

DESIGN AND DEVELOPMENT OF A MANUALLY OPERATED AGARBATTI POWDER MIXER FOR MICRO ENTERPRISES IN INDIA

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Abstract

Incense sticks called agarbattis in India, are becoming internationally known as a ritual product used for spiritual purpose producing fragrance for aromatherapy and meditation. The agarbatti workers in India lack efficient tools and education to develop better means of processing agarbattis. The current manual mixing processes are physically exhausting and time demanding to complete. In order to help agarbatti producers, this project focuses on providing a better means of mixing the raw materials involving in making incense sticks.

In-depth study was carried out using several methodologies including personal interview, observation, and site visit. The data was collected and analyzed using QFD, to select the characteristics of mix, types of materials, manufacturing processes and ergonomic issues involved. In addition easy of manufacturability, cost consideration and safety factors were considered while designing the machine, and PDS was arrived upon. The final concept was selected by participatory and weighted ranking method to show the problems faced by the manual labours in this industry.

Capturing the form and shape of rugged products in an efficient manner, a real-time full scale prototype was developed for converting manual mixing process to semi-automatic mixing, which helps in reducing the mixing time successfully from 5Min to 2Min per Kg. Through the success of the design small scale micro enterprises will be able to generate more revenue with increased production, creating more opportunity in manufacturing agarbattis in rural India.

Key Words: Manually Operated, Agarbatti Powder Mixer, Micro Enterprises India

Nomenclature

Kg	Kilogram
mm	Millimetre
Min	Minutes

Abbreviations

AIAMA	All India Agarbathi Manufactures Association
CAD	Computer Aided Design
DFM	Design For Manufacturing
DFA	Design For Assembly
DFS	Design For Serviceability
ISI	Indian Standard Institute
MIN	Minutes
PDS	Product Data Specification
QFD	Quality Function Deployment
RPM	Revolution Per Minute

1. INTRODUCTION

India is a vast country and the Indian people follow various religions, speak different languages and follow different customs and traditions. In spite of this diversity, all people use agarbatti (Incense sticks) at all the places of worship, religious functions, festive occasions, weddings. This itself speaks volumes of the high importance

agarbatti has. The burning incense in religious and social functions has been practised in India since early times. The demand for agarbatti is increasing both in the domestic and export markets because of the improvement in quality and increase in the types of products. India is the largest producer of agarbattis in the world. The focus of this project is to improve the current agarbatti powder mixing process. The aim of the project is to design a manually operated agarbatti powder mixer for micro enterprises in India focusing functionality, ergonomics, hygienic and safety.

1.1 Industrial Background Study:

Cottage industries in India have slowly changed to rural cottage or semi-urban micro enterprises with limited assistance from government. Agarbatti Industry is a real employment generator and is capable of providing employment to the weaker sections of both the urban and rural population.

Most of the persons engaged in fashioning agarbattis are women. Agarbatti making is one such industry it has responded well to increased

demand for its products both in rural and urban areas, mainly because of the continued availability of cheap labour force dominated by women and children. At the same time, greater advertising costs and quality improvement have pushed up the prices. Agarbatti has become a significant foreign exchange earner because of its demand in overseas markets.

1.2 Aim of the Research

The focus of this project is to improve the current agarbatti powder mixing process. On average, mixing by hand takes time to complete. The average agarbatti workers makes less than 50 Rupees per day, and this income must cover the cost of medicine, food, and clothing for an entire family. Women work very hard in these communities to maintain the health of their families. Basically agarbattis work mostly belongs to womens thus making agarbatti an area, were women can gain more economic freedom.

2. PROBLEM DEFINITION

There is requirement for large quantity of agarbattis particularly in Karnataka, where the manufacturing process are been assigned to micro scale enterprises, there they run the unit with the help of 5-10 workers and agarbattis are manufactured with some semi automatic machine and as well as manually. By observing the following process a need was identified that there is no any proper powder mixing machine. The aim of the project is to design a manually operated agarbatti powder mixer for micro enterprises in India focusing functionality, ergonomics, hygienic and safety.

2.1 Project Objectives

- To carry out literature review on agarbatti power mixing methods and effects of mixing through bare hands.
- To collect data of existing designs through product study, visual design exploration, user study and market study.
- To identify the real problem and changing it to necessary needs.
- To find low cost in manufacturing and ease maintenance.
- To find simple working process and replacement of parts should easily available in market.
- To create QFD on basis of customer voice and arrive at PDS to meet the customer requirements.
- To fit machine for all micro enterprises environment.
- To generate concepts as per PDS, create 3D models of the generated concepts and select

the final concept using weighted ranking method.

- To develop a prototype model of the final concept and take user feedback.

3. METHODOLOGY

- Review on agarbatti power mixing machine will be carried out by referring magazines, journals, manuals, catalogues and related documents.
- Data collection will be done by product study, user study and market study through ethnography, interviews, images, videos etc
- QFD will be generated based on the needs identified and the target PDS is arrived at based on the QFD.
- Concepts of powder mixing machine will be generated using sketching, ideation tools such as brain storming, mind mapping, theme boards.
- Five concepts will be generated and modelled with detailed features using software such as CatiaV5, Alias studio tools, Adobe Photoshop.
- Rendering of agarbatti powder mixing machine models will be done using software such as Catia V5 and Photoshop.
- Concept evaluation for selecting the final concept will be carried out by weighted ranking method.
- Prototype model of the agarbatti powder mixing machine will be made with detailed features.
- Design validation will be carried out through user feedback.

4. LITERATURE REVIEW

Literature survey and review has been carried out based on the reference gathered, on agarbatti manufacturing, and discuss about the aspects of technical, economic, safety and ergonomic aspects from the project materials collected. Besides, this chapter will also explains about data requirement and the basic concept in designing machine, the required functions and finally obtain details manufacturing specifications sufficient for fabricating and assembling the desired project.

4.1 Summary of Literature Review

- The literature reveals agarbatti (incense stick) has a huge demand and a sizeable market both in India and abroad, very little development has taken place in this field [1].
- The people involved in this trade are mostly below the poverty line and still use primitive ways of manufacturing incense sticks [2].

- It was concluded from the existing literature that there is no proper safety measures during agarbatti manufacturing to the workers [3].
- The literature review concludes there is a need for improved ergonomic machines and safety design to be introduced there is low or almost nil awareness of the new designs and techniques that have been developed in our country [4].
- Emerging of new technology in agarbatti manufacturing will make India leading producer of agarbatti thought the world [5].
- The government has come out with loan facility which helps interested people in starting up business of agarbattis manufacturing especially of rural peoples [6].
- All India Agarbathi Manufactures Association (AIAMA), the main purpose of the association was to overcome the problem of sales tax. But now the association addresses the issues facing the industry at a national level [7].
- The study reveals there is lot of business opportunity in agarbatti manufacturing were design intervention is required fill those gaps [8].
- Latest Powder mixing technology and different types of mixing methods and their mixing ratio, how to find the perfect mixing and which type of blenders shafts are suitable for best mix and their specification detail was carried out in the study [9].

5. DATA COLLECTION, ANALYSIS & PDS

Raw material study, Process study, market study and user study have been conducted for data collection. As a part of data collection, raw material properties, powder mixing technologies, agarbatti clusters are included in my research. Data collected through these primary research methods has been analyzed and utilized for deriving QFD and PDS.

5.1 Raw Material Study

Charcoal, jigat and wood powder is the main most essential ingredient to make agarbatti and incense is composed of aromatic plant materials, combined with essential oils. Figure 1 show the raw materials used in the process.



Fig. 1 Raw Material Study [5]

5.2 Agarbatti Process Flow

The flow chart of an agarbatti making process is shown in Figure 2.



Fig. 2 Agarbatti Process Flow

5.3 Opportunity Mapping

During the visit of agarbatti cluster, some of the design intervention opportunity mapped is explained in Figure 3.

Raw Material	<ul style="list-style-type: none"> •A low cost Powder mixer machine •A local community store for better quality raw materials. •A common facility center.
Bamboo Cutting	<ul style="list-style-type: none"> •Modern machinery for better quality and large scale production, as opposed to the manual process.
Drying Process	<ul style="list-style-type: none"> •A defined space to dry raw sticks •New technologies for drying, for instance a furnace designed for this purpose.
Process	<ul style="list-style-type: none"> •Better training for implementation of efficient practices, aiming towards wastage re-utilization. •Awareness of modern.
Sitting Posture	<ul style="list-style-type: none"> •Proper training regarding scientific sitting postures in order to reduce physical strain. •New accessories that would aid in achieving

Fig. 3 Opportunity Mapping

5.8 Task Analysis During Manually Mixing Agarbatti Powders

Complete process of making agarbatti is explained by individual task analyzes process shown in Figure 4.

5.9 Ergonomic Study During Mixing Process

Mixing involves taking raw material, and weighing it to the required quantity and sieving the raw materials by removing the dust material in it. And by bare hand mixing the required powders first and then by adding water mixing it to form dough. This operation requires awkward arm, neck, and trunk postures force is required to push the dough continuously. Some of the common ergonomic issues are shown in Figure 5.

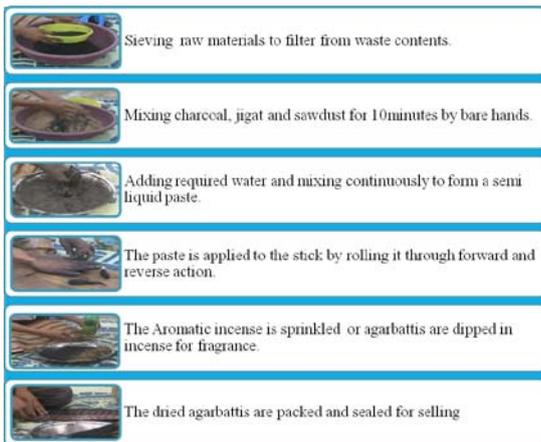


Fig. 4 Task Analysis During Mixing



Fig. 5 Ergonomic hazards during mixing process

Ergonomic Parameters (50th percentile)

- Ergonomic workstation dimension 1000x950x600 mm.
- Hand dimension Grip diameter 49mm hand breath 81mm.
- Maximum Hand Reach Length 849mm.

5.10 Quality Function Deployment (QFD)

In Agarbatti powder mixer machine development, Quality Function Deployment (QFD) used in order to fulfill customer expectations or requirements. It is a disciplined approach to product design, engineering, and production and provides in depth evaluation of a product. Figure 6 & 7 explains the important attributes required for the development of mixer machine.

5.11 Product Data Specification (PDS)

Product design specification compiles requirements that have to be included in the product. The PDS data can vary with respect customer need, the below Table 1 explains some of general attributes required for the powder mixer machine.

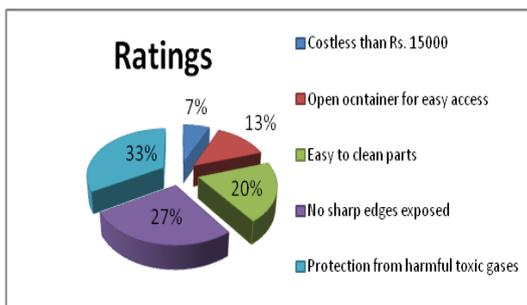


Fig. 6 QFD Ratings

6. CONCEPT GENERATION

Concept generation is putting out best ideas in form of sketches, considering all the background research finalized data the PDS parameters and QFD was derived, and concepts are generated emphasizing on form, usability, mechanism and function aspects.

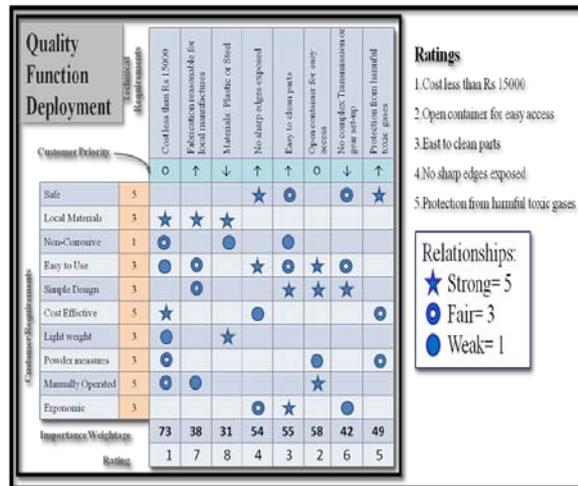


Fig. 7 QFD

Table 1. PDS

PDS for Manually Operated Agarbatti Powder Mixer for Micro Enterprises in India		
	Factors	Specifications
1.	Product Name	Agarbatti Powder Mixer
2.	Target customers	Micro Enterprises
3.	Country	India
4.	Color	Blue
5.	Material	Mild Steel
6.	Weight	10 to 15 Kg
7.	Capacity	1 to 5 Kg
8.	Working	Manually operated
9.	Mounting	Table top, Grounded
10.	Assembling	Assembly Instruction Video
11.	Texture	Smooth
12.	Cost	10000 to 15000 INR
13.	Process of manufacturing	Sheet metal pressing and fabrication
14.	Features	Hopper, Ribbon mixer, extruder
15.	Size	600x540x330mm

6.1 Inspiration Board Rugged Form & Shapes

The inspiration board presents images of rugged forms and shapes which conveys the

intended mood, these visual theme are often derived from mood board, and from these theme board different products are selected which conveys the expression of aggressive mood and various visual elements are identified and used for generating new concepts and styling process for Mixer machine product development. Figure 8 shows the inspiration board which was considered.



Fig. 8 Inspiration Board – Rugged Form & Shapes

Even though aesthetic is important in developing agarbatti powder mixer the preference is very less because the final product mixer machine is to be used in micro enterprises, Where the users give preference to the features like mechanism, size, capacity, functions, weight, size and shape and the performance of the machine. So some of the basic elements like form, shape, mechanism and function are derived from the inspiration board.

6.2 Concept Generation

Mind mapping method was used in generating the 5 concepts, which are explained below.

6.3 Concept -1

- The concept was derived from flour mill machine form shape and their mechanism.
- Body base container is rectangular hollow shape where the extruder screw can be seen.
- The base container top position is connected with cylindrical drum, which has vertical plough blade for powder mix.
- Sliding flange is provide in-between base container and vertical drum in order to avoid the free fall of powder to container in the start of mixing.
- Both the mixer blade shafts would be rotated through crank handles.
- The front slide flange extruder casing is fastened with base container.
- The total mixer machine can be mounted on table with the help of fasteners.

Figure 9 shows the concept 1.

6.4 Concept -2

- The concept was derived from horizontal rotatable chicken roasting machine form shape and their mechanism.
- The mixer consist of L-shape flange were the two mixer containers placed one another below.
- The containers are rotatable with respect to their axis.
- Upper container holds ribbon blade and lower container consist of extruder screw.
- Three hoppers are placed in the top of the mixer to fill the exact quantity of three powders.
- With the help of hand crank motion is given to each mixer blades.
- The total mixer machine can be mounted on table with the help of fasteners to the table or any other holders.

Figure 10 shows the concept 2.

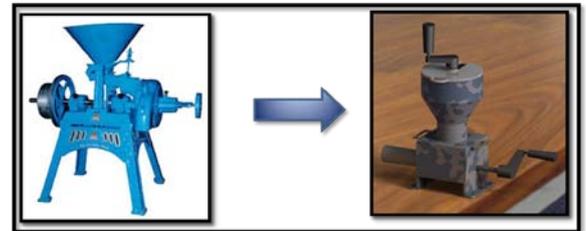


Fig. 9 Concept-1 [10]

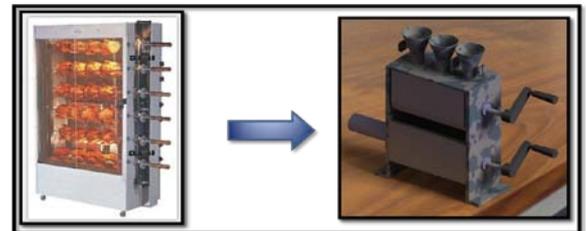


Fig. 10 Concept-2 [11]

6.5 Concept-3

- The concept is derived from Juice extractor form, shapes and their functions.
- The base container have L-shape flange stand on both side to hold up mixer machine rigidly with help of fasteners on table.
- The base container holds the two mixer shafts with the bush attached.
- With hinge provision upper lid is open type, so checking the quality of mix would be easy.
- Hopper is provided on the top of mixer with the shut off valve to measure and use the powders before mix.
- The crank handle is designed with ergonomic, which is easily removable and used for both ribbon and extruder screw shaft rotation.
- The extruder screw extra length outside the mixer is covered with side flange for safety

purpose and the flange is screwed with base container.

Figure 11 shows the concept 3.

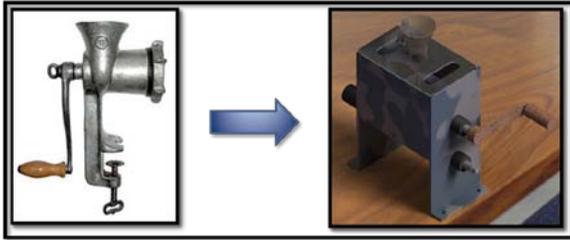


Fig.11 Concept-3 [12]

6.6 Concept-4

- The concept was derived from sand siever machines their form, shapes and function.
- Mixer consist two different chambers for mixing and extruding one another below.
- The ribbon blade gets the power for rotating through muscular energy developed while rotating the handle.
- Once the mixing is completed the powders falls to extruder chamber, when the circular sliding knob operated.
- Powder is guided by a rectangular hopper to flow through another chamber.
- Guiding hopper is designed in such shape were the complete mix falls on one side of extruder chamber for a perfect mix.

Figure 12 shows the concept 4.

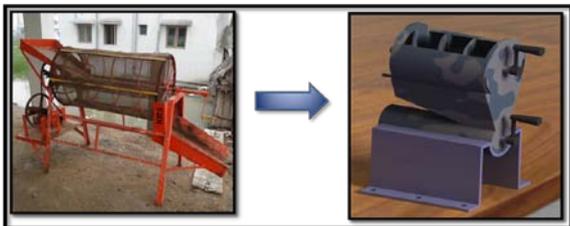


Fig. 12 Concept-4 [13]

6.7 Concept-5

- The concept was derived from horizontal concrete mixer machine form, shapes and their function.
- Powder measurable scaled hopper is installed in the top of the mixer machine outer frame with valve arrangement for the fall of powder.
- Mixer consists of two chambers, while rotating the handle the upper cylindrical container itself rotates were the ribbon blade would be ideal.
- Once the mix is done the powder falls to the extruding chamber below by opening arrangements.
- With the help of extruder screw action the powder is compressed and extruded out.
- The ribbon blade and extruder screw are rotates smoothly with the help of bearings

Figure 13 shows the concept 4.

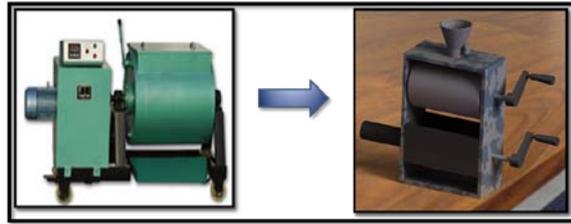


Fig. 13 Concept-4 [14]

6.8 Concept Selection

Concept selection is done based on participatory method the features in the concept were explained and user interviews have been conducted among 10 to 15 end users in this phase for concept selection. Shortlisted concepts are further weighed in weight ranking method for various parameters such as simple design, functionality, ergonomics, features, usability and aesthetics. Figure 14 shows the concept selection.

Design and development of manually operated agarbatti powder mixer for micro enterprises		Concept-1	Concept-2	Concept-3	Concept-4	Concept-5
Scoring criteria	Weightage	Score	Score	Score	Score	Score
Simple Design	80%	3	2	5	3	3
Ergonomic	70%	3	2	3	3	2
Cost effective	90%	2	3	4	2	3
Features	70%	3	5	5	4	4
Aesthetic	40%	2	3	3	4	2
Total Score		13	15	20	16	14
Ranking		5	3	1	2	4

Fig. 14 Concept Selection

The weighted ranking method used for final concept selection. Required criteria have been evaluated with respect to each concept for ranking. Concept-3 has been shortlisted from weighted ranking method for further development.

7. DETAIL DESIGN AND PROTOTYPE MODEL

Product detailing has been done for the final concept selected considering manufacturability aspects and dimensional details. All the sub parts and sub assemblies in final concept are analysed to understand its manufacturing process, its function and assembly sequence. Design iterations has been done considering feedbacks collected from end users and agarbatti experts.

7.1 Working and specification of Mixer Machine

The working process and its specification details of the mixer machine is explained below. Table 2 shows the working of mixer machine.

Table 2. Working of Mixer Machine

	Function	Specification
1.	Agarbatti ingredients are measured in hopper and falls in the mixing chamber with the help of manually rotatable valve arrangement in the hopper.	Powder Capacity in hopper is 500grams
2.	Mixing chamber consist of ribbon blender attached to shaft, by rotating the shaft clockwise and anticlockwise with the help of handle the ingredients gets mix inside the chamber.	Capacity of mixing chamber 3 -8Kg. Time Required: 2Min
3.	Extruder screw beneath the ribbon shaft gets power through shifting the rotating handle to extruder shaft, which collects the mixed powder from the chamber and transfers out the mix.	Handle Revolution: 60rpm

7.2 Design for Manufacturing (DFM)

The important criteria followed during designing mixer machine is Design for Manufacture, because using CAD a complex design can be developed easily but the most important factor is manufacturing the components with the limitation of budget and technology. So considering these things in mind most of the part were designed simple which can be manufactured using basic conventional machines like lathe, milling, drilling and standard hand tools. The mixer machine was designed considering simple form and shape, easy to repair and replace parts, economical, reliable, strong and accurate. Table 3 shows the DFM of mixer machine.

7.3 Design for Assembly (DFA)

The final design of the mixing machine requires minimal tools necessary for assembly. Minimum number of parts are used to reduce the need for special tools in assembling the machine. All other parts are either hand tightened or welded further eliminating the need for expensive tools. With bolts mixer is secured to table.

Design for assembly (DFA) is a process by which mixer machine was designed with ease of assembly in mind. The mixer machine contains fewer parts, so it take less time to assemble, thereby reducing assembly costs. The mixer machine most of the parts were provided with simple features like thread to assemble instead of using welding or fasteners. which makes it easier to grasp, move, orient and insert them, this will

also reduce assembly time and assembly costs. The reduction of the number of parts in an assembly has the added benefit of generally reducing the total cost of parts in the assembly, both Manufacturing and assembly will be completed by the local craftsmen. Any failures or problems resulting from daily use of the machine can be easily maintained by users. Table 4 shows the DFA of the machine.

Table 3. DFM

Design for Manufacturing on Agarbatti Powder Mixer Machine	
Standardize components	Only standardized components were used (4Bolts 15x25, 4Nuts15x10)
Minimizing part count	In the total assembly only 5bolts and 4nut is been used
Communized usage	Same mixer machine can be used for different powders and dough mix
Multifunctional parts	Single handle is used to rotate both ribbon and extruder shaft.
Ease of fabrication	Common material used is mild steel which can be easily machined.
Keep designs simple	Overall design is simple no complex mould or CNC machine involved in manufacturing
Standardize design features	Most of the components are assembled and disassembled manually by bare hand with scandalized thread option.

Table 4. DFA

Design for Assembly on Agarbatti Powder Mixer Machine	
Subassemblies	The mixer main frame and side stands LH and RH are welded together to form an single sub-assembly helping in saving time in assembling and disassembling.
Mistake-Proof	Ribbon blade and extruder screw locking mechanism is provide to avoid unambiguous.
Minimize Part Count	The overall mixer machine consist of only 20 parts.
Minimize Fasteners	Only 5 bolts is used rest of the parts are assembled through threading feature.
Minimize Handling	All components used are easily accessible to assemble and disassemble.

7.4 Prototype Creation Stages

Prototype model has been made for the final concept in full scale. Various materials was referred by experts such as Polymer, steel and mild steel, finally mild steel was used for prototype creation, Conventional machine and tools used for model creation work are milling, turning, pressing, drilling, grinding and welding and the supporting tools used finishing are, steel rule, L-Square, cutter, hammer, spray painting unit, grinder, hacksaw, chisel, compass and scissors. Model has been made in number of steps such as roughing of raw material, machining of the profiles, groves, cut outs and threading and finishing. Figure 15 shows the images of prototype model machining stages of each part.



Fig. 15 Machining Stage

7.5 Prototype Finished Stages

Machined each parts are finished by grinding process in removing sharp edges and burrs, finally the parts going to have contact with powder are chromium plated for easy cleaning and corrosion avoiding purpose, and the rest of the outer body is been spray painted to add glossy look for colour blue. Figure 16 shows the prototype stages.



Fig. 16 Prototype Finished Stages

8. VALIDATION

The Validation of the final concept has been done with the working model developed to ensure the potential of the final design. Validation of the Working model identified to be important in order

to understand, how good the product can solve the current problems in agarbatti industries. The validation of the device has been carried out with different people. Figure 17 shows the design validation.



Fig. 17 Design Validation

8.1 General Parameter validation

Functionality, ergonomics, hygienic and safety are the major parameters considered in my design concepts, hence validation has been done on these components from a group of end users and results are compiled in below list.

Functionality

The function of each components and their simple mechanism are explained below.

- Machine can be operated with minimum training.
- Manufacturing operation of each part can be done within basic conventional machine.
- Rotating blenders with handle is easy due to bush usage.
- Assembling components can be done with basic knowledge.
- Disassembly is easy because it requires minimum tool, this allows for the easy cleaning of the mixer.
- Ingredients can be measured and used within the mixer machine.

Ergonomics

The ergonomic consideration of each featured parts are explained below.

- Rotating handle palm gripping feels easier and comfort during load.
- Reachability of each component are within comfort zone.
- Transferring machine would be difficult due to overweight.
- Opening the top cover with help of knob produces strain to fingers due to hopper weight.
- Activating valve on/off using circular knob is comfortable even through hopper powders weight falls on valve.

Hygienic

Considering the hygienic factors the machine functions are explained below.

- Mixing powders inside the mixing chamber produces toxic fumes which doesn't come out of the mixer.
- Direct interaction with powders is minimum till packing.
- No leakage of powders during mixing.

Safety

The safety factors taken care, while designing mixer machine parts are explained below.

- No sharp edges are exposed
- Gloves and face mask is required during mixing process.
- Cleaning ribbon blade and extruder screw the operator should be careful due to complex form and shape.
- Moving components are locked with locking screws to avoid accident and damages.
- The machine has bolting arrangements to the table to avoid vibration and movements during mixing.

9. CONCLUSION

Through research and experimentation on agarbattis was able to develop a successful prototype. Using feedback from the agarbatti workers was vital for the final design. User comfort was kept in mind for ease of use, range of motion, and the location of the power source. The manually powered machine met all customer and engineering design requirements. Using the mixer, can produce twice as much powder free mix and dough with little to no physical strain. The final design was able to greatly reducing the average mixing time. With reduced mixing time, reduced physical strain and an increase in batch size, production of agarbatti products will increase.

Micro enterprises in rural India will be able to disseminate the machine themselves and can modify with respect to their requirements as micro enterprises India begins working with this machine hope so will fight against poverty.

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