Design of Cooking Stove for Visually Impaired
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Abstract
Very less products are available in market specifically for the visually impaired. Some equipment for mobility, Braille for reading and other special products can be found, but household products and other commodities from abroad are not easily available because of high cost and a lack of awareness of availability. The impact of kitchen appliances in day to day life is high for the visually impaired people. They face various kinds of hazardous situations at the time of cooking with existing types of cooking stoves available in the market. So there is a scope to introduce a new type of cooking stove for this segment of the market.

The aim of this project was to design a cooking stove for visually impaired for safe cooking. The process of the project had many stages, which include understanding of problems of existing products and the usage of features; literature survey and market study to identify the user’s desires, conversion of user voice into technical voice through Quality Function Deployment and finalization of design outlines in the form of Product Design Specification. Concepts were generated based on the requirements and modeling was done using ALIAS and Bunk Speed Hyper shot.

Out of five concepts one concept was selected using user feedback. Detailing of selected concept was done in Auto CAD software. A working prototype was developed in order to validate the concept. The usability issues were checked by the users by using this working prototype.

Key Words: Cooking Stove, Blind, Safety

1. INTRODUCTION
Blindness has an enormous personal, social and economic cost, limiting the access to education and life choices for every physically challenged person [1]. Few numbers of facilities and products are available at an affordable cost in the Indian market for the visually impaired. Some equipment for mobility, Braille for reading and other special products can be found. Household products and other commodities from abroad are not easily available because of high cost and a lack of awareness of what is available [2], and cooking stove is one of them.

The physically challenged (blind) people go through some types of training to learn the correct process of handling a cooking stove to avoid any such kind of hazards. They learn to do many daily life activities in some training centres like how to sit, stand or move in and around; and how to recognize various kinds of objects and handle them.

Cooking is the process of preparing food by the application of heat. At the time of using the cooking stoves [3], one should handle them with utmost safety in order to avoid any hazards.

An innovative cooking apparatus is very much needed to the visually impaired to handle cooking activities safely at their kitchens. Many institutes in India train the visually challenged with specialised teaching techniques. They introduce thoroughly researched syllabi, unique teaching aids to the trainee together with an academic and vocational curriculum replete with self-help skills that is aimed at rehabilitating them from and making them self-sufficient individuals [4]. In addition to the prescribed academic syllabus they like to learn tailoring, making telephone call, screen printing, horticulture, nursery development, cookery and other vocational training such as chair caning, chalk making, candle making, phenyl packaging and sewing.

2. LITERATURE REVIEW
There is not much literature available about ergonomics and safety issues related to work activities of physically challenged (blind) people. An empirical study was very much required to observe their work pattern and realise their problems. Initially, many training schools for the visually impaired people, and families with blind members were visited, in order to understand the ways they organize their life activities. Ten visually impaired people, four sighted colleagues and four sighted home science teachers were interviewed about their perceptions of the difficulties faced because of blindness.

It was observed that handling LPG stove or kerosene oil stove, while cooking, was a particular problem for them. Those cause many fatal accidents at the time of cooking.

2.1 Cooking Apparatus to Train in Blind Schools

Home Science trainers teach the visually impaired using LPG stove, wooden handle utensils. Chopping board is used for teaching the partially sighted. The
chopping board has a particular type of feature with one half with dark colour and the other half with light colour. This colour difference helps them to identify the vegetables easily.

At present the visually impaired are forced to use pressurized burner stove (kerosene), wick kerosene stove, LPG stove and electric stove.

2.2 User Study – Face to Face Interaction

Many issues related to usability were identified by user study (figure 1). They are listed below:

- Complexity in cleaning of burner: Before lightening the burner of pressurised kerosene stove, it is difficult to clean it. Dust blocks the nozzle of the burner and it is difficult to insert needle into the nozzle properly and clean it. Fuel spreads all around the burner and dust get stuck on it, so cleaning of it becomes a regular problem for the user (figure 2).

- Uncontrolled flame flash: After cleaning the nozzle, flame gets spread because of uncontrolled fuel supply to the burner, which may cause the fatal injury to the user (figure 3).

- Difficulty in tracing the utensil holder on the burner of LPG stove: The cooking utensil holder on the burner of LPG stove is flat, so the user can’t locate the position at the time of keeping the cooking utensil; due this there is a chance of fatal accidents (figure 4).

3. PROBLEM DEFINITION

It’s very difficult to cook with the conventional cooking stove for visually impaired people. Design of electric stove with an innovative and break through concept understanding the latest trends and to make the regular kitchen activities - such as cooking, heating of milk/water etc. and focusing on usability and ergonomics.

The following risks were recognized at various steps while cooking with LPG stove

- Lighting the stove
- Difficult to position the cooking vessel on the burner
- Difficult to recognize whether the intensity of flame is more or less
- Difficult to know about spill over of liquid food from vessel
- Difficult to recognize whether the burner is on or off at the time of spill over occurs from cooking vessel
- Chances of both major and minor burn at each and every step
- Chances of catching of fire by cloth at any stage of the cooking process
- Chances of cuts and grazes to the hands whilst cleaning the stove.
- The following risks were recognized while cooking in pressurized-burner stove
- Difficult to recognize quantity of fuel comes out from the nozzle
- Difficult to identify the position of nozzle in burner
- Difficult to position the pot on the burner
- Difficult to light after the spill over from cooking vessel
- Chances of catching of fire by cloth at any stage of the cooking process
- Chances of cuts and grazes to the hands whilst cleaning the stove.
- Lack of affordability of buying good quality stove
- The chart below (figure 5) shows various profession of visually impaired and affordability for stove
Concepts were generated with the help of collected data and theme board. Five concepts were created in the form of hand sketches, digital models were generated using Alias studio tool and rendered by using Hyper shot. The final concept was selected out of the five concepts and detailed out using AutoCAD. A full scale working prototype was built and manufactured as per the detailed drawing. The working prototype was exposed to few of the targeted users & the conclusions were drawn from the feedback of users.

Table 1 Product feature comparison chart

<table>
<thead>
<tr>
<th>Features</th>
<th>Company Model</th>
<th>Local manufacture</th>
<th>Local manufacture</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Size LxWxH in mm</td>
<td>300 x400 x280</td>
<td>300 x200</td>
<td>650 x400 x120</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>6 Kg</td>
<td>2.5 Kg</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Burner</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Body</td>
<td>MS</td>
<td>Ceramic / MS</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>Mixing Chamber</td>
<td>-</td>
<td>-</td>
<td>Aluminium</td>
<td></td>
</tr>
<tr>
<td>Ignition</td>
<td>Manually</td>
<td>Auto</td>
<td>Auto</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>Kerosene</td>
<td>Electric</td>
<td>LPG</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>Rs 400</td>
<td>Rs 460 / 1950</td>
<td>Rs 2500</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 QFD matrix

<table>
<thead>
<tr>
<th>BURNER BOARD</th>
<th>EASY TO RECOGNIZE PARTS</th>
<th>SWITCH OFF WHEN SPILL OUT</th>
<th>EASY TO KEEP THE POT</th>
<th>LITE NOISE</th>
<th>EASY TO CLEAN</th>
<th>SAFETY</th>
<th>TECHNICAL IMPORTANCE</th>
<th>IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>92</td>
<td>82</td>
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<td>7</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
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<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>51</td>
<td>51</td>
</tr>
</tbody>
</table>

The data collected from the users was analyzed and the customer voice was converted into technical voice through Quality Function Deployment (QFD) -

4. METHODS AND METHODOLOGY

The following methodology was used to meet the objectives and is as follows:
- Literature survey
- Product study
- Market study, User study, Observation
- Data collection
- Photos, Videos, etc.

5. MARKET STUDY

Table 1 shows the comparison between the available products feature and their comparison. The available products may cause fatal accidents at the time of use, because these were not design for visually impaired.

6. QUALITY FUNCTIONAL DEPLOYMENT

The aim of QFD is to design a product that satisfies the needs of users by building a matrix between the requirements to design characteristics all
the way downstream to production. The user voice has been converted into technical voice in QFD. From the above QFD matrix (Table 2) it was clear that more priority was given for safety criteria and where as less priority was given for putting off the stove at the time of spill over. The above QFD matrix also shows more priority for new technology, shape, size and buzzer indications. These results were considered to generate the concept and search for the related technology. The above QFD suggests for a design of electric cooking stove for the visually impaired considering all kinds of hazardous situations from user studies as well as usability and technical issues.

7. PRODUCT DESIGN SPECIFICATIONS

The following PDS (Table 3) sets a structured description of the functions, characteristics those will be required for an electric cooking stove.

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Coil</td>
<td>2 kW/200V AC</td>
<td>Temperature controller</td>
<td>Contact type 220 V DC, 50-300°C</td>
</tr>
<tr>
<td>Expected life</td>
<td>Up to 3 Years</td>
<td>Buzzer</td>
<td>24 V DC</td>
</tr>
<tr>
<td>Insulating material</td>
<td>Fireclay, Glass wool/ Asbestos</td>
<td>Manufacturing process</td>
<td>Sheet metal work, Spot welding and grinding</td>
</tr>
<tr>
<td>Size</td>
<td>360×400×150 approx.</td>
<td>Warranty</td>
<td>1 Year</td>
</tr>
<tr>
<td>Spill cover</td>
<td>Stainless steel</td>
<td>Cost</td>
<td>Rs 1300</td>
</tr>
<tr>
<td>Weight</td>
<td>6 kg</td>
<td>Ergonomics</td>
<td>Temperature controller knob</td>
</tr>
<tr>
<td>Body material</td>
<td>MS with powder coating</td>
<td>Safety</td>
<td>Buzzer indication, shock proof, automatic off when power come back</td>
</tr>
<tr>
<td>Pot support</td>
<td>MS with powder coating</td>
<td>Disposal</td>
<td>Plastics and metals are separated and disposed or reused</td>
</tr>
<tr>
<td>Legs</td>
<td>Bakelite</td>
<td>Customer</td>
<td>Visually impaired people</td>
</tr>
</tbody>
</table>

Design Outlines:
From the above analysis, the points are refined and narrowed down as given below:
- Buzzer indication when system is “ON/ OFF”
- Ease to clean
- Address Safety
- Ease of use
- Channel out of spilling over of liquids
- Proper design of support for vessel on the burner
- Use of Braille for indicators on product
- A distinctly new form to recognise by touch feeling

The Issues below should be considered in case of electric stove design
- Electric shock
- More electricity consumption
- Heat loss
- Safety factor

8. CONCEPT GENERATION AND SELECTION

The basic technology for all the concepts was taken from fire clay technology called ‘Envirofit clean cookstoves’ (figure 6) [5]; a specialized insulating material (fire clay) inside the stove which accumulates all the heating energy and directs them towards the cooking vessel on the top of the burner. Fireclay withstands the temperature up to 1200 degrees Celsius and it takes more time to cool. In this way it can minimise the wastage of energy. Taller section of design increases air flow, which helps to mix fuel and air in a better way and increases the scope of complete burning of fuel (figure 7). Following are the advantages of this new technology for new stove design
- Shock proof
- Power consumption is less
- No heat loss
- Safety

The above technology was incorporated in new concepts of stove in the following manner (figure 7). The electric coil is fixed on the MS frame, which is covered by fire clay insulating material. Once the power supply button is ON, heat induced by the coil is concentrated at the opening of the fire clay at the top. Distance between the coil and the top of opening of fire clay is kept at a distance where it will heat the vessel placed on the burner. The buzzer indication in the system is activated when the system is “ON/ OFF” and the appliance is completely safe. The concept of easier cleaning is kept in mind so that the proposed electric stove is easy to clean with stainless steel spill cover and stainless steel pot support. A distinctly new form to recognise by touch feeling is added for Braille indicators on product. The safety factor is increased by the buzzer indication, shock proof, automatic off when power come back. The issues below should be considered in case of electric stove design
- Electric shock
- More electricity consumption
- Heat loss
- Safety factor

Fig. 6 Inspiration for concepts
clay is of 50 mm to avoid electric hazard at the time of cooking. This technology was used in all concepts.

**Fig. 7 Working principle of concepts**

The concepts were generated from the collected data and analysis. Based upon the PDS (Table 3), all the engineering parts were freeze. Concepts were derived through the sketches. Then the concepts were made in ALIAS software and were rendered in the Hypershoot software.

**Fig. 8 Digital rendering of concept 1**

Effort was put to cover all the user requirements in every concept including the technology aspect. Various types of forms of cooking stove were generated considering the ergonomics also.

**Concept 1:**

Salient features of concept 1:

- The rectangular shape of Concept 1 creates a modern look and it helps to realise the shape of the cooking stove and memorise the positions of every features for reference at the time of functioning; for example, keeping cooking vessel on the burner of the stove. (figure 8)
- Tapered sectional form of support helps to keep the cooking utensil firmly on the stove.
- Liquid sensor at liquid collector can sense the liquid at the time of spill over and automatically put off power switch of the system after creating some buzzer sound.
- Buzzer sound indicator can be used for both power supply and power cut.
- Braille system is included to the temperature controller knob with six operational positions for easy interaction. The moulded knob gives an effective sense of pointing to various position of intensity of temperature. The control positions are indicated by dots embossed around the knob. The size of those embossed dot are in increasing order according to increment of heat.

**Concept 2:**

Salient features of concept 2:

The features of Concept 2 are similar to concept 1, except there is no Liquid sensor at the spill collector in this case. The spill collector, at the top, is supported by tapered body. The spill over liquid is first collected into the spill collector and when the limit exceeds, it spills down along the sectional form of tapered surface and drains out of the stove. The details of Concept 2 are shown in Figure 9.

**Concept 3:**

Salient features of concept 3

The features of Concept 3 are similar to concept 2. The details of concept 3 are shown in Figure 10.

**Concept 4:**

Salient features of concept 4:

The features of Concept 4 are similar to concept 1. The details of concept 4 are shown in Figure 11.
Concept 5:

Salient features of concept 5:

- The overall asymmetric form of the cooking stove helps to realise the position of every feature on the stove. The user can easily perceive the position and function of every feature by touch and feel.

Features:
1. Shock-proof
2. Flammability
3. Specially designed pot support
4. Buzzer indication
5. Easy to recognize all parts
6. Automatic "Off" when set temperature reached

Selection of Final Concept: The teachers of home science of blind schools selected Concept 3 as the final concept considering the factors of usability, safety, ergonomics, shape and size. The design of Concept 3 was also refined for easy manufacturability. It meets all the needs of users and justifies its design.

Following are the features of the concept 3 (figure 13) those meet the requirements of the users:

- The tapered section of the support of vessel helps to keep the cooking vessel firmly on the cooking stove.
- The design of Concept 3 protects from electric shock and heat.
- The Buzzer indicates at the time of supply of power and power cut.
- Temperature control Knob is ergonomically designed for easy interaction.
- The control positions are indicated by dots embossed around the knob. The size of those embossed dot are in increasing order according to increment of heat.

9. DETAILING OF SELECTED CONCEPT

The detail design of selected concept was done in Auto CAD software. The dimensions of all the parts of the cooking stove are freeze according to the standard parts available in the market; those are like coil, PC board, Knob, Power supply socket and ON/ OFF switch. Each part of the stove was detailed to a scaled drawing.

Assembly process: At the first step of assembly process the coil was fixed to the MS support frame. Transformer and PC board were fixed at the bottom plate. In the next step the Temperature controller, Socket and switches were fixed, to the main body. As per assembly drawing all parts of the stove were assembled (Figure 14).
Finally wire connection layout drawing was made for all electrical and electronics connections.

Working Prototype: All the parts were manufactured according to detailed drawing. Figure 15 shows various stages of prototype making. Base plate, main body, spill collector and vessel supporter were manufactured as per detailed drawing in MS sheet. The pieces of MS sheet were welded together and grinded to avoid the sharp corners. Tapings were done as per drawing. At the end, all the parts were powder coated to prevent from corrosion.

After finishing of all fabrication work and painting, electronic and electrical components were fixed at respective places of cooking stove and wiring was done (Figure 16).

10. VALIDATION AND DISCUSSION OF RESULTS

User interaction with the final prototype: There are many features of the concept which make the cooking stove (Figure 17) useful to the users. One of the features is the tapered section of the vessel-support, which helps to keep the vessel firmly on it. The front rectangular shape helps to perceive the reference for all other parts of the cooking stove.

Ergonomically designed temperature controller knob with control positions are indicated by dots embossed on the front of the stove. These sizes of these dots are increased incrementally to get the feeling of increment of heat.

At the time of cleaning the stove, user can easily remove the vessel-support and spill collector. The round shape of the main body and tapered form of the vessel-support helps to easily locate the spill collector part on the stove.

Overall the users were satisfied with the new prototype of cooking stove and the communication process for functioning.
11. CONCLUSION

The problems of the usage of cooking stove for the visually impaired were addressed properly by various kinds of survey methods like, observation method, interview, questionnaire survey etc.

The new design of electric cooking stove is better in comparison to LPG or kerosene oil cooking stove to avoid any kind of hazards.

Every feature was designed following the touch, feel and perceive phenomena of human activities. The Braille system of representing the features was used for designing features.

In some cases the sound system was used to design the warning system for this cooking stove.

Proper care was taken to minimize the provision of sharp edges.

User feedback was taken to validate the efficiency of the product.

REFERENCES