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## Design and Fabrication of Ragi Ball Machine

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**ABSTRACT:** Finger millet, popularly known as ragi flour is an annual herbaceous plant widely grown as a cereal crop in the arid and semiarid areas in Africa and Asia. Ragi Mudde or Ragi Sangati is a wholesome meal in the state of Karnataka and the Rayalaseema region in Andhra Pradesh. In this project, a Ragi Mudde Machine is proposed, where the finger millet and the water are boiled inside a stainless steel vessel using a burner and then the dough is made by continuous stirring of the mixture by using stirrers and pusher plates. Thus obtained mixture is forced out automatically through a pipe via pusher plates and then formed into round shape using a bowl powered manually.

**KEYWORDS:** Stainless steel vessel, Stirrers and Pusher Plates, Extrusion pipe, Rotating bowl, Sol-gel coating.

### I. INTRODUCTION

India is the leading producer of small millets namely, finger millet (ragi), kodo millet (kodo), foxtail millet (kangni) and little millet (kutki). Annual planting area under them is around 2.5 million hectares and nearly 1.5 million hectares is under finger millet comprising 40-50% of crops global area. Its annual production is maintained around 2.4 million tonnes. The protein content in ragi is more or less equal to that of wheat, rice and maize. Finger millet contains the lowest fat. It is relatively rich in iron and phosphorus. It has the highest calcium content among all the food grains.

The most common primary processing of finger millet is to convert the grain in the form of flour which is achieved by pulverizing or milling. Some of machines for milling are conventional stone mills, burr mills, hammer mills, ball mills etc. on demand of the recipe the coarser flour is separated by sieving the whole meal. Finer flour is preferred for making chapathi (rotti), whereas coarser flour is suitable for mudde. Mudde is a typical preparation of Karnataka and very often prepared using social functions. Coarser flour helps in making lumps during mudde preparation and that of finer flour absorbs more water due to higher surface area and facilitates flatter for chapathi making.

In recent years the consumption of finger millet along with other millets has been increased particularly in the urban sector due to awareness about the inherent nutritional and medicinal properties of millets. Millet is gluten free and safe to eat for those who experience gluten sensitivity.

### II. MATERIAL SELECTION

Various materials are analyzed and the most suitable ones are selected. Several properties including corrosion resistance, chemical inertness, hardness, ductility are considered.

#### STAINLESS STEEL

Stainless steel is an alloy of iron containing at least 12 per cent chromium. Chromium combines with oxygen in the surroundings to form an adherent chromium oxide film on the surface. This oxide film, also referred to as the passive layer, offers resistance to corrosion and will spontaneously self-repair when damaged in air or water. So the corrosion

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resistance is in the metal surface, and the stability of the passive layer is therefore decisive to the corrosion resistance of the stainless steel.

## STAINLESS STEEL GRADE 316

Grade 316 is the standard molybdenum bearing grade, second in importance to 304 amongst the austenitic stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304[4], particularly higher resistance to pitting and crevice corrosion in chloride environments. It has excellent forming and welding characteristics. It is readily brake or roll formed into a variety of parts for applications in the industrial, architectural, and transportation fields. Grade 316 also has outstanding welding characteristics. Post weld annealing is not required when welding thin sections.

In this project, we have used this material as it is of corrosion resistance which makes safe for contact with the food materials.

## SOL-GEL COATING TECHNOLOGY

Sol-gel technology is a hybrid of organic and inorganic chemistry. Coatings produced using sol-gel technology are more accurately described as ceramic-like; they feature many of the same characteristics as ceramic but to a lesser extent. Compared to PTFE, sol-gel coatings are harder (9H pencil hardness), and can function at higher temperatures (up to 450°C/840°F).

With sol-gel coatings, there is a specific time by which the activated and filtered coating should be applied to achieve maximum effectiveness. The coatings are applied via conventional spray equipment. They are available in one- and two-coat systems. Sol-gels must be applied only to preheated parts that maintain about 50-70°C/120-160°F throughout the spraying process. If parts are not heated and kept at this temperature, the coating could sag, cause wetting defects or dry spray. An IR thermometer can help check the pans to ensure proper temperature.

In this project, we have covered the stainless steel vessel, stirrers and the pusher plates with this coating to ensure that dough is non-sticky to the surface of the vessel which reduces the resistance for mixing action.

## III. METHOD OF FABRICATION

- The supporting frame structure for the machine is fabricated using stainless steel 202. The SS bars are welded according to the design plan.
- The metal parts that do not come in direct contact with the food particles are fabricated using MS, machined and formed to the required shape. These parts include washers, plate to house the gearbox, coupling to connect the gearbox to motor.
- The parts that come in contact with the food particles are fabricated using Stainless steel 316. These parts include vessel, shaft, stirrers, pushers, and cap.
- The parts that cannot be welded are fastened using suitable fasteners.
- The parts which are required to be removed are fastened using bolts and nuts.
- The parts that come in direct contact with the food are coated with non-stick Sol-Gel coating.
- The parts are not painted to avoid food contamination. Also the outer visible parts that don't come in contact with the food are buffed for aesthetic appeal.
- The gearbox and motor are mounted in such a way as to avoid leakage of oil.
- All the components are mounted in such a way as to distribute the weight evenly.
- Sufficient gap has been provided under the structure to house the gas burner.

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- The cap has been provided on the side of the structure to easily access the dough.
- The design and fabrication is done keeping in mind the servicing and ergonomics aspect of the machine.
- The various parts, materials, and their details are included in the Bill of Materials.

## IV. PROBLEM DEFINITION

Ragi consumption is increasing because of its high nutritional contents in the form of mudde, rotti and ambli. Ragi mudde is the highest consumed ragi food in Karnataka and some parts of Andhra Pradesh. But preparation of mudde involves lot of efforts since the ragi dough is very thick to stir. It is prepared manually by adding the finger millet to the boiling water and again cooked for few minutes. Once the mixture of water and ragi flour is boiled, it is stirred well by using a wooden stick continuously until all the lumps formed are totally broken and a thick uniform consistent dough is obtained and is allowed to expand under low flame. Thus obtained dough is picked in smaller quantities and made into round shapes by hand and served. Addition of salt and butter also reduces the formation of lumps and will result in much softer and tasty ragi mudde. However, preparation of mudde in larger quantity manually is a tedious task as large force is required for mixing by more number of people.

In this project, we have tried to reduce the effort in making mudde by designing and fabricating a machine that could mix the water and flour to required consistency and force it out through a pipe and finally ball shape is made by rotating the dough in a round vessel.

## V. PARTS OF RAGIBALL MACHINE

### 1. Stainless Steel Vessel

The vessel used here is made of stainless steel 316 of around 2mm thick. It is made by welding a sheet in cylindrical form with a round sheet welded to it at the bottom. It helps to store the mixture of ragi flour and water during the preparation. It also houses the stirrer blades and the pusher plates used for stirring the mixture inside it connected by shaft at the centre of the vessel.

### 2. Support Structure

The support structure is made of stainless steel square bars of 202 type. It helps the vessel rest on it to accompany the overall procedure. It also provides for accommodating motor, gear box along with batteries to run the machine.

### 3. Shaft with stirrers and pusher plates

The shaft and stirrer assembly is made of stainless steel 316 which rests on the vessel above a ball bearing. The four stirrers are provided at an angle of 45 degrees to the centre and the 2 pusher plates are provided at an angle of 180 degrees to each other. The stirrers and the pusher plates helps in stirring the mixture inside the vessel to required consistency and also helps in forcing out the dough out of the vessel.

### 4. Extrusion pipe

A Stainless steel pipe is being welded tangentially to the bottom surface of the vessel which is used to force the mixture of it once it is ready. The pipe will be closed with stainless steel cap with a rubber flap to avoid leakage of water and flour during the process using nut and bolt assembly.

### 5. Non-stick sol gel coating

Coating is provided on the inner surface of the vessel, stirrers, pusher plates and extrusion pipe to avoid the mixture getting stucked to it and also for smooth rotation during mixing process. Its composition is PTFE and its thickness is around 60 – 70 microns.

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6. Motor with gear box

To run the shaft assembly for mixing, it is powered using a 0.5HP DC motor coupled with a gear box of 30:1 ratio to obtain a speed of 100 rpm which is run by a 24 volts battery.

7. Fasteners

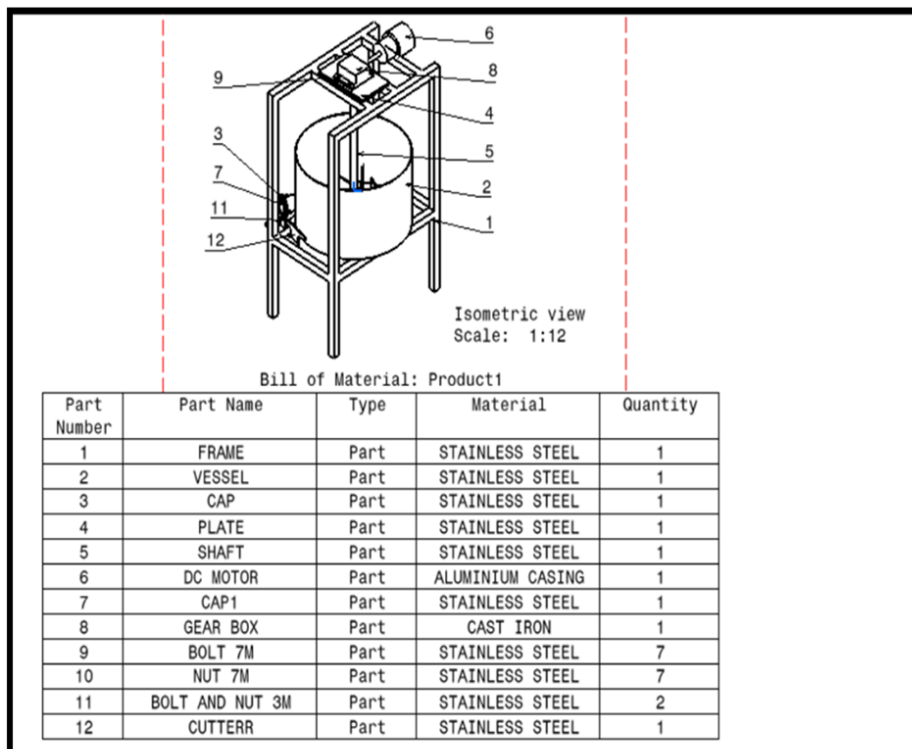
Fasteners are used to mount the vessel on the outer structure and also for resting the motor on the support structure an assembly of steel rod is fastened to it.

8. Rotating bowl

A stainless steel bowl with an handle is being used to rotate the dough coming out from the extrusion pipe and form it into round shape.

9. Burner

A detachable burner is provided at the bottom of the vessel to heat the mixture to the required temperature powered by a gas cylinder.



**Figure 1: 2D model of assembled parts of ragi ball machine**

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## VI. EXPERIMENTAL RESULTS

Water is added to the stainless steel vessel and boiled using a burner. Then 2-3 spoons of ragi flour is added to it in order to obtain malt like mixture along with 2 cubes of salted butter and is allowed to boil again until it reaches the brim of the vessel. Then ragi flour is added onto it and again allowed to boil for around 6 minutes. Then the stirrers are powered which stirs and blends the mixture continuously until all the lumps break and the flame is lowered and the mixture is allowed to expand. Once the consistent dough is obtained, the cap on the extrusion pipe is opened where the dough starts coming out and is cut by a cutter provided at the end of the pipe. The dough is collected on a steel bowl where it obtains round shape by continuous hand rotation of the bowl and finally ragi mudde will be ready to be served.

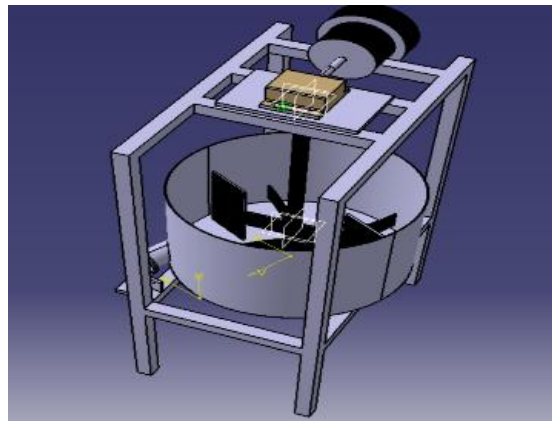


Figure 1: Isometric view of ragi ball machine

The above figure shows the isometric model of the machine designed using Catia. All the components were designed individually and then assembled.

## VII. CONCLUSION

This equipment will help in reducing the effort to make mudde in large quantities. Mass producers of mudde like in temples, hostels, restaurants can make good use of the machine. It also saves the time required to clean after cooking in it due to the non-stick coating. Thus, it helps to produce healthy ragi mudde which is very soft, tasty and completely free from lumps.

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