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Research Article

Design and development of low cost special purpose machine for making items of confectionary

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Abstract

The items of confectionery like laddu, barfi, pedha, etc. are famous sweets in India. 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. At the same time, maintaining the quality of the product. This can be achieved by using an SPM for large scale production for such demands. In order to cope up with demands to be fulfilled in shorter time span, automation can come in handy. The paper describes project to automate the process of making items of confectionery. 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, adhering to safety regarding material used for constructing machine. The material used is food grade material to keep the machine hygienic and corrosion free. The paper evaluates the advantages of automation in food industries with supporting content.

Keywords: *Low cost, confectionary, feed screw, food extrusion.*

1. Introduction

During festivals, there is rise in the demand of sweet products and many times due to limited production, only a few customers are satisfied, so there is a need for automating the process of sweet product making plants. Automating the process will definitely improve the productivity of these plants as productivity is directly related to how efficiently the input resources are utilized to transfer them to marketable end products. Other factor that is influenced by automation of the sweet products making plant is quality. 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 manufacture 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.

We backed the project by taking a market survey as in initial stages of our project, we were curious about the amount of sweets needed on daily as well as on special occasions. So we went to some renowned local sweet shops to inquire about the demand, amount of the material required and time taken for production of sweets by traditional processes. According to the survey, amount of product needed on daily basis was one kilograms and that in festive seasons was more than twelve kilograms per day. This gave an insight into how much the need must be set for production, as we were to work on making a SPM for that process. So the aim is to design and develop S.P.M. for making items of confectionery to reduce labour requirements and thereby reduce the labour costs, to achieve uniformity of shape and size of the product, to increase productivity i.e. large scale production in very short time, to reduce gap between order time and delivery time, create a setup which should be in budget for small scale organizations.

2. Process flow

Following block diagram depicts the process flow of the sweet making machine.

Fig.1 Block Diagram of the assembly

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The machine is divided into 4 assemblies, namely

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

2.1 Feeding Assembly

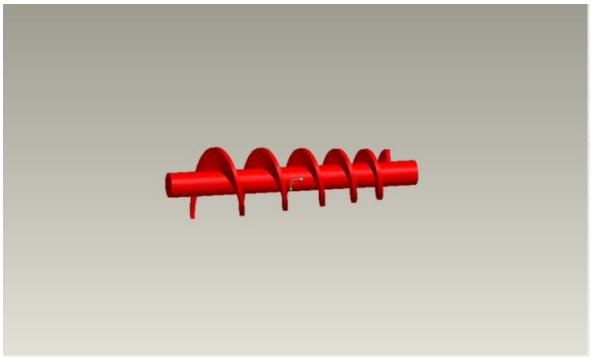

Fig.2 Feeder assembly- Tapered feed screw

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. And it should not loose its shape and deform during the process. It should also set quickly after shaping and should not get too dried to break into pieces by becoming brittle.

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 design used is unique in its place and is not an orthodox practice to go with. Speed of the motor is maintained optimum to give proper efficiency of items made per second. The screw is made by cutting the SS sheets having optimum thickness in varying diameters (inner and outer) and then curling it in helical shapes. These helical shapes are mounted on the shaft one by one and then welded. As the design is unique, this type of screw is not available in the market. So we constructed it ourselves.
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. If it is too large then the feeding material will get dried affecting the consistency of the material. If it is too low then it will be an exhausting job to feed it again and again. The hopper is detachable to make it handy for cleaning purpose.

As all parts are in contact with the food material, the metal used for the parts in contact with the food is also of food grade for proper hygiene. Material used is SS304.

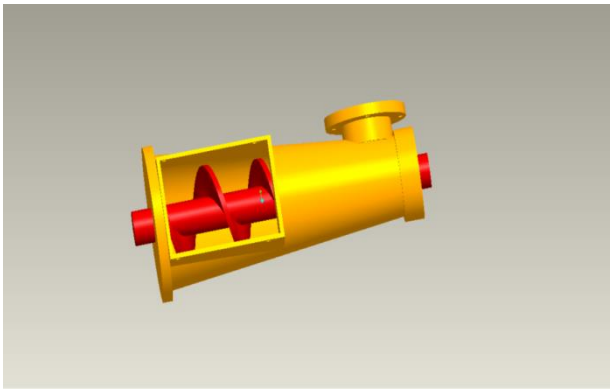

Fig.3 Feed screw + casing

2.2 Die plate assembly

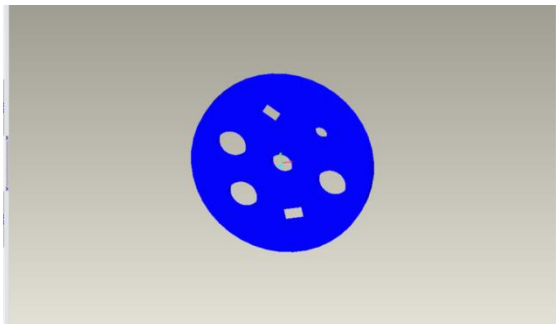

Fig.4 Die plate

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. Spaces

are provided between the dies for attaching it firmly to the outlet of the feed screw. This attachment is necessary for sustaining the forces acting on the plate and to keep it in a fixed position. Material used should be food grade for example SS304.

2.3 Cutting assembly

The cutting assembly has two sub parts

1) Mechanical limiter
2) Cutter

2.3.1 Mechanical length limiter: 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 mechanical 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 lever like arrangement with roller at one end and other end fixed to the casing of the feed screw. The centre of the roller lies on the axis of the output of feed screw.
The material of the roller is sponge type with aluminium coating over it. The scope and angle of the limiter plays an important role in its functioning. The cutter gets resistance in its path by the limiter until and unless proper amount of material is ejected from the feeding mechanism. Once the desired amount of material is gained then the limiter makes the path for the cutter to cut proper amount of material.

2.3.2 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. Cutter is actuated by an electric motor having an optimum horse power for cutting.

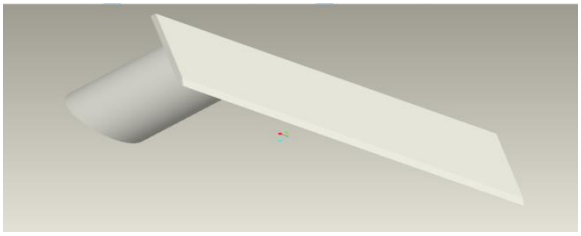

Fig.5 Cutter

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 interfered by the mechanical limiter. This action times the cutter for the proper cutting at perfect time, giving some size and shape of 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.

2.4 Shaping assembly

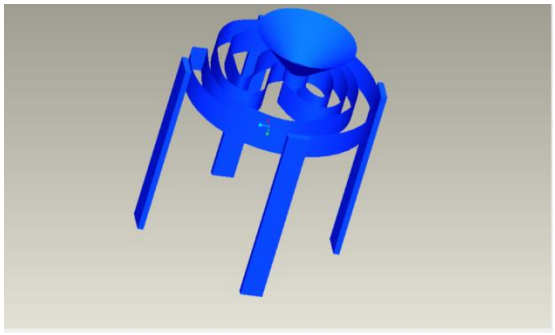

Fig.6 Shaper

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 our setup.

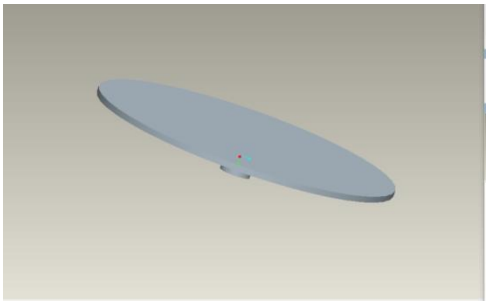

Fig.7 Rotor

It 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 ball. Since the fixed guide and the base disc are in the contact of the material, they are to be made of food grade material. Uniform diameter of the laddu balls is ensured by rolling it over sufficient length of the friction material.

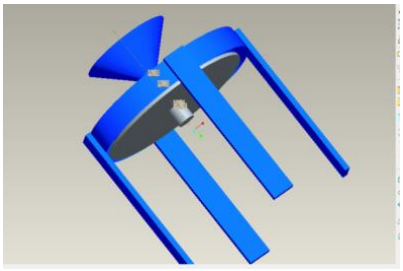

Fig.8 Shaper and rotor assembly bottom view

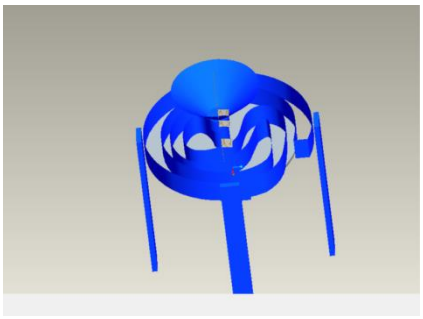

Fig.9 Shaper and rotor assembly

3. Cost comparison

The SPM available in market are too costly as compared to the one presented in the paper. The design is compact and the amount estimated is by considering the use of food grade material SS304 L grade. The cost estimation is based on practical survey of the cost needed for procuring the required material for assembling the machine.

Table 1 cost comparison.

Sr.no.	Variables	Machine available in market	Proposed machine model
1	Material	SS-Food grade	SS-304-Food grade
2	Automatic	Yes	Yes
3	Production rate	40 units per minute	55 units per minute
4	Cost	4,00,000 INR TO 5,75,000 INR	50,000 INR

Conclusions

The use of automation for making items of confectionary will increase the production rate, maintain uniform consistency in the products and maintain good hygiene, which will indirectly increase the efficiency of the production.

Fatigue causing activities will be eliminated due to lesser human intervention. The lead time of the product will also be decreased and will directly affect the on-time delivery performance of the company as lead time reduction is one of the key factors in all competitive companies. The capacity of the product can be varied by easily scaling the product for required capacity due to which it can be used for small to large scale production as per the vendor's requirement. Since the cost of machine is lesser it is affordable to small vendor which are the main targets for manufacturing the machine. The machine sets a future scope for making universal special purpose machine in food industries by expanding the requirements of the customers.

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