

Design and Fabrication of Domestic Puffed Rice Making Machine

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Abstract - The project work addresses development of a Domestic puffed rice making device hygienically. The reason for this development has arisen because of unhygienic way of preparing puffed rice, exposes the workers to health hazards due environmental effects and temperature effect in mass production facility. The critical parameter in the product design is related to the temperature operated with; which also influences the quality of puff with right crispiness. Salt is used instead of sand which provides the same quality of hygienic puffed rice. The product efficiency is quantified by the puffed volume, will be enhanced due to consistency in the temperature.

The device is being designed keeping in mind the following parameters –

- Hygienic and healthy
- Domestic Usability
- Ease of operation
- Cost effective
- Efficiency

Keywords: Puffed rice, Temperature, Hygienic

1. INTRODUCTION

Puffed rice (Locally known as *Mandakki, kallepuri*) is a processed food which is a popular snack. It is prepared by roasting conditioned rice grains in a hot sand bed. The oldest puffed grain as per documented literature found in west central New Mexico in 1948 and 1950 dates back to around 4,000 years old. These pieces of puffed grain were smaller than a penny to two inches in size and can be made in a similar way to popping popcorn. Scientific methodology of puffing grains dates back to December 1901. Botanist Dr. Alexander Pierce Anderson created puffed rice while experimenting with starch crystals in his laboratory. The modern process of making puffed grains was invented by Dr. Alexander P. Anderson. The puffed grain was shot from a battery of eight guns and on a poster it was called "The Eighth Wonder of the World." Currently in India as evolved from century's preparation of puffed rice happens with age old method of heating the grains in sand medium. Sand is heated using fuel which is basically a mixture of waste rubber tires and bio-residues like rice husk, wood shavings

from plywood industry and others depending on the availability at affordable prices. The combustion method used is inefficient and highly polluting. The pollution levels were so high that, in earlier days the production sites were banished to areas away from cities. The growth in population has ensured no such areas are available. Health concerns by local residents and hired operators became paramount and this prompted the local administration to issue eviction orders to the manufacturers leading to other social problems. There are many different ways to manufacture puffed rice. Before any manufacturing of puffed rice is done, the rice grains used are processed. The detailed process is explained here.

- Paddy is selected based on the variety of puffed rice required.
- It is soaked in hot water for about 6-8-hours.
- Water is drained out and paddy is roasted for about 30 min in roaster.
- Once again paddy is soaked in normal water for 3-4 hrs and next day it is dried in sun
- Husk of paddy is removed in a machine.
- Next rice is soaked in 4 lts of water, 1/2 ltr of salt water, little soda and sugar with equal quantity rice. Rice is stored in this solution for 2 days
- Then for a day rice is dried in sun and roasted in low heat twice.
- This processed rice is later manufactured in different processes in different countries.

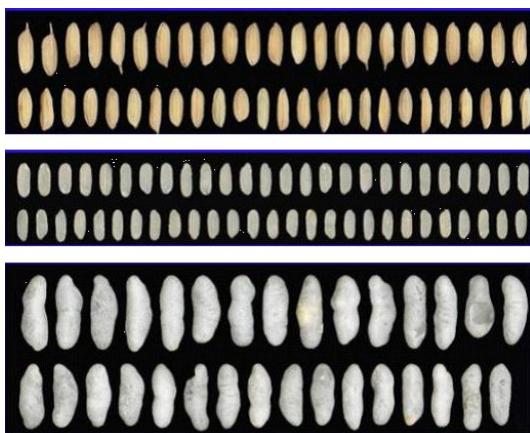


Fig 1: Rough rice, parboiled rice, puffed rice



Fig 2: Hot sand puffing



Fig 3: Cannon gun puffing



Fig 4: Machine puffing

5.2 Cannon gun puffing

In this process steel pressure chamber is heated over an open flame for about 2- 3 min. High pressure puffed rice is created by placing whole grains under pressure with steam in a containment vessel .when the vessels seal is broken, the entrained steam then flashes and bloats the endosperm of the kernel, increasing its volume to many times its original size. The great booming sound produced by the release of pressure serves as an indicator, with this pressure puffed rice will enter into a big lengthy bag which is later collected. This process is usually seen in Japan and China.

5.3 Machine puffing:

This is the advanced process in which there will be no direct interface of the employee. The machine used here is big and will occupy a large room. The process starts where cup conveyor carries the rice grains to small cylinder where salt water is sprinkled .This rice is transferred to a rotating cylinder where sand is already heated and puffing of rice is done ,from the sieve sand and puffed rice is separated and puffed rice is collected.

3. PROBLEM STATEMENT

To design and fabricate domestic puffed rice making machine.

4. OBJECTIVES OF THE STUDY

Based on the research problem, the following objectives are formulated for study.

- To design a domestic product that is compact and portable.
- To select the desired components for the model based on calculation and experimentation.
- To generate concepts through sketches and CAD concepts.
- To fabricate the model according to the design.
- To experiment the model for final output.

5. CURRENT METHODS OF MANUFACTURING

5.1 Hot sand puffing:

In this process sand is heated in a big wok till it attains the required temperature of 200-220° c. Here rubber tires, rice husk and wood shavings are used as fuel .when sand attains the temperature processed rice is roasted in hot sand ,within 10-12 seconds rice will puff up and with the help of sieve sand n rice are separated. Later this puffed rice is packed into bags and sold. This process is followed in India from thousands of years and the even now they manufacture by same the same process in most parts of India.

5.4 Present work:

There are few constraints which will affect the entire process of puffing. If any one factor is altered the result obtained will not be desirable. Hence before going into the detail design these factors have to be evaluated.

5.5 Temperature

In this process temperature is the major constraint, temperature required to puff the rice is around $180-210^{\circ}\text{C}$. Temperature should be maintained constant during the whole process. If temperature exceeds puffed rice will be burnt, if it's less puffing process will never happen. So to maintain this temperature constant heat has to be supplied and it should be regulated within the band not to exceed and not to reduce.

5.6 Humidity

There has to be 10-20% moisture content in the rice grains to puff up. Hence the rice is processed first before using it for puffing, when there is right amount of moisture the volume of the puffed grain will be large and the results will increase. Before the rice grains are roasted in the sand bath salt water is sprinkled on the rice to increase the volume of puffed rice and to maintain the taste.

5.7 Time for baking

Time taken for baking is an important factor; this depends on the temperature which is maintained inside container. First salt is heated till it reaches 200°C time consumed to reach this temperature is 2-3 min. once the temperature is attained rice grains are added to salt mixture it takes 8-10 sec to puff up .

6. DESIGN OF THE PRESENT MODEL:

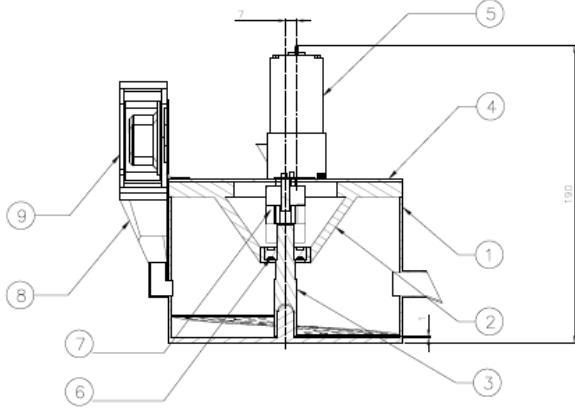


Fig 5: Sectional view 1-container,2-stirrer mount,3-stirrer,4-lid,5-motor,6-bearing,7-coupling,8-blower duct,9-blower.



Fig 6: A- 3D model b-fabricated model

6.1 Components used in the model

1. Container: The whole process of puffing the rice grains is performed in the container. There were many food grade materials available in the market as stainless steel, copper, aluminum, cast iron. Based on the properties stainless steel of grade 304 was selected.

- Density – 8g/cc
- Modulus of elasticity - $193-200\text{Gpa}$
- Specific heat capacity- 500J/KgK
- Thermal conductivity – 16W/m-k
- Melting point – $1400-1455^{\circ}\text{C}$

Table 1: Process Selection Table

PROPERTY	Stainless steel	Aluminum	Copper	Cast iron
Thermal Conductivity	Not good	Excellent	Excellent	Good
Reactivity	Non Reactive	Reacts to acidic and alkaline foods	Reacts to acidic and alkaline foods	Non Reactive
Durability	Durable for a longer time	Durable	Requires constant attention	Not durable for a longer period of time
Heating time	Longer duration	Short duration	Short duration	/longer duration
Taste of food products	Taste remains same	Taste may change as it reacts to food	Traces of copper will be mixed in the food	Taste remains same
Cost	Inexpensive	Affordable	Expensive	Inexpensive

2. Heating medium: Puffed rice is presently made by sand which is replaced by salt in this process because the specific heat of salt is higher than sand and it gives a better output with hygienic puffed rice.

For 1 mole at 298K & 1 atm pressure:

Salt (NaCl) Enthalpy : 411.15 KJ/KgK

Entropy : 72.13 KJ/KgK

Specific heat: 0.88 KJ/KgK

Sand (SiO₂) Enthalpy : 910.94 KJ/KgK

Entropy : 41.84 KJ/KgK

Specific heat: 0.8 KJ/KgK

3. Heating coil: Heating coil is a medium which is used to attain the required temperature. Based on the container design and dimension heating coil is selected.

The dimensions of the bottom plate: Diameter = 150mm
Area = 0.01767 Thickness = 2mm

Inner temperature required is : 200⁰c (478K)

Heat required at inner side of container : 132KJ

Time required at attain this heat : 150 sec

By heat required and time required rate of heat transfer is 0.88KJ/sec.

Approximately 1kw heating coil is required

5. Motor: DC brushless geared motor is selected. Typical brushless motor use a rotating permanent magnet in the rotor and stationary electrical current/coil magnets on the motor housing for the stator but the symmetrical opposite is also possible. A motor controller converts DC to AC. This design is simpler than brushed motors. As per the requirement calculations KGC3448 geared motor is selected which meets the requirement as closely as calculations.

Type - DC brushless

Power - 2.18 Watts

Motor Speed - 5000rpm

Shaft speed - 30rpm

Torque - 6 kg cm

Supply voltage - 12 V

6. Blower: a small centrifugal blower is selected. These blowers increase the speed of air stream with the rotating impellers. They use kinetic energy of the impellers or the rotating blade to increase the pressure of the air stream which in turn moves them against the resistance caused by ducts, dampers and other components. They are sturdy, quite, reliable and capable of operating over a wide range of conditions. BCB 30-4-12D 3000rpm, 3.36W, 12V DC,.28Amps is selected.

Working principle

The working principle of this device is to produce puffed rice. Stirrer shaft and container is press fitted with shaft pin which is placed in the inside bottom of container. The stirrer mount ends are locked in the grooves which are present on the circumference of container, now the shaft and container are perfectly fit. Salt is filled to the level of stirrer and the lid is closed, when the jaw coupling present on the end of shaft and end of motor shaft is attached lid is completely locked. Later the whole assembly is placed on the heating coil and it is connected to the electrical supply. Since DC motor is selected it is connected to the adaptor where AC is converted to DC. When the motor is turned on stirrer starts rotating and

salt is continuously stirred. Once the salt reaches 180⁰c processed rice grains are fed into the container through input feeder. At this temperature rice grains will be puffed up within 10-12 seconds, now the blower is turned on which will lift the light weight puffed grains towards the output port.

7. TESTING AND RESULTS:

The model which has been fabricated according to design is tested in the real environment. Following are the experimental trials and results

Trial 1:

Time taken for salt to heat up to 200⁰c with 1Kw heat = 13 minutes

Time taken for the rice grains to bake = 15-20seconds

Time taken to discharge the puffed rice = 40 seconds

Trail 2:

Time taken for salt to heat up to 200⁰c with 1Kw heat = 12 minutes

Time taken for the rice grains to bake = 12-17seconds

Time taken to discharge the puffed rice = 50 seconds

Trail 3:

Time taken for salt to heat up to 200⁰c with 1Kw heat = 14 minutes

Time taken for the rice grains to bake = 10-12seconds

Time taken to discharge the puffed rice = 55 seconds

Average time taken to heat up the salt bath up to 200⁰c is 13 minutes.

Average time taken to bake the rice grains is 13-18 seconds.

Average time taken to discharge to puffed rice is 50 seconds.

For 50 grams of rice grains, output obtained was 70 grams of puffed rice where the quantity of the puffed rice will be 4 times larger than the original input and the density of the puffed rice will be reduced.

8. CONCLUSIONS:

The Domestic Puffed Rice Making Machine is designed considering all the parameters, which is fabricated and tested in the virtual environment. The product is behaving as expected. The quality of the puffed rice has improved compared to which is available in the market. As it is a new product many features could not be incorporated, aesthetic features can be added. Once the product is improvised, it can be commercialized under any business case.

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