Improving the Quality of Coffee Shops in Jabodetabek Area by Application and Modification of Coffee Roaster Machine Capacity 400-600 Gram Coffee Beans Using the Reverse Engineering and Engineering Design Method

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Abstract. Coffee roaster machine or commonly called coffee roaster is a tool for cooking coffee beans that have been fermented during the process of cherry coffee into coffee beans in a measured and controlled manner. Coffee shops have constraints in fulfilling the ingredients of the coffee beans themselves by using a roaster coffee machine available at the market less 400 grams or bigger than 1000 grams, so that does not match with the needs of the limited ingredients of coffee beans, the coffee shop buys cooked coffee beans at a more expensive price. Therefore, in this research a coffee roaster machine will be designed at the capacity of 400 grams up to 600 grams. Reverse Engineering is a process of analyzing existing products or machine as a reference for designing similar products by minimizing and increasing an excellence product. Reverse Engineering activities have carried out by dismantling and replacing the old coffee roaster. Engineering Designing a new roaster machine, and the last is built a prototype machine. The new design of a roaster machine can produce a faster roasted coffee with the capacity between 400 grams up to 600 grams/77 minutes, in the process of roasting coffee with additional in weight of 200 grams of coffee in a roasted coffee machine after modification.

Keywords: Roasting machine, coffee, Reverse Engineering Design, coffee shop.

1. Introduction

Coffee roaster machine or commonly called coffee roaster is a tool for cooking coffee beans that have been fermented during the process of cherry coffee into coffee beans in a measured and controlled manner. This tool with a temperature and heat gauge that can be adjusted to the needs. With an increase in people's needs and desires in consuming coffee, coffee shops have great opportunities in developing and matching the needs and desires of the community. Reverse Engineering is the process of citing knowledge or blueprints from existing machines or assistive devices. The application of reverse engineering focuses on man-made tools [1]. Reverse engineering is usually specified to obtain better modifications to knowledge, ideas, and designs when information is not available and is a shortcut that makes it easy to work the machine into many components and about disassembling, and rearranging products and physically researching to find the secrets of the design [2],[3],[4],[5],[6],[7],[8].

Benchmark is a process in a management to measure and compare products, services and practices in order to compete with competitors or companies concerned as industry leaders [9]. The main objective is to understand and evaluate the current process or product and to find ways or best practices to improve the process and product quality.

In designing assistive devices, a design engineering method is needed in which this method is one of the several methods can be selected, to solve problems and optimize the use of materials, technology, and economic conditions. According to Pahl G, W. Beitz, J. Feldusen, K.H Grote [9] engineering design method (VDI 2221) consists of several stages, namely:
Clarification of the task; Conceptual design; Embodiment design; Detail in designing. Each stage there needs to be attention to whether the next steps can be taken or the need for a review process of the previous stages. There are theoretical aspects in the main stages in the application of the design process and its explanation. In the design of task clarification is the first stage of the design process. Clarification of duty is an activity carried out in the form of information gathering and design constraints. The results obtained are in the form of design criteria specifications. Clarification of assignment can be made with the following questions: What are the problems in the design?; How the results produced by the design; Are there any limitations on the design?; Whether the concept chosen meets the design goal? The things that are owned and not owned by the results of the design [9].

2. Research Methodology

Preliminary study begins with the determination of topics to be discussed and then continued with the study of literature as a basis for what will be discussed and observed from the work process. Collecting data and then identifying what are the needs for the roaster coffee machine to increase its usefulness and based on the needs of the design, the design is carried out and then tested and analyzed the results of the coffee roaster machine that has been modified. Figure 1 is the flow chart of the conducted research study of modified roasting machine.

![Figure 1. Research flow diagram the study](image-url)
3. Results And Discussion
Performance tests as preliminary study was conducted at the Laboratory of Department of Industrial Engineering Tarumanagara University. The study carried out from January up to June 2020. The performance tests of the roasting machine SCR-300 with main variable of three different temperatures 220º C, 230º C and 240º C, and 5 replication, respectively. Each trial used 400 grams of raw coffee beans to be cooked with a span of 1 day / trials based on SNI 7465: 2008. The results of the roasting machine performance test can be seen in Table 1 and Table 2.

Table 1. Results of roaster machine performance (dark brown color)

|   | A | B | C |
|---|---|---|---|
| 1 |   |   |   |
| 2 |   |   |   |
| 3 |   |   |   |
| 4 |   |   |   |
| 5 |   |   |   |

Information:
(1,2,3,4,5): Experiment replication
(A, B, C): Temperature (220,230,240)ºC

Table 2. Results of the roasting machine SCR-300 performance

|   | A   | B   | C   |
|---|-----|-----|-----|
| W | S(°C)| K   | W   | S(°C)| K   | W   | S(°C)| K   |
| 1 | 1:32 | 29  | 49% | 1:25 | 28.5| 48% | 1:00 | 29.2| 50% |
| 2 | 1:27 | 28.4| 54% | 1:13 | 28.5| 52% | 0:56 | 28.5| 56% |
| 3 | 1:04 | 29.7| 49% | 0:59 | 29.7| 45% | 0:56 | 27.1| 48% |
| 4 | 1:27 | 27.4| 56% | 1:09 | 28.5| 54% | 0:57 | 28.2| 51% |
| 5 | 1:11 | 26.9| 51% | 1:00 | 28.1| 52% | 0:56 | 28.2| 49% |

Information:
A. The temperature is 220ºC, B. The temperature is 230ºC, C. The temperature is 240ºC
W: Time, S: Room Temperature, K: Humidity
The next steps of this study is to observe the components that are on the roasting machine by doing the Reverse Engineering method. At this stage the SCR-300 model roasting machine is disassembled to find out and analyze the functions of each product component and to verify the dimensions and specification of the components (Figure 2).

![Components of a Roaster Machine SCR-300](image)

**Figure 2. Components of a Roaster Machine SCR-300**

Information: 1-7 is presented in Table 3

| No | Component       | Picture | Information                                                                 | Dimensions and Specifications |
|----|-----------------|---------|------------------------------------------------------------------------------|------------------------------|
| 1  | The cover       | ![Image](image) | The cover of the roasting machine serves as a barrier to hot air which helps speed the process of maturity | Length: 20 cm                |
| 2  | Stirrer         | ![Image](image) | Roaster machine mixer that functions as a coffee bean mixer to make the level of maturity in the coffee beans evenly | Material: Aluminum           |
| 3  | Grill           | ![Image](image) | Toaster roasting machine which functions as a coffee bean roasting process | Diameter: 30 cm              |
| 4  | Insulation Pads | ![Image](image) | Plastic pads that function as grills and separators to prevent electrical backflow | Depth: 4 cm                  |
| 5  | Machine Bodies  | ![Image](image) | Roasted machine body that functions as a motor drive and temperature measuring devices | Thickness: 0.3 cm            |
| 6  | Legs or Supports| ![Image](image) | The foot of the roasting machine which functions as the roasting machine holder to make the roasting machine stand stable | Material: Aluminum           |
| 7  | Scatter Motor   | ![Image](image) | Motor for roasting machine that serves as a stirring propeller | Length: 5 cm                 |

Based on the results that have been known after conducting the performance test on the roasting machine, the temperature that can be used as a benchmark in roasting the appropriate coffee beans are 220º C, 230º C and 240ºC with a dosage of 400 grams of coffee beans. In this case to modify the roasting machine by increasing the capacity in the roasting process to
become 600 grams. After knowing what components are in the coffee roaster, the next step will be the design activities using the VDI 2221 design engineering method and is expected to facilitate the construction of the design system without having to master in detail. Demand (W) is a must that must be met with product specifications so there is no damage to the system, while Wish (W) is an optional wish on the product. The table of initial specifications can be seen in Table 4.

Table 4. List of initial specifications of the modified roaster machine design

| Parameter   | Specification          | D/W |
|-------------|------------------------|-----|
| Geometry    | Diameter D            | W   |
|             |                        |     |
|             | High W                 |     |
| Energy      | Efficient use of energy| W   |
| Material    | Easy to get D          |     |
|             | Components W           |     |
|             | are not easily W       |     |
|             | damaged                |     |
| Assembling  | Easy to install D      |     |
| Production  | Affordable manufacturing costs D | |

After making a list of initial specifications, the next step is to select the existing concept variants so that one concept can be created using a choice of solution variations. Table 5 is the selection for solution variants of new design roaster machine.

Table 5. Selection Chart for the Solution Variants of New Design Roaster Machines

| Decision sign variant solution (SV) |
|-------------------------------------|
| (+) Yes                              |
| (+) Improve the solution             |
| (-) Not                              |
| (-) removes the solution             |
| (?) Lack of information              |
| (?) Gather information               |
| (!) Check specifications             |
| (!) Check specifications for changes |

Based on the variant selection in table 5, it shows that variant 1 fulfills the design criteria to make a new modified coffee roaster machine, then variant 1 will be continued and analyzed for the next step of stages. Selected drawings concept the front (A) and back (B) of the new
design can be seen in Figure 3. The dimensions of the new design roaster coffee beans is presented in Table 6.

![Figure 3](image)

**Figure 3.** Selected concepts of the new design roaster coffee beans

| No. | Information               | Size (cm) |
|-----|---------------------------|-----------|
| 1   | Machine body diameter     | 28        |
| 2   | Machine height            | 17        |

**Table 6. Dimensions of the New Modified Designing Machine**

Increasing the power of the driven motor or replace the driven motor that has a power of 2 watts, to become 4 watts or greater so that it can rotate and stir at the rate of adding coffee beans of 200 grams in the roasting process. The application of induction electric heater can increase speed rate of the heat in reaching the specified level of maturity. Create a plenum chamber is to regulate hot air and store hot air that can make the maturity of coffee beans faster and more efficient. The new drawing design of modified coffee roaster machine is shown in Figure 4.

![Figure 4](image)

**Figure 4.** Design Sketch of the new design roaster machine with additional plenum chamber

### Implementation and Results Analysis of the New Modified Roaster Machine

The design components of the new modified roaster machine is presented in table 7. Comparing with the benchmark there are additional plenum chamber, increasing the power of the driven motor for stirring propeller for mixing the coffee beans, and a new electrical induction heater in the new modified roaster machine.

The performance test the new modified coffee roaster bean carried out on a new roasting machine with main variable of temperature of 220º C, 230º C and 240º C, and 5 replications where each trial uses a dosage of 600 grams of raw coffee beans to be cooked, with a span of 1 day / trials based on SNI 7465: 2008. The results of test can be seen in table 8. The comparison of time of experiments when roasting coffee beans roaster pan capacity increase
from 400 to 600 grams there were no differences in terms time of maturity in roasting process. From the results obtained in roasting machine experiments, by comparing with trials before modification the most obvious level is the dosage of coffee beans with an increase 50 % or 200 grams of the capacity of coffee beans pan, which was originally 400 grams. The results of the average coffee bean roasting time are presented in Table 9.

Table 7 Design components of the new modified roaster machine

| No | Picture | Information | Dimensions and Specifications |
|----|---------|-------------|------------------------------|
| 1  | ![Picture](image1.png) | Toaster roasting machine which functions as a coffee bean roasting process pan | Diameter: 30 cm  
Depth: 4 cm  
Thickness: 0.3 cm  
Material: Stainless |
| 2  | ![Picture](image2.png) | Plenum chamber of a roaster coffee machine: functions as a storage and hot air circulation so that the coffee beans can be faster and more evenly distributed in the level of maturity | Diameter: 28 cm  
Depth: 2 cm  
Thickness: 0.3  
Material: Stainless |
| 3  | ![Picture](image3.png) | Induction electrical heater: functions as a toaster on a roasting machine | Diameter: 28 cm  
Thickness: 2.7 cm |
| 4  | ![Picture](image4.png) | Roaster machine mixer: functions as a coffee bean mixer to make the level of maturity in the coffee beans evenly | Length: 20 cm  
Material: Aluminum |
| 5  | ![Picture](image5.png) | Motor for roasting machine that serves as a stirring propeller | Power: 4 watts |

Table 8. Test results using Electrical induction Heater

| A | B | C |
|---|---|---|
| W | S(ºC) | K | W | S(ºC) | K | W | S(ºC) | K |
| 1 | 1:30 | 29 | 49% | 1:20 | 28.5 | 48% | 1:05 | 29.2 | 50% |
| 2 | 1:23 | 28.4 | 54% | 1:14 | 28.5 | 52% | 0:58 | 28.5 | 56% |
| 3 | 1:00 | 29.7 | 49% | 0:58 | 29.7 | 45% | 0:59 | 27.1 | 48% |
| 4 | 1:21 | 27.4 | 56% | 1:03 | 28.5 | 54% | 0:53 | 28.2 | 51% |
| 5 | 1:13 | 26.9 | 51% | 1:00 | 28.1 | 52% | 0:55 | 28.2 | 49% |

Information: A. Temperature is 220ºC, B. Temperature is 230ºC, C. Temperature is 240ºC  
W: Time, S: Room Temperature, K: Humidity
Table 9. Results of average roasted time

| Temperature (°C) | Benchmarking | Electrical Induction Heater |
|------------------|--------------|-----------------------------|
| 220              | 1:20         | 1:17                        |
| 230              | 1:09         | 1:06                        |
| 240              | 0:57         | 0:57                        |

5. Conclusion
The analysis of performance test of the new machine design roasted coffee beans compared with the previous roasted coffee machine before it is modified by adding plenum chamber and replacing the motor with greater driven power have main variable of three level of temperature, and 5 times replication, gave results that there are no significant differences at temperature of 220°C, 230°C and 240°C, in time set of the process of roasting the coffee beans is 1:20 (80 minutes) and after modifying the time needed in the coffee roasting process is 1:17 (77 minutes); 1:09 (69 minutes) compared with 1:06 (66 minutes) and 0:57 (57 minutes) compared 0:57 (57 minutes). When comparing the capacity of the roaster pan, it can be concluded that the design modification of the coffee roasting machine can be faster in the process of roasting coffee with additional weight of 200 grams of coffee beans, on roasting process in new modified coffee roaster machine.

5. References
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