate assembly

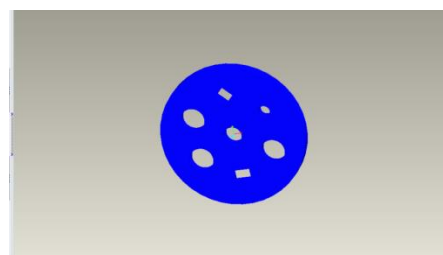


Fig.3 Die plate

For obtaining the desired shape of the sweet item, it is necessary to pass it through a proper shaped die. The output from feeder is taken as input for the die plate. This process of passing the material through the

proper die gives the material desired shape so that it can be cut precisely and also sets a metric for cutting proper amount of material. Proper amount of material is important for achieving the target of 'x' pieces per second for the manufacturer which varies from manufacturer to manufacturer.

The die plate used consists of multiple die shapes cut through it. Main shapes to focus are the circular for laddu and pedha, star type for chakkli, square and rectangular for barfi, perforated type for noodles.

The thickness of the die is varying. The speed of the cutter is kept same to compensate the thickness of the material to be cut. This allows cutting of particular product at same rpm of the feed screw and cutter. The cutter plate is mounted on a shaft and is supported by a base on the ground. It is aligned such that the die corresponding to the required shape can be attached to the output of the feed screw. This makes it a unique arrangement and has to be designed separately.

4.3 Cutting assembly

The cutting assembly has two sub parts

- 1) length limiter (sensor)
- 2) Cutter

Length limiter (sensor)-It plays an important role in timing of the cut and the amount of the material to be cut. A metric is set by the limiter for proper cutting of the material in proper amounts. This makes every piece of same size thereby keeping uniformity.

The length limiter is mounted on the output surface of the feeder casing which comes over the die to perform the respective operation. It consists of a sensor arrangement with roller at one end fixed to the casing of the feed screw.

Cutter- The cutter takes the action of cutting the material after desired intervals with proper force. The force and torque required for cutting is provided by the motor.

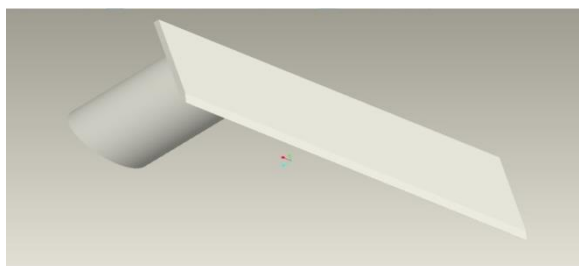


Fig.4 Cutter

Cutter is actuated by an electric motor having an optimum horse power for cutting. The speed of the cutter should be maintained such that the cutting

action should not damage the cutter as well as the material extruded from the feeder. It will indirectly affect the motor efficiency and motor life. The cutter path is integrated with the length limiter sensor. This times the cutter for the proper cutting at perfect time, giving same size and shape to the material. The cutter is kept heavy to give one cut action in rapid motion of the material. This also ensures proper balance of the forces provided by the extrusion material form feeder.

4.4 Shaping assembly: -

The raw material is pressed and continually supplied by the feeder in desired shape through die and cutter cuts it at regular intervals according to the required amount. Now, cylindrical like items are to be rolled into spherical uniform balls of desired diameter. This is done by shaping part of the setup.

Rotor takes the item dropped from the cutter at a little offset from centre of a rotating disc below, this disc has friction, so that it does not stick to the surface also facilitating rolling of the ball.

The rotating disc has a fixed guide above it which takes the item from centre to exit of the guide in a radially outward fashion with help of centrifugal force. We have modified it by giving it a taper to add a component of gravity to facilitate enough force to ensure rolling of the desired product.

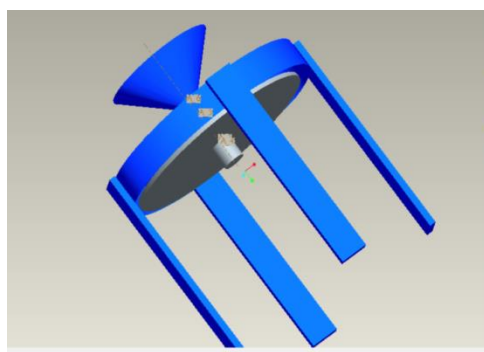


Fig.5 Shaper and rotor assembly

5 Algorithm of the process

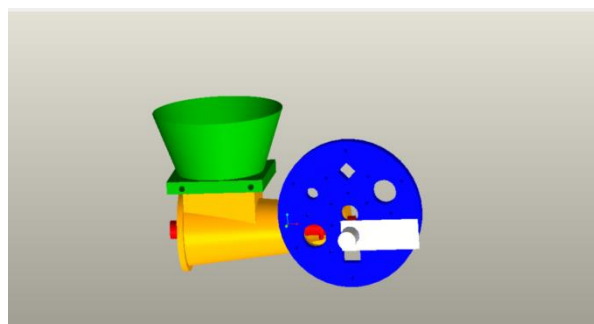


Fig.6 basic set up

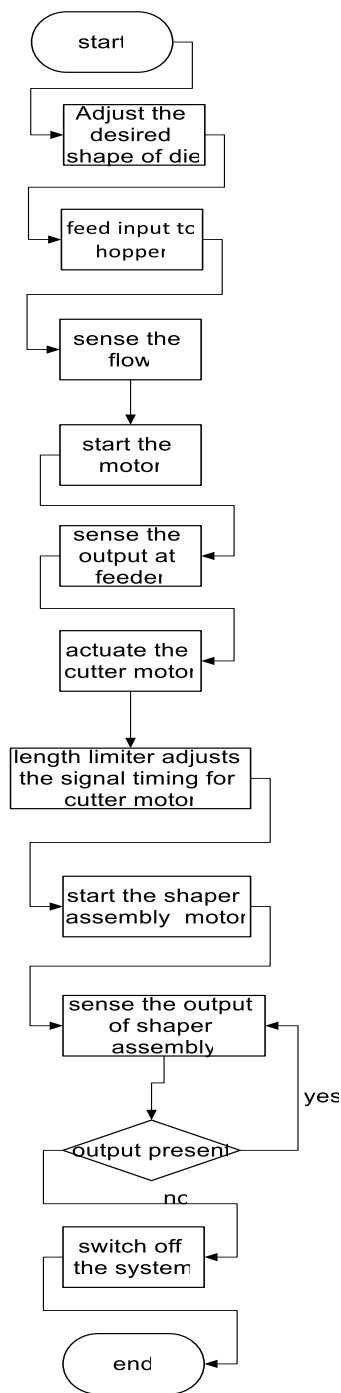


Fig.7 process flow

Before starting the machine the die plate should be adjusted for obtaining desired shape of the product. This can also be done by using controllers that can be similar to the process that takes place in an automatic tool changer in CNC machines. When the feeder is loaded with in the material, the sensor senses the flow of material and turns on the motor coupled to feed screw whose prime function is to push the material ahead for extrusion through the die plate. Then the output at the feeders end is sensed by the length limiter sensor whose output is coupled to the cutter motor and has a prime function of accurately cutting of required volume on the basis of length of extrude from the die. The output signals simultaneously switches on

the shaper motor. The sensor at the output of the shaper senses the number of units produced by the machine and turns off the system if there is no output for a particular time.

Future scope

The machine currently operates with the help of basic mechanisms like Feeding, extruding, cutting and shaping. The current design can form one shape at a time, a more advanced machine having multiple hoppers and feeders can be developed for manufacturing multiple products simultaneously.

A faster feed screw engraved with good technology can be used. Also the output can be obtained at both the ends to save time and obtain volumetric accuracy. The system can be scaled heavy production.

Conclusions

By using the available data and information on various automation techniques and mechatronics systems the future machines can be developed by automating and reducing the basic time consuming processes. It can comply with simple as well as complicated design and allow use of low cost reliable components. The machine automated for making sweet making process by using microcontrollers will cost be cost effective as compared to other machines build with conventional controllers. Hence, the Low cost automated sweet making Machine is successfully developed which can benefit small Industries and manufacturers, adhering to Safety of the workers and quality to be maintained.

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