Soap Making Machine Development For Home Appliances

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Abstract. Nowadays, most of the time people will using cooking oil to bake, fry and other type of cooking. There are many types of cooking oil such as olive oil, palm oil, canola oil, vegetable oil and etc. Normally, only two or three times the oil can be used for fry. After that, the oil will throw away. The disposal of used cooking oil is an important factor for the waste-management. Most people will dump the used cooking oil in the kitchen sink. This will led to blockage to the pipe and contaminate water. Without people realise, used cooking oil can be recycled in to soap for general purposes. The aim of this research is to develop a semi-automatic machine for making soap by using used cooking oil as main ingredients. There were a lots of process involved such as how to gain the voice of customer (VOC), concept selection, detail design, fabrication and testing process in order to verify the quality and time taken to produce the soaps. This machine can be used in every kitchen of household and not for mass production. Meanwhile, user can make their own soap for general purpose such as to wash floor, car and drain. Moreover, this can save environment.

Keywords: Soap; Saponification; NaOH Pallet; Prototype; Design and Development

1. Introduction
This paper presents the development process of Soap Making Machine for Home Appliances. This Soap Making Machine is semi-automatic machine system. The main ingredients to make soap are by using used cooking oil, warm water, NaOH pallets and fragrance. It will be mixed together in this Soap Making Machine by using the mixer mechanism. This machine is small in size and easy to store in every kitchen...
in the house. The objectives of this research are to design a Soap Making Machine, to develop a functional prototype and also to test the machine by compare the best method by semi-automatic vs manual to make soap in term of time and quality of the soap being produced. The testing have been done between preparation and procedure how to make soap manual vs semi-auto. This machine can be used in every kitchen of household and can make these soap as an alternative detergent to wash floor, car and drain. This can save environment and reduce pollution. This smart soap making machine is very special and practical because the design is suitable for home user.

2. Research Methodology
Plan or flow of the research is very important in order to plan and arrange the sequence of the process involved. It will explain the process, material, equipment and procedure for every stage of the research as shown in figure 1.

2.1 Fundamental of soap making process, method and ingredients
Word ‘soap’ originates from Latin sapo, which is origin from Latin sebum, tallow. Nuttall defined soap as “an alkaline or unctuous substances utilized as a part of washing and cleaning” In science, soap is a salt of an unsaturated fat. Soaps are mainly used as surfactants for washing, showering furthermore cleaning. It is perfect by going about as a surface agent active, wetting and emulsifying. Soap is the result of blending an alkaline solution with fat in specific amounts, with the right temperature, for the most part around 40.5oC to 42oC [1].

The two most critical soluble bases which more often than not utilize are sodium hydroxide (NaOH) and potassium hydroxide (KOH). To produce soap, there are three main methods that are direct saponification of fats and oils, neutralization of fatty acids and saponification of fatty acid methyl esters describe by Ogoshi, T. & Miyawaki, Y. [2]. When they are combined well together specific circumstances, a chemical process changes the fat and alkali blend to a single substances, which is soap. This substance procedure is called “saponification”.

Saponification [3] is a procedure of making soap. It is made by blending rendered fat which from beef or mutton fat, with an alkaline solution. Within 24 hours 80% to 95% of the saponification is finished, over the following a few days to weeks it will proceed with this saponification process, getting to be milder and milder.
The step of making soap is easy and some ingredients are used for all types of soap. There are four basic ingredients to make soap that are used cooking oil, NaOH and water and scented oil as additional for odour [5]. All four ingredients will be mix up to make soap. It is easy because when the NaOH is mixed with water, there are chemical reactions that take place. When the solution is mixed with used cooking oil, the saponification reaction happens. Saponification is a process of turning into soap. The saponification need three to eight weeks to happens. There are some fats that saponification quicker than other; it is quicker if when hot processing is used. There are two sorts of soap, which are, soft soap and hard soap.

Soft soap can be made using either a cold procedure or hot procedure, however hard soap can only be made using a hot procedure. The cold procedure and the hot procedure are the principle forms for making soap. To make any soap it is important to weaken the alkali, blend it with the fat or oil and mix the mixture until saponification happens [6].

2.2 Customer surveys
To know the customer needs, a survey is distributed to 100 public respondents. Data about customer needs are obtained by manual and online. For this survey, it is done by 50 respondents for manual and 50 respondents for online. There are 100 members of the public which consists of male and female customers.

Through the survey, what customer needs for the product can be known. The need statement and technical specification of the product can be listed. The target market and where the product can be located can be identified. Questionnaire have been conducted to determine the customer needs. The results from the questionnaire are able to identify the needs of consumers and other aspects as well. Answers given in the questionnaire will be used as a guide in making these products [8].

Figures below will elaborate more detail results obtained from the customer survey questionnaire. Based on the pie chart shows in figure 4, the percentage of respondents did not know to make own soap is 68% where the other 32% of respondent know and there are able to make their own soap. Figure 5 below show the percentage of respondents throw used cooking oil into the sink. There are 70% of respondents throw used cooking oil into the sink and the rest 30% of respondents did not throw used cooking oil into the sink. This is shown majority are does not know a better way to reuse a used cooking oil and shown the
high percentage of water pollution can be occur.

**Figure 4.** Respondent know to make own soap

![Pie chart showing 70% yes and 30% no](image)

**Figure 5.** Respondents throw used cooking oil into the sink

![Pie chart showing 62% yes and 38% no](image)

**Figure 6.** Respondents agree smart soap making machine can save the environment

![Pie chart showing 93% yes and 7% no](image)

This pie chart in figure 6 shows the percentages of respondent agree smart soap making machine can save the environment. There a better way to dispose or reuse used cooking oil. There are 93% of respondents agree smart soap making machine can save the environment while another 7% of respondents does not agree smart soap making machine can save the environment. This is shown majority respondents are agree smart soap making machine can save the environment by using used cooking oil as a main ingredients to turned it into soap.

### 2.3 Concept selection

Based on the survey results, it can identify that people really like this product and they realize that the used cooking oil can be converted to something else that very useful with a few consideration such as interm of user friendly, durability and functionality as listed in Table 1.
Table 1. Customer requirements consideration

| Item          | Specification                  |
|---------------|--------------------------------|
| User Friendly | Safe design                    |
|               | Automatic                       |
|               | Compact design                  |
| Functionality | Easy to mix                     |
|               | Easy to operate                 |
|               | Easy to maintenance             |
| Strength      | Have good quality               |
|               | Can stand in high temperature   |
| Time          | Save time                       |

House of quality (HOQ) shows the customer requirements gained from survey results being transformed to engineering characteristic which is more specific and detailed. As a result from HOQ method (rank 1-3), it shows that automatic system is a main important factor to be highlighted during design process followed by easy to operate and last is regarding to compact which is more to sizing issue. All these things need to be considered during the detailed design stage.

For concept selection, the concept has been described based on consideration with the sketches as shown in figure 7. Although each concept nominally satisfied the key customer need, the best concept still need to be choose for further design and refinement. Firstly, the process of evaluating concept with respect to customer needs and other criteria has been done. Next, compare the relative strengths and weakness of the concept. Lastly, one or more concepts have been selected for further investigation, testing, and development. Although the focus is on the selection of an overall product concept at the beginning of development process, the method presented is also useful in the development process while selecting components and manufacture process. This concept selection is the process of concept alternatives under consideration. The set of concepts is initially winnowed down to a smaller set. Finally, the concept has been selected.

Concept screening is to determine the concept and criteria that should have in this product. The concept and criteria that has been chosen. The criteria were chosen based on what customer need that has been identified before. The selection criteria were chosen based on what the suitable to the concept. Chosen concept must be fulfilling all the criteria that have been listed. The score that has given is based on “+” for the criteria that has in that design, “-” for the criteria that does not have in that design and “S” for the criteria which not related to the design. Based on the score that have given, concept III and IV have better designs compared to other design which will remove at the next selection.
In this scoring process, focus has been put on the differences relatives to the concept screening. In the screening concept, classification has been made based on criteria that already listed on need statement. Screening concept is to define which the most suitable design that can satisfy the customer and the scoring stage is to make the choice of the best design. To make the decision, concept scoring used to help making a good decision. After the criteria have chosen, some important thing has been added such as weight, which it to determine the scoring. Several different schemes have been used to put the score. The scoring based on important value from 1 to 5, and locates the 100 percentage point among them. As in the screening stage, it is generally easier to focus its discussion by rating all of the concepts with respect to one criterion at one time. Table 2 shows how to classify the scoring.

**Table 2. Scoring classification**

| Relative Performance Rating | Rating |
|-----------------------------|--------|
| Unsatisfactory              | 0      |
| Just tolerable              | 1      |
| Adequate                    | 2      |
| Good                        | 3      |
| Very Good                   | 4      |

Once the ratings are entered for each concept, weighted scores are calculated by multiplying the raw scores by the criteria weights. The total score for each concept is the sum of weighted scores. Finally, each
concept is given a rank corresponding to its total score. By explore this initial evaluation, the ranking can be assessing whether uncertainly about a particular rating has a larger impact on the design choice. The concept has been selected based on the concept screening and scoring method. It clearly state that concept sketch 4 is the best idea and fulfill customer requirements and ready for detail design and development process.

2.4 Smart soap making machine detail design
Detail design is the phase where the design is refined and the plans, specifications and estimates are created. Detailed design will include outputs such as 2D and 3D models, cost build up estimates, procurement plans and more. In detail design, CAD drawing, which are part drawing and assembly drawing, of the chosen concept need to be design. The part name and bills of material should be listed to know what is needed and what is not needed. Besides that, all the components of the product and where will it be located will be identified. There are some CAD software which can be use, such as SolidWorks and CATIA. For this research, SolidWorks 2014 software is used. These drawings should be done before the manufacturing process take place. This is to make sure that all parts in this product are manufactured with accurate dimension. Figure 8 is 3D model final design of smart soap making machine. Figure 9 shows the exploded view of the smart soap making machine together with components involved as listed in Table 3.

2.5 Smart soap making machine development
Smart soap making machine functional prototype development process begin from rapid prototyping for several parts such as strainer holder, soap mold, and mixture housing. The complete parts will assemble together with an electrical component before this machine being tested. Prototyping development is the design verification phase of Product Development that will be able to demonstrate or verify aspects of the design. Figure 10 & 11 below clearly explain how this machine being developed and process involved.

| Item No. | Component Name       | Quantity |
|----------|----------------------|----------|
| 1        | Mixture Housing      | 1        |
| 2        | Stirrer              | 1        |
| 3        | Body Cover           | 1        |
| 4        | Soap Mold            | 1        |
| 5        | Drawer               | 1        |
| 6        | Pipe                 | 2        |
Glass is cut into desire dimension. Total glass have been used is 15 pcs of glass sheets. Silicone is used to stick glass together and prevent leaking. Because of that, silicone is the best glue for glass. All the glass sheets are stick together based on desired shape. After that, one of the glass side will be drill for hinge perspex top purpose. Then, Perspex top is cut into desire size and dimension in order to make filter housing and mixer housing will be place at the top of the perspex easily. Hinge are attached to the perspex and glass side and it will allow to open and close the perspex for maintenance purposes. The main body is combine together with the bottom soap drawer and piping to complete assemble the whole body of the smart soap making machine. There are few parts need to fabricate via 3D printer such as mixer housing, strainer holder and soap mold. 3D printer that been used is model 2UPS. Figure 12 show the final functional prototype of smart soap making machine while the Table 4 explain the specification of this smart machine.
Figure 11. 3D Printing process

Table 4: Specification of Soap Making Machine

| Specifications          |                                                                 |
|-------------------------|------------------------------------------------------------------|
| Dimension (L x W x H)   | 300mm x 468mm x 233mm                                            |
| Weight (kg)             | 8.9 kg                                                           |
| Materials               | Glass, Perspex and plastic ABS                                   |
| Colour                  | Transparent, Red and white                                       |
| Performance             | Automatic mixer and save time                                    |
| Product Life Span (year/s) | 2                       |
| Maintenance             | Wash it properly using water and dish soap                       |

Figure 12. 3D Functional prototype
2.6 Testing process
Testing process will take place after the functional prototype completely ready to be tested. Testing by manually vs semi-automated of making soap will be done. The purpose of testing manually vs semi-automated is to compare the best time taken to mix the soap ingredients and also the quality of the soap by both method. The expected result is to proof that semi-automated method much better than manual method as shown in figure 13 below.

![Testing process](image)

3. Result and Discussion
At this stage, the result of making soap by using this smart soap making machine will be discussed. Table 5 and Table 6 are the results obtained from manual vs semi-automated soap making method. It includes the time taken to mix the soap, the ratio of the ingredients, cooling time and the quality of the soap shows in figure 14.

| Table 5. Result of manual method |
|----------------------------------|
| Criteria                        | Testing |
| 1 Time taken                    | 15 minutes |
| 2 Time taken                    | 16 minutes |
| 3 Time taken                    | 20 minutes |
| 1 Cooling time                  | 10 minutes |
| 2 Cooling time                  | 10 minutes |
| 3 Cooling time                  | 10 minutes |
| 1 Quantity                      | -1500 ml of used cooking oil |
| 2 Quantity                      | -600 ml of warm water |
| 3 Quantity                      | -300 gram of NaOH |
| 1 Quantity                      | -Scented oil |

| Table 6. Result of semi-automated method |
|------------------------------------------|
| Criteria                  | Testing |
| 1 Time taken              | 90 minutes |
| 2 Time taken              | 100 minutes |
| 3 Time taken              | 96 minutes |
| 1 Cooling time            | 10 minutes |
| 2 Cooling time            | 10 minutes |
| 3 Cooling time            | 10 minutes |
| 1 Quantity                | -1500 ml of used cooking oil |
| 2 Quantity                | -600 ml of warm water |
| 3 Quantity                | -300 gram of NaOH |
| 1 Quantity                | -Scented oil |
| 2 Quantity                | -Scented oil |
| 3 Quantity                | -Scented oil |
The quality for semi-automatic method is much better in appearance and surface rather than manual method. Manual method have bad in appearance and surface, in fact, there are defect on soap which is bubble as shown in figure 15. This is because of the ingredient is not mix well. The viscosity that manual method can create is not enough to give good quality or at least in good shape. This is shown that by using semi-automatic method the quality is improve and the quantity of soap can be made also increase from manual method.

4. Conclusion
The product has been successfully designed and developed based on customer needed and testing to proven the best method. It show that semi-automatic gives good result. It is proved that the objectives have been achieved.
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