Modeling and Fabrication of Advanced Sorghum Peeler Machine

Chandramouli T V[1], Disha M Nayak[2]
P. G. Student[1], Assistant Professor[2],
BMS College of Engineering, Basavanagudi, Bengaluru, Karnataka, India

***Abstract*— Sorghum belongs to the grass family, Gramineae. It is essential that producers know the crop they are cultivating in order to develop the most effective production practices. Sorghum is mainly cultivated in drier areas, especially on shallow and heavy clay soils [3]. The production of sorghum in Karnataka varies from 100 00 tones to 180 00 tons per annum. The Karnataka provinces are the largest contributors to the area planted to sorghum and sorghum production. Here in this study we are modeled and fabricated the advanced SORGHUM peeler machine which is very farmers friendly in operation and economical for the pocket. Here we first modeled the machine using CATIA V5 a 3D modeling software, then started fabricating the machine after taking feedbacks, suggestions from the farmers, in order to produce a machine which helps the farmers to make his job easy, efficient and profitable.**

***Key Words:* 3D Modeling, Fabrication, Sorghum peeler machine, CATIA V5 software etc.**

I. INTRODUCTION

Sorghum [Sorghum bicolor (L.) Moench] is an indigenous crop to Karnataka, and through commercial needs and uses may change over time, sorghum will remain a basic staple food for many rural communities [1].

Peeling of the seeds from sorghum is challenging as its very small size and delicate handling. Following are three generally followed methods of peeling sorghum seeds.

Figure 1: Sorghum plants with seeds

a) Lye peeling

Lye or caustic peeling applies a solution of lye (sodium hydroxide) at 10–20% at 100–120 _C for 2–6 min. During this process, the lye hydrolyzes the pectin, loosening the skin, and a high-pressure water spray with rubber disks or a perforated mesh cage is then used to remove the skin. The average product loss during this peeling method is 17% (Fellows, 2000). Lye peeling can be used in the peeling of peaches, nectarines, apricots, pears, tomatoes, potatoes, apples, carrots, sweet potatoes, and onions. components, incorporating the applicable criteria that follow.

b) Steam peeling

Steam peeling is the application of high-pressure steam at 1500 kPa in a pressure vessel to peel fruits and vegetables (Fellows, 2000). It can be used in the peeling of beets, potatoes, tomatoes, carrots, and onions. In steam peeling, peel removal is possible because of rupture of the cells just underneath the peel. Due to the high temperature and pressure, the temperature of the water inside these cells exceeds the boiling point but remains in a liquid state.

c) Mechanical peeling

Mechanical peeling is mainly used for peeling fruits, such as apples, pears, pineapples, oranges, and other citrus fruits. Some vegetables can also be peeled by mechanical peelings, such as carrots, potatoes, and sweet potatoes. The most common mechanical peeling method uses either cutting tools (knife peeling) or an abrasive peeler.

II. LITERATURE REVIEW AND MARKET SURVEY

Literature Survey including journals, conference proceedings, trade magazines, government reports, market, consumer and product information about sorghum peeling machine in specific and other vegetable peeling machine, in general, was carried out with the help of electronic searches. This search was conducted to identify the different types of peeling machine existing in the market and also to find out a similar product in other areas, which will help the current product development. The patents survey was also carried out to collect info about available patent pertaining to the area of peeling machine for study and understanding. Maintaining the Integrity of the Specifications.

Following are the few patents we referred.

1. Apparatus for peeling eggs: Inventors: Hilbert R. Hill; Patent number: US 3602280, patented on Aug. 3l, l 971
2. Peeling the machine: Inventors: Leslie .W. Driggs Patent number: US 3774525, patented on Nov27 1973.

3. Vegetable peeler: Inventors: Dennis L. Vanosdall, Patent number: US4,519,305 Patented on May 28, 1985
4. Peeler: Inventors: Egil Norrvik, Dagsmark (Fl), Patent number: US 2006/0048653 A1, Patented on Mar. 9, 2006

An exhaustive search for manufacturer and retailers of the sorghum peelers was carried out on the internet and their sites were visited. An insight of products produced by them and related peeling are obtained via their product catalog.

Finally, we started modeling Sorghum peeler machine and consulted many farmers and took their feedbacks, inputs to the model and fabricate a new advanced sorghum peeler machine with cost-effective model along with farmer user-friendly operations.

III. PRODUCT DEVELOPMENT PROCESS (PDP)

Figure 2: Phases in product development [5]

a) Planning Phase:

The planning activity is often referred as to "phase zero" since it precedes the project approval and launch of the product approval process. This phase begins with corporate strategy and includes assessment of technology development and market objectives. The output of the planning phase is the projected mission statement, which specifies the target market for the product, business goals, key assumptions and constraints [5].

b) Concept development

In the concept development phase, the needs of the target market are identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing. A concept is a description of the form, function, and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products and an economic justification of the project [5].

c) System - level design

This phase includes the definition of the product architecture and the decomposition of the product into subsystems and components. The final assembly scheme for the production system is usually defined during this phase as well. The output of this phase usually includes a geometric layout of the product, a functional specification of each of the products subsystems, and a preliminary process flow diagram for the final assembly process [5].

d) Detail design

This phase includes the complete specification of the geometry, materials, and tolerances of all of the unique parts of the product and the identification of all of the standard parts to be purchased from suppliers. A process plan is established and tooling designed is designed for each part to be fabricated within the production system. The output of this phase is the control documentation of the product – Drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts, and the process plans for the fabrication and assembly of the product. Two critical issues addressed in the detail design phase are production cost and robust performance [5].

e) Testing and refinement

This phase involves the construction and evaluation of multiple preproduction versions of the product. At this stage, alpha and beta prototypes are fabricated and evaluated. Alpha prototypes are usually built with production intent parts with the same geometry and material properties as intended for the production version of the product but not necessarily fabricated with actual processes to be used in production. Alpha prototypes are tested to determine whether the product will work as designed and whether the product satisfies the key customer needs. Beta prototypes ate usually built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process [5].

f) Production ramp - up

In this phase, the product is made using the intended production system. The purpose of the ramp-up is to train the workforce and to work out any remaining problems in the production processes. Products produced during this phase are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws [5].

By analyzing the existing post-harvest technology with respect to sorghum, with existing design and technology of variously available peeler machine, we started to model a 3D Sorghum machine using CATIA V5 3D modeling software, with keeping inputs from the farmers in mind as wells as to reduce the cost of manufacturing the sorghum peeler machine. The main challenge was to model a peeler machine which can handle and peel the sorghum seeds with low mass as shown in below Table-1.

Table-1 Composition of the sorghum grain as a fraction of total mass

Description	Percentage (%)
Seed coat	7.3 – 9.3
Embryo	7.8 – 12.1
Endosperm	81.1 – 84.6

IV. CONCEPT GENERATION- 3D MODELING OF SORGHUM PEELER

A product concept is an approximate description of the technology, working principles, and form of the product. It is a concise description of how the product will satisfy the customer needs. A concept is usually expressed as a sketch or

as a rough three-dimensional model and is often accompanied by a brief textual description. The degree to which the product satisfies customers and can be successfully commercialized depends to a large measure on quality of the underlying concept. The concept generation is relatively inexpensive and can be done relatively quickly in comparison to the rest of the development process.

The concept generation process begins with a set of customer needs and target specifications and results in a set of product concepts from which it is decided to make a final selection. The mission statement for the project, the customer needs a list, and the preliminary product specifications are the ideal inputs to the concept generation process, although these information's are still being refined as the concept generation phase begins. The method is focused primarily on the overall concept for a new product; however, the method can and should be used at several different points in the development process. The process is useful not only for overall product concepts but also for concepts for subsystems and specific components as well [6].

The concept generation is an inherently creative process, teams can benefit from using a structured method. Such an approach allows full exploration of the space and reduces the chance of oversight in the types of solution concepts considered. It also acts as a map for those team members who are less experienced in design problem-solving. It includes a mix of external search, creative problem solving within the team, and systematic exploration of the various solution fragments the team generates [6].

a) Function structure diagram:

A Function Structure Diagrams (FSD) is a graphical representation of the functions a product performs on its inputs and outputs. In an FSD, the overall function is broken down into elemental or atomic sub-functions. Each sub-function cannot be broken down further and is solution neutral. The sub-functions are connected by "flows" on which they operate. Flows are materials, energy or information that is used by or affects the product. FSD's are used for many tasks in the design process. Most importantly they can help break down a complicated design problem into manageable chunks. Solutions for each chunk can be found and then an engineering concept assembled from a group of solutions for each chunk. The functional diagram for sorghum peeling machine as shown in figure 3 below.[7] [8].

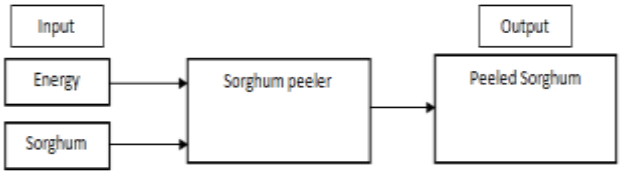

Figure 3: Black Box Diagram

b) Concept Brief Introduction

To facilitate the sorghum peeling with high productivity, less human effort a sorghum peeler is planned. It is proposed to have a rigid steel structure to mount the entire assembly. In process of concept development five-step method and described below is followed[7].

1. Clarifying the problem:

- A machine to peel the sorghum
- It reduces the strain and manual effort
- The machine will be portable/easy to move from one place to another
- Machine deseeds the sorghum faster than the manual method
- Machine cost will be affordable to the small farmer

2. Search externally: Gathered information from lead users, experts, literate and related product users.

3. Search internally: Used individual and group methods to retrieve and adopt the knowledge of the customers.

4. Explore systematically: Organized the thinking of the customers and synthesized the solution fragments.

5. Reflect the solution and the process: Identified the opportunity for improvements in subsequent iterations [8].

V. 3D MODELING OF SORGHUM MACHINE

CATIA V5 is feature based mechanical design software, a parametric solid modeling design tool. It uses windows graphical user interface and user-friendly software. Without or with constraints, fully associative 3D solid models can be created with the help of CATIA. In the meantime, we can use user-defined or automatic relations for capturing the design intent.

a) Solid Modeling

CAD system uses solid model supposed to be the best complete geometric model. All the surface geometry and wireframe are contained in it which are required to describe fully the model's faces and edges. Apart from geometric information, the topology of solid models is also conveyed bythem. Geometry together are also related by solid modeling. As an example, identification of faces (surfaces) at edges (curves) may be included in topology.

Based on the literature review and interactions with farmers we have started solid modeling of the advanced SORGHUM peeler machine.

Concept model 01: Pularity of Abrasive drum sorghum peeler

This concept is made is made up of cast iron angles stand in order to resist the whole load of the machine or the device. Two abrasive rollers are placed very close to each other and connected to the motor with the help of a chain drive. The chain drive is so arranged to get pularity of rotation. In

operation, the sorghum is screened or passed through the abrasive rollers and these abrasive rollers impart frictional force thereby peeling the sorghum.

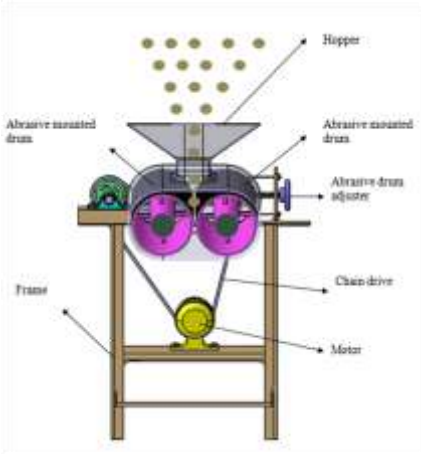

Figure 4: Popularity of abrasive drum sorghum peeler

Concept model 02: Abrasive Drum and Brush roller Sorghum peeler

This concept is similar to concept-1. However, the left-hand roller is made of nylon brush to impart more frictional force as compared to concept-1.In operation, the sorghum is screened or passed through the abrasive rollers and these abrasive rollers impart frictional force thereby peeling the sorghum. The pularity of rollers is achieved by 4 sprocket and chain arrangements as shown in the figure. The chain is so attached so that it completely enroll the first sprocket and tangentially touches the second sprocket and completely enrolling the third sprocket thereby making the rollers with abrasive rotated in the opposite direction inducing friction on the sorghum leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

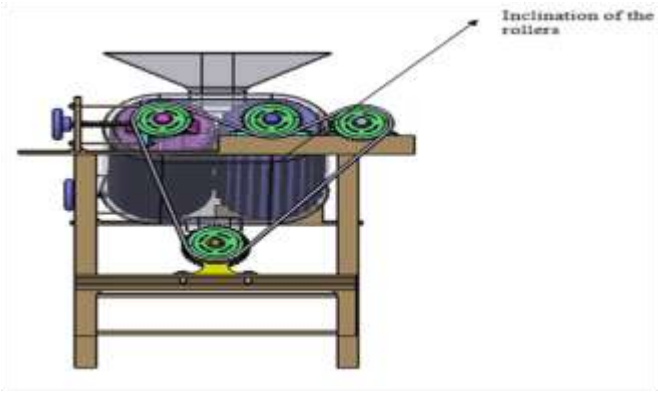

Figure 5: Abrasive Drum and Brush roller Sorghum peeler

Concept -3 Perforated drum and stationary roller sorghum peeler

This concept is conceptualized with a rotating circular drum with segregation and a stationary roller attached through the bearings to the frame as shown in the above figure. In operation, the sorghum is fed through Hooper and sorghum by gravity come in contact stationary roller. The sorghum is peeled by the rubbing action between the segregations and stationary roller.

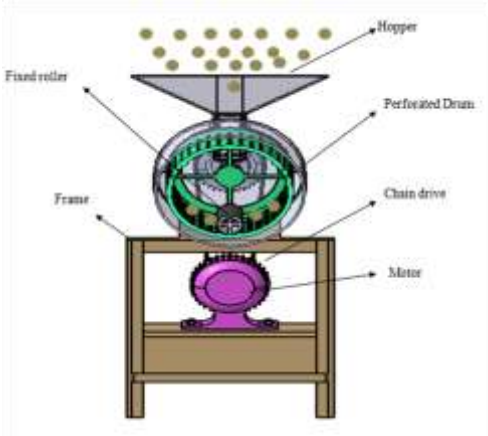

Figure 6: Perforated drum and stationary roller sorghum peeler

Concept 4: Trapezoidal Roller Sorghum peeler

This concept consists of Rotatable trapezoidal roller connected to the motor via chain drive and trapezoidal perforated outer cover. The rotatable trapezoidal outer cover is connected to the frame by the angles. In operation, the sorghum is fed through the hopper the semicircular dome on the trapezoidal roller pushes the sorghum by the centrifugal force to the gap between the trapezoidal roller and trapezoidal cover. The gap is very minimal to allow only peeled sorghum to pass through, here the sorghum is peeled one by the sorghum striking the trapezoidal cover by centrifugal force, second by the frictional force between the two rollers.

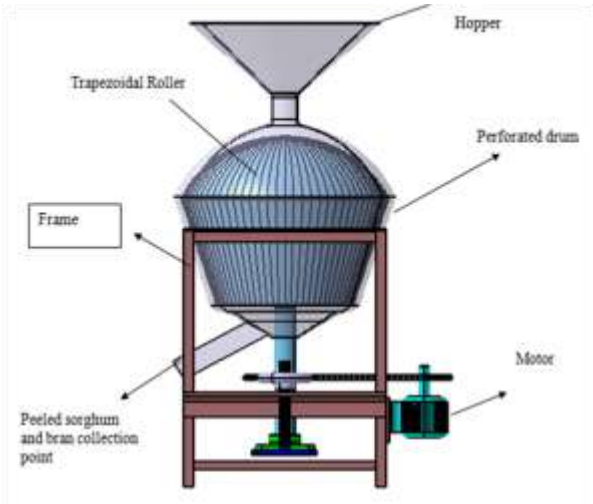

Figure 7: Trapezoidal Roller Sorghum peeler

Concept 5: Separating tray sorghum peeler

This concept is conceptualized with reciprocating tray and the reciprocating tray is connected motor and quick return

motion mechanism. Also the tray is inclined at 450 to the ground as shown in the figure. The reciprocating tray has pointed serrations.In operation when sorghum is poured into the hopper the sorghum comes in contact with reciprocating tray, the tray due to the reciprocating action makes the sorghum to jump up and fall due to gravity this causes the sorghum to strike the separation on the reciprocating tray. The sorghum is peeled by the impact force by sorghum striking the separations.

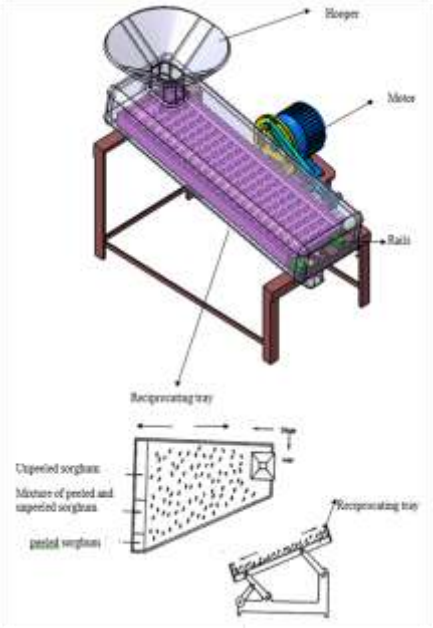

Figure 8: Trapezoidal Roller Sorghum peeler

VI. FINAL CONCEPT FOR FABRICATION OF SORGHUM PEELER MACHINE BASED ON EVALUATING CONCEPTS

Concept selection is the process of evaluating concepts with customer needs, and comparing the relative strengths and weakness of the concepts, and selecting one or more concepts for further investigation, testing or development. Around 36 farmers which included the people from the rural region of Karnataka were interacted with, to find out the importance and problems faced with the existing machine. These customers included the men and women and small contractor.

The selection was finalized based on the following criteria based on Concept Screening Matrix for Design concept synthesis.

a) Manufacturing consideration

b) Ease of manufacture

c) Ease of Assembly

d) Maintainability consideration

e) Serviceability with readily available tools

The customer selection matrix is created and Concept model 01: Pularity Abrasive drum sorghum peeler is selected for fabrication.

VII. SCOPE FOR FUTURE WORK

A Pularity Abrasive drum sorghum peeler is selected for fabrication, now after the fabrication is done we have following challenges in front of us for further investigations.

1. Fabrication of Concept model 01, Pularity of Abrasive drum sorghum peeler and the extent to which the problem of sorghum peeling is addressed by this concept 01 has to be measured with machine performance as per the farmer's requirement by taking feedback from farmers.
2. Static and modal analysis of Pularity Abrasive drum sorghum peeler machine using FEM techniques.
3. Reducing the complexity of design in Pularity Abrasive drum Abrasive drum sorghum peeler using FEM techniques.
4. Optimization of Pularity Abrasive drum sorghum peeler machine with respect to weight reduction and cost-effectiveness.

VIII. CONCLUSION

The mechanical method of peeling sorghum is unsafe and discourages the farmers to continue manual peeling. The literature survey, a market survey was conducted to identify the patents and existing products related to sorghum peeling, the outcome of the literature survey shows that the existing peelers were too concentrated on industrial or large commercial applications and they are not affordable for the small farmers. In this direction, to identify the customer needs, the survey was carried out and latent needs of the customers were identified. Five concepts were generated to satisfy the customer needs and concept 01 was selected based on the Pugh matrix and Concept Screening matrix. Detail design of concept-01 was carried out and the prototype of Pularity Abrasive drum sorghum peeler machine has to be manufactured. Later the machine has to be tested with different conditions to ensure the optimum performance satisfying the needs of the farmers. In case of any requirement in design modification or refabrication are discussed with farmers and has to be modified as per the farmers requirements.

ACKNOWLEDGMENT

The authors like to thank Principal, Head of the Department Industrial Engineering, B. M. S. College of Engineering, Bengaluru, for giving the opportunity to work on the above project and providing the lab facilities and technical guidance.

REFERENCES

[1] Lewis, Y. S. and N. Krishnamoorthy. 1980. Processes for production of green pepper and buff coloured white pepper. Invention Intelligence. 15(3): 121-122.
[2] Singal, V. 1999. Pepper. In: Indian Agriculture. Indian Economic Data Research Centre, New Delhi. pp. 453-462.
[3] Anonymous. 1993. Preparation of white pepper. Spice India. 7(12): 15-16. Chandrasekar, V. and R. Viswanathan. 2002. Development and evaluation of low cost coffee pulper.

[4] Journal of Food science and Technology. 39(2): 139-143. E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," *IEEE Trans. Antennas Propagat.*, to be published.
[5] Karl T. Ulrich and Steven D. Eppinger(2004).Product design and development : [ISBN 0072471468]C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.
[6] Archer, B. (1974). Design awareness and planned creativity in industry. Toronto: Thorn Press Limited. [ISBN 0850720168].
[7] Hawker, Chris (2005). The Inventor's Mind: 10 Steps to Making Money from Inventions. Columbus: Trident Design.
[8] J. Hauser and D. Clausing, "The House of Quality," Harvard Business Review, May 1988, pp. 67-73
[9] Gopalam, A., T. J. Zachariah, K.N. Babu, A. K. Sadanandan, and A. Ramadasan. 1991. Chemical quality of black and white pepper. Spice India. 4(4): 8-10.
[10] Bayindirli L (1994) Mathematical analysis of lye peeling in tomatoes. Journal of Food Engineering 23(2): 225–231.
[11] Knoblich M, Anderson B, Latshaw D (2005) Analyses of tomato peel and seed byproducts and their use as a source of carotenoids. Journal of the Science of Food and Agriculture 85(7): 1166–1170
[12] Fellows P (2000) Food Processing Technology: Principles and Practice, 2nd edn. Boca Raton, FL: CRC Press.
[13] A text book on Product Design and Development Karl T Ulrich and Steven D Eppinger.
[14] Concept Screening Matrix for Design concept synthesis.