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Conceptual design of *Khandvi* making machine using 3D-computer aided design (CAD) (SolidWorks)

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Abstract - *India is known as a land of taste and traditional foods, which have a long history and are consumed by people all over the country. The practices followed in traditional method is unhygienic, labor-intensive and non-uniform quality. Hence, mechanization is a right solution to overcome the drawback of traditional practices. Today's food making machines are most popular and machine development for traditional foods is an exclusive area for engineers. Most traditional foods are mechanized now a days but no one worked on the mechanization of Khandvi making process. The main objective of this study is to develop a conceptual design of Khandvi making machine using 3D-Computer Aided Design (CAD) software (SolidWorks). Machine was conceptualized base on the unit operations followed in present Khandvi making process like cooking, spreading, cutting and rolling operation.*

Key Words: Traditional food, *Khandvi*, Mechanization, Solidworks, 3D-CAD

1.INTRODUCTION

India is known as a land of taste and traditional foods, which have a long history and are consumed by the people all over the country. Commercial production of traditional foods requires appropriate process technology. Traditional foods are becoming increasingly popular, and there is a growing demand for food making machines. The traditional methods have several limitations like improper mixing, unhygienic condition, poor keeping quality and non-uniform product quality together with small scale production. Considering, limitations of traditional method, mechanization is the right solution which may result in production of *Khandvi* with uniform quality, better sensory and rheological attributes having larger scale of operation. Mechanization may reduce cost of product also save energy and labor. Mechanization in the food industry can produce a consistent supply of high-quality products with hygiene, cost-effective and better quality. Most traditional foods have been mechanized like *Rasgulla* [5], *Halwasan* [15], *Boondi* [12], *Jalebi* [11], *Kajukatli* [3], *Halwa* [1], *Appam* [13], *Chakali* [9], *Dosa* [10], *Laddu* [2] and *pakoda* [8] but very little work has been undertaken for the mechanization of the *Khandvi* making process. *Khandvi* also known as Suralichya Vadya or Patuli, is a popular savoury snack in Maharashtra and Gujarat, made from a simple batter of chickpea flour, buttermilk/water and spices.

SolidWorks is a versatile 3D computer-aided design (CAD) software widely used in various industries, including the design and engineering of food processing machines, to create comprehensive models and prototypes. It not only facilitates the creation of virtual prototypes but also enables the simulation of the structural integrity of the model. Using 3D-CAD software, Salahuddin et al. (2019) [14] conceptualized a dough-shaping machine for shaping oatmeal-based cookie dough and *mudde* making machine was designed by [7].

The primary objective of this research is to conceptualize the design of a *Khandvi* making machine using SolidWorks. This machine is intended to automate the *Khandvi* preparation process.

2 TRADITIONAL *KHANDVI* MAKING PROCESS

In general, *Khandvi* is prepared using chickpea flour (besan) and water/buttermilk in a ratio of 1:3 with adding small amount of salt, citric acid, sugar and turmeric powder. The process involved several steps: mixing, cooking, spreading, cooling, cutting, and rolling. Mostly *Khandvi* is made in batch. The batter is cooked in a heavy-bottomed pan or a traditional kadai over a low flame to make a smooth paste-like consistency. It is then spread on a greased plate to form a thin layer. After allowing it to cool, the sheet is sliced into strips and elegantly rolled into the shape of a Swiss roll. It is then seasoned with mustard seeds, cumin seeds, and curry leaves crackled in oil. It can be further garnished with shredded coconut and chopped coriander leaves [6].

Fig -1: *Khandvi* making process

3 BASIC OBJECTIVES

These basic objectives that a *Khandvi* making machine should fulfil are:

1. Flexible in terms of quantity and suitable for uniform large-scale quality production
2. A reliable and efficient heating system for cooking
3. Automation with minimum manpower for operation
4. Minimum human touch to the product
5. Low operational costs
6. Simple and easy to maintain.

4 PROBLEM IDENTIFICATION

Khandvi is prepared manually in a batch process in small quantity. The unit operations like mixing, cooking, spreading, rolling and cutting are involved in manual *Khandvi* making process. The operational problems are:

- The manual processes take more time,
- Variation in thickness and size of *Khandvi*,
- Laborious and tedious operations,
- Energy intensive and
- Unhygienic

Hence, the main objective of this research is to develop a conceptual design of *Khandvi* making machine.

5 DESIGN CONSIDERATIONS

Mechanization of processing operations undoubtedly plays a vital role in eliminating the negative aspects of traditional processing methods and encouraging timely, large-scale production of desired quality. Making *Khandvi* by hand is a laborious process that requires skill and experience and also time consuming.

The basic function required to be performed by machine is to mix, cook, spread, cut and roll the *Khandvi* according to desired length and width. Considering the unit operations involved, design of *Khandvi* making machine and its components were undertaken with considering the following aspects.

Consideration of machine components

- It should have a cooking system with a proper stirring mechanism.
- It should have a proper food-grade spreading mechanism.
- It should be equipped with a cutting mechanism that ensures consistent and precise cutting of the sheet.
- It should have an appropriate system for collecting the finished product.
- The main frame should be structurally stable during operation.

The design of the machine requires various factors to be consider, including its capacity and functionality. The main components were ensured by using food-grade materials for fabrication. Accommodate the cooking vessel to ensure better cooking using a proper heating mechanism. Consider the belt made from food-grade material for spreading the cooked batter sheet on the surface of the belt with a proper mechanism of spreading. To ensure proper sheet cutting at equal length, accommodate the cutting mechanism. Strong parts and the main frame were considered to ensure the structural stability and support for the machine. The machine to be powered by a single-phase geared electric motor. Materials for components and parts selected based on their specifications, Table 1.

Table -1: Materials and specifications of the machine

Components	Materials	Quantity
Cooking vessel	Stainless steel sheet (SS-304)	1
Agitator	Stainless steel (SS-304)	1
Roller	Silicon/Stainless steel (SS-304)	2
Pedestal bearing	Cast iron	4
Chain and sprocket/v-belt	SS/Polyurethane	1
Spreader belt	PVC food grade/Silicon, Polyurethane fabric	1
Spreader plate	Stainless steel (SS-304)	1
Cutting roller	Stainless steel (SS-304)	1
Bolts and nut	Steel	As per required
Main frame	Mild steel	1

6 DESIGN CONSIDERATIONS FOR THE MACHINE COMPONENTS

1. Cooking Assembly

Volume of cooking vessel (m^3):

Based on the material density and known mass, the required volume can be calculated using the density formula given,

Density(kg/m^3) = Mass (kg))/Volume (m^3)

Agitator

Vessel must be equipped with a proper agitation system so it can effectively mix and prevent burning or sticking of batter. Add scrapers or wipers on the agitator blades to prevent batter from sticking to the vessel's walls and ensure even cooking.

2. Spreading cum Sheeting Assembly

Food grade spreader belt to be provided for spreading/sheeting of cooked batter with the desired thickness using the proper spreading mechanism. According to the *Khandvi* sheet width, belt width should be determined by considering both sides' clearance. The size of the belt can be calculated as follows:

Length of spreader belt

One must ensure the spreader belt's total length (L) so that it meets the capacity requirements. The total length of the belt (L) and the distance between the centre (X) of the two rollers can be calculated using the following formulas, [4].

$L = \pi/2\ (d1 + d2) + 2x + 〖(d1 - d2)〗\ ^2/4X$

$x = (d1 + d2)/2 + d1$

Where,

L = Length of belt, mm

d1 = Diameter of driven roller, mm

d2 = Diameter of driver roller, mm

x= Centre distance between two rollers, mm

3. Cutting Mechanism

The cutting mechanism is provided to cut the *Khandvi* sheet at regular length. The length of the roller kept as the width of the belt. Considering the length of the sheet is equal to the circumference (C) of the roller, the required diameter of the cutting roller can be calculated using circumference formula.

7 MACHINE DESCRIPTION AND OPERATIONS

The machine was conceptualized to make *Khandvi*. The machine was developed using the 3D CAD software (SolidWorks) (Fig 2). The machine consists of four main parts including agitator with suitable drive mechanism, rollers, belt drive mechanism and main supporting frame.

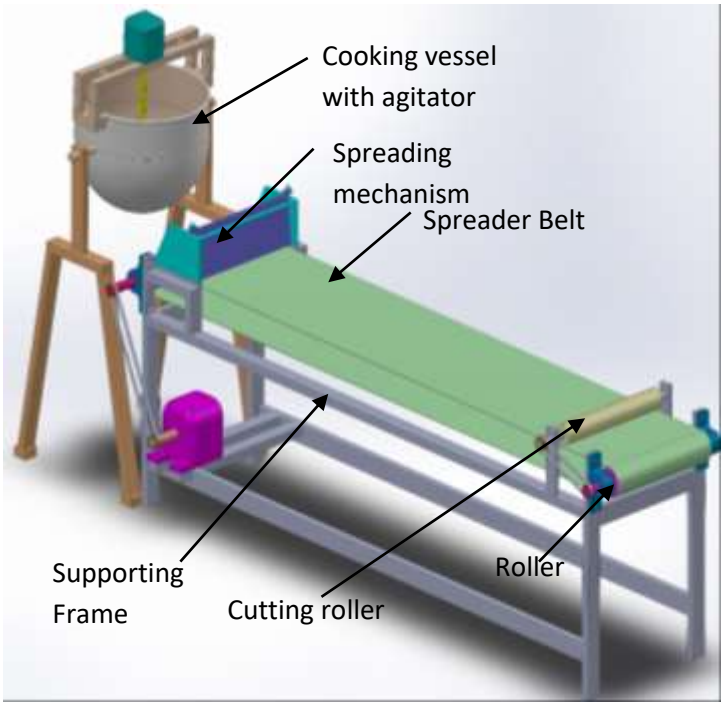

Fig-2: Conceptual design of *Khandvi* making machine

The vessel (SS-304) with suitable heating mechanism is attached on supporting frame where the batter mixture will be poured manually. The roller for belt attachment is made of silicon of SS-304 material which is driven by chain and sprocket or belt mechanism. The spreader plate (SS-304) is attached above the belt for spreading the cooked batter with desired thickness and the plate width is same as the belt width. For continuous cutting of sheet at regular length, SS roller is used which is driven by the belt roller at same speed of the belt. All parts are mounted on the supporting main frame to make single unit.

8 WORKING PRINCIPLE OF MACHINE

The mixture of chickpea flour and water cooked in the vessel and continuously stirred by the agitator which is mounted on the vessel. After cooking the batter poured over the belt where batter is spreaded by the spreader plate at set thickness. Spreaded sheet having width same as belt width, cut at regular length with food grade cutting roller.

3. CONCLUSIONS

The work has been focused on developing a conceptual design of the *Khandvi* making machine. The parts of the machine were designed using the SolidWorks software. The conceptual design give idea to the food engineers for mechanization of the traditional process. CAD software empowers engineers to re-imagine, improve and innovate existing machines, offering a range of benefits from efficiency and cost savings to improve quality and sustainability.

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