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Design and production of multifunctional food oven with energy-saving gas fuel

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Abstract. Ovens sold in the market have many features that make them easier to use but are not suitable for the needs of Small and Micro Enterprises (SME), namely large capacity, multifunction, use of gas fuel, energy-saving, and ease to operate. It is necessary to design and manufacture an oven according to the needs of SME users. The purpose of this study is to design, build, assess the feasibility, and evaluate the operating energy usage of the oven. The oven design process uses the French's model and Quality function deployment (QFD) methods. Experiments to test the oven's feasibility. The study's result is that oven design validated user requirements by design experts, manufacturing experts, and users (SMEs). The oven prototype has shown performance to reduce water content according to food products with a distribution permit in Indonesia. The energy consumption of oven prototype has been compared to an electric oven similar capacity that showed that there is an energy-saving of 6.8%. Based on validation of design and product feasibility and calculation of oven energy consumption, the oven meets the small and medium enterprises (SME) users' needs.

1. Introduction

Ovens are food processing tool that has the function to toast and drying of food. A toast is a food processing that affects the nutritional content and physical properties of the finished product [1]. Drying is the process of removing water from a solid or liquid food by evaporation in order to get a solid product with a low water content [2]. The use of an oven as a widely used tool in the production process requires an oven with exclusive features but at an affordable price so that SME actors can use it.

SME actors need an oven that suits their needs, where the oven must be able to be used in large-scale production with different sizes of food ingredients. Large capacity ovens circulating in the Indonesian market are available using electric heaters with considerable electrical power, so they are unsuitable for SMEs.

Research on making ovens by Emalue [3] found a toaster and dryer oven with solar heat with a length of 80 cm, a width of 50 cm, and a height of 40 cm. This oven can only be used in hot weather, can only be used in a small capacity, and cannot be used indoors. Yus conducted a study on an LPG gas-fired dryer that can only be used to dry flour with the help of a pneumatic dryer with a maximum moisture content of 12% wb[4]. Rowe researched an oven that uses solar power using a reflector focused at a certain angle that can reach a temperature of 78˚C in 120 minutes [5].

Hegde studied a solar-powered dryer with a length of 2.04 m, a height of 1.38 m, and three shelves [6]. This dryer's disadvantages are that it cannot for used indoors, has a limited capacity, and can only be used for thin foodstuffs. Demissie researched a dome-shaped solar dryer; this dryer can only be used outside and achieves a temperature of 41˚ in 35 minutes [7].

Ilesanmi researched an oven with gas fuel dimensions of 860 mm x 660 mm x 1150 mm, with a capacity of 6 Kg and a maximum temperature of 210˚C [8]. This oven has lacked small power, so it is not suitable for MSMEs. Ngu researched ovens [9]using fuzzy controls that function regulate the temperature oven, but there have been no trials with food ingredients carried out the oven. Lingayat conducted of study on a banana dryer with dimensions 1 m x 0.4 m x 1 m equipped with four shelves using hot airflow as a dryer [10].

Duangnakhon conducted studies on drying ovens with a dimension of 1200 mm x 800 mm x 600 mm with one shelf [11]. This oven uses a fan as a dryer which is driven the power from solar panels. This dryer can only be used to dry grains and does not allow for processing other foodstuffs.

Olugbade researched an oven with a heating element with two shelves with 600 mm x 600 mm x 600 mm, which are regulated using a thermostat [12]. This oven has dimensions that are too small to be used in industry and SMEs. Morakinyo conducted of study on a gas-fired [13] oven with dimensions of 920 mm x 650 mm x 600 mm equipped with three shelves and can reach a maximum temperature of 220˚C and a capacity of 12.5 Kg[14]. Igo conducted a study to test a locally made gas-fired oven[15] with an oven efficiency of 35% and heat loss by 50%.

Multifunctional ovens with large capacities, gas-fired, energy-efficient, easy to operate, and energy efficient are not yet available in the market also have not been developed by related studies. None of the above literature has designed and made a prototype of a large capacity oven, which can be used for baking and drying various foodstuffs, fueled by gas with an automatic control system with a smartphone. It is necessary for designing and manufactures an oven that follows the user's needs using the French and QFD methods. The study's goal is to develop and manufacture an oven prototype that satisfies the needs of SME users, examines the oven's feasibility, and evaluates the operating energy consumption.

2. Methods

The research methods used are the Quality Function Deployment (QFD) and French design methods for product design, manufacturing methods, and experimental methods for product feasibility testing. Quality Function Deployment is a structured process or mechanism to determine customer needs. QFD is a methodology that helps translate customer requirements into design requirements[16]. QFD is a structured method in product development to meet the definition of all consumer wants and needs [17].

In this study, the author uses two methods, namely the QFD method and the French method because both ways can be combined to produce designs based on user needs with the following process: 1) Analysis of user needs is obtained through the results of questionnaires distributed to users (respondents); 2) The level of importance of the needs of multifunctional food oven users is carried out by assigning a value to each attribute with a priority scale; 3) Evaluation of competitors' product attributes is obtained through the level of importance of attributes through a questionnaire; 4) The house of quality is a combination of technical characteristics and attributes that the user wants; 5) Morphological matrix based on quality house data; 6) product concept creation; 7) Selection of product concept; 8) making 3-dimensional drawings based on the selected concept; 9) Validation of design results carried out by design experts, manufacturer experts, and users; 10) Product and control manufacture; 11) feasibility test of the prototype.

Equation 1 is used to determine the level of difficulty in manufacturing the product, while Equation 2 is used to calculate the degree of significance. While Equation 3 is utilized to estimate the cost.

$$\text{Level of difficulty } = \frac{W_{TC}}{N_{TC}} \text{x } 100\% \quad (1)$$

Where W_{TC} is the total weight of each technical characteristic and N_{TC} is the Total weight of the technical characteristic relationship.

$$\text{Degree of interest} = \frac{W_{TA}}{N_{TA}} \text{x } 100\% \quad (2)$$

Where W_{TA} is the total weight of each technical characteristic relationship with attributes, and N_{TA} is the Total weight of relationship between technical characteristics and attributes.

$$\text{Cost estimation} = \frac{W_D}{N_D} \text{x } 100\% \quad (3)$$

Where W_D is the difficulty level weight and N_D is the Total difficulty score.

The frame of the oven table must be strong in accepting the load so that a stress analysis was carried out on the frame components using the finite element method.

The finite element method is a numerical method used to solve partial differential equations and integral equations [18]. FEM is one method for predicting or analyzing stresses and deformations caused by loads [19-21]. Ansys be used to conduct material strength analyses such as stress and safety factor. Finite element equation generally uses the matrix in Equation (4).

$$[K]\,\{u\} = \{F\} \quad (4)$$

Where K is the (element) stiffness matrix, u is the (element nodal) displacement vector, and F is the (element nodal) force vector.

The component is simulated experiences static loads. The load applied to the oven table design which is calculated from equation 5. The ASTM A36 material properties are present in Table 1.

$$W_m = W_{b1} + W_{b2} + W_{lo} + W_p + W_t + W_o \quad (5)$$

Where W_m is the total load on the oven table; W_{b1} the outer body load; W_{b2} the inner body load; W_{lo} the pan load; W_p the fire pipe load; W_t the elbow seat load, and W_o the food load.

Table 1. Material properties of ASTM A36 [22]

Material	ρ[kg/m^3]	v	σ_y[MPa]	E[GPa]
ASTM A36	7850	0.26	245	200

Where ρ is the density, v is the Poisson ratio, σ_y is the yield strength of the material, and E is the modulus of elasticity.

The safety factor used in the frame is calculated based on the ratio yield strenght (σ_y) in the material used with the maximum von mises stress as in the equation. According to Mott [23], the safety factor (*SF*) is 1.25 to 2.0 for the design of structures that receive static loads with a high level of confidence for all design data.

$$SF = \frac{\sigma_{yield}}{\sigma_{design}} \quad (6)$$

The prototype of oven is made to meet user needs with ease of control using a microcontroller that is smartphone-controlled. The feasibility test of the prototype was carried out by testing the water content and doneness check of the food after it was roasted. A moisture meter has used to measure the moisture content of the product processing by oven prototype during the product feasibility test. The product variation at the roast temperature of 100˚c and 120˚c with times 30 and 45 minutes. The product was varied at the roast temperature of 100c and 120c with time 30 and 45 minutes. Culinary practitioners and MSME actors conduct an examination of the level of doneness through the dense texture of the bread and the colour of the cake that is dark on the outside and brighter on the inside. The test was compared the roasting results with control products in the form of products similar to the Brownies Cinta brand made in the Magelang City of Indonesia. The energy consumption of the oven prototype is calculated by equation 8.

$$I = \frac{m_f\, E}{\Delta t} \quad (7)$$

Where I is the combustion power, m_f is the mass of fuel used and E is the calorific value of fuel, and Δ_t is the time of use.

$$P_{tot} = I + P_r + P_0 + 2P_s \quad (8)$$

Where P_r is the electric power of raspberry pi, P_o is the power of thermostat, P_s is the power of solenoid valve, and P_{tot} is the total power used.

3. Result and Discussion

3.1 Design of Oven

The customer's needs have been obtained through data retrieval to respondents using a closed questionnaire to several employees in the OTARA production house, Semarang City, Indonesia. The attribute data of the multifunctional food oven desired by respondents is present in Table1. The importance of user needs of multifunctional food ovens has been assessed by a priority scale ranging from 1 to 5. The attributes importance of the multifunctional food ovens is also present in Table 2.

Table 2. User desired oven attribute data and product importance value

No.	Attribute data			Level Interest
	Primary	Secondary	Tertiary	
1	Design	Dimensions	width less than 80 cm	5
2			height (approximately 150 cm)	4
3		Ease of assembly	use nuts and bolts	5
4		Operating control	use a microcontroller	5
5		Yield retrieval	use a retractable shelf	3
6		Maintenance	spare parts are easily available in the market	3
			easy to maintain	4
			ease of assembly	4
7		Mobility	use castor wheels	4
8		Capacity	max capacity of 40 kg	5
9		Oven capability	able to roast and dry food like bread, pastries, eggs, and other food ingredients	5
10	Materials	Frame	frame material is strength and light	5
11		Oven wall	refractory, corrosion resistant, food grade	5
12	Function	Main	food roaster (bake) and dryers	5

Competitor 1's product is a stove oven with dimensions of 50 cm, usually used for home production. Competitor 2 is a large-scale industrial oven with a large capacity and has modern features such as automatic ignition and adjustable shelves. Competitor 3 is a locally made oven. Fire-fueled with manual ignition and has no special features. The competitor's product attribute data is present in Table 3.

The house of quality of the oven shows the relationship between engineering characteristics and product attributes. Product attributes as explained in the 'what' column, technical explanations are presented in the 'how' column in the quality house. The house of quality also performs the relationship between fellow technical characteristics. The matrix of quality house shows in Figure 1.

Based on the house of quality (HoQ) obtained the technical requirements of the multifunctional food oven according to the user's needs. The function diagram of the multifunctional food oven is shown in Figure 2. The function diagram and a morphological matrix regarding the multifunctional food oven concept are created based on the technical requirements. The morphological matrix is shown in Table 4.

Table 3. Competitor product attributes

Attribute	The interest level of competitor		
Tertiary	1	2	3
Width less than 80 cm	3	3	4
Height (approximately 150 cm)	3	4	3
Use nuts and bolts	4	4	4
Use a microcontroller	5	4	3
Use a retractable shelf	4	3	3
Spare parts are easily available in the market	4	3	4
Easy to maintain	4	4	4
Ease of assembly	3	3	3
Use castor wheels	3	3	4
Max capacity of 40 kg	3	4	3
Able to roast and dry of food like bread, pastries, eggs, and others	4	3	4
frame material is strength and light	4	4	3
refractory, corrosion resistant, food grade	5	4	4
Food roaster (bake) and dryers	3	5	5

Table 4. Morphology matrix of Oven

Energy Sub-function	Mechanic
Product holder	A.1 Flat shelf A.2 Hook rack
Energy	B.1 Microcontroller
Control	C.1 Solenoid Valve C.2 Thermostat C.3 Lighter
Heat source	D.1 Heating element D.2 Fire
Heat resistant	E.1 Aluminium foil E.2 double jacket

Based on the morphology shown in table 4, several variations of the product concept are arranged as follows:
Concept 1 = A.1+B.1+C.3+D.1+E.2
Concept 2 = A.1+B.1+C.1+D.1+E.2
Concept 3 = A.1+B.1+C.3+D.1+E.2
Concept 4 = A.1+B.1+C.2+D.1+D.2+E.1
Morphology concept design, these functions are realized in the form of a sketch intended to explain the concept of the product to be made.

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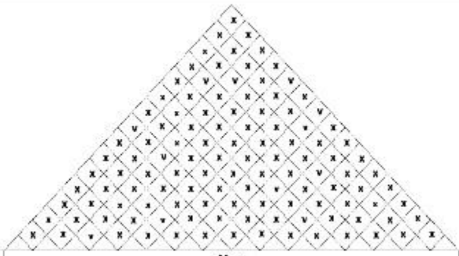

Multifunction Food Oven			Relative Importance	How																Now (A Oven (Design); B Oven on stove; C Locally Made Oven; D Imported Oven)				
				Ease of taking results	Product composition	Size as needed	Easy to move	Comparison of fixed and non-fixed	The number of common parts in the	Number of tools to tune	Number of buttons to operate the machine	Ergonomic oven height	Environmental condition	Number of variations of raw materials	Using low energy	Material is not contaminated with	Percentage of spilled material	Number of machine component mechanisms	Added assembly time	1	2	3	4	5
WHAT	Design	Oven width < 1 single door leaf width (<80 cm)	5	x	x	V	v	x	x	x	x	x	x	x	x	x	x	x	x			D		ABC
		Asian ergonomic height (±150 cm)	5	x	x	v	x	x	x	x	x	V	x	x	x	x	x	x	x			BD	C	A
		Using welding, nuts and bolts	5	x	x	x	x	x	x	x	x	x	v	x	v	x	x	x	x					ABCD
		Using automatic control	4	x	x	x	x	V	x	v	x	x	x	x	x	x	x	x	v			B	ACD	
		Using shelves with adjustable height	3	x	x	x	x	x	x	x	V	x	x	x	x	x	x	v	x			A		BCD
		Easy to get spare parts	4	V	x	x	x	x	x	x	x	x	x	x	x	x	v	v	x			BC	A	D
		Easy maintenance	4	x	x	x	x	x	V	x	x	x	x	x	x	x	x	x	x			B	ACD	
		Ease of assembly	5	x	x	x	x	x	V	v	x	x	x	x	x	x	x	x	x				BCD	A
		Oven table with wheels	4	x	x	x	x	x	x	V	x	x	x	x	x	x	x	x	V			BD	AC	
		Large production capacity	4	x	x	x	V	x	x	x	x	x	x	x	x	x	x	x	x		BD		AC	
		Able to bake and dry food (cake, egg, etc)	5	x	x	V	x	x	x	x	x	x	x	x	x	x	x	x	x		B	C		AD
		Using gas fuel	5	x	x	x	x	x	x	x	x	x	x	V	x	x	x	x	x			B		ACD
		Using heat insulator	5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	v	x		B		C	AD
	material	The table material is strong and light	5	x	v	x	x	x	x	x	x	x	x	x	x	v	x	x	x				BD	AC
		Oven material is strong, lightweight, and food-grade	5	x	v	x	x	x	x	x	x	x	x	x	x	v	x	x	x				BD	AC
	Function	Food grills and dryers	5	x	x	x	x	x	x	x	x	x	x	V	x	x	x	x	x			B		ACD
Level of difficulty				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
Degree of interest				6	7	7	6	6	7	7	6	6	6	7	6	6	6	7	6					
Cost estimation				6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6					

Level of difficulty
1 = easy = 1-20%
3 = quite easy = 21-40%
5 = difficult = 41-60%
7 = very difficult = 61-80%
9 = absolutely difficult= 81-100%

Degree of interest
1-15 = quite important
16-30 = important
31-45 = very important

cost estimation
1-15 = Inexpensive
16-30 = Expensive
31-45 = Very expensive

V = Strong positive relationship = 4
v = Medium positive relationship = 3
x = Medium negative relationship = 2
X = Strong negative relationshi = 1

Figure 1. House of Quality

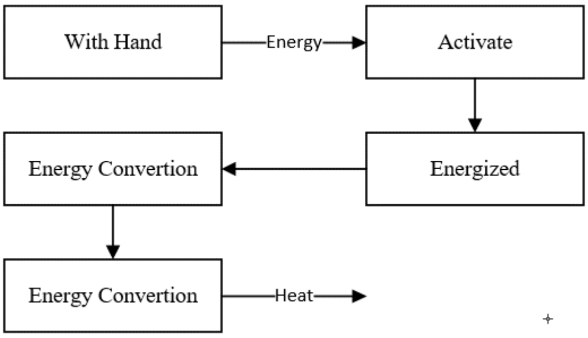

Figure 2. Multifunctional food oven function block

3.2 Product concept selection

Product selection is made by scoring each product concept and comparing it between product concepts. The higher the weight value obtained on the technical criteria, the higher the technical measures have higher importance than other technical criteria. The reference product uses the concept of the first product, which is an oven with a heating system on the right and left sides of the roasting room with a heat source in the form of a fire channelled through a pipe. The rack used in the first concept is a permanent shelf that aims to increase the frame's strength in holding the load in the form of food ingredients.

The second concept oven with a heat source heating element is five shelves equipped with time and temperature control. The third concept is a gas fuel oven with a non-permanent shelf in the form of a hook rack intended so that the position of the stand does not change quickly when the stove is used. The heat source is placed at the top and bottom of the roasting chamber.

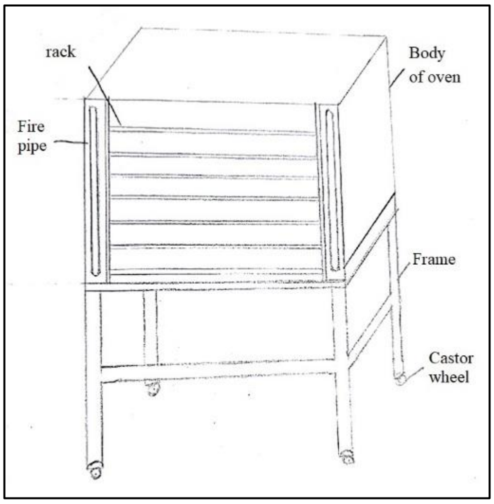

Figure 3. The 1st Concept

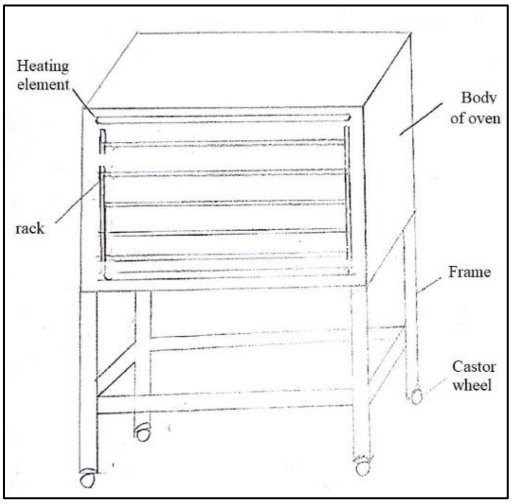

Figure 4. The 2nd Concept

The fourth product concept is a gas-fueled oven with a fire pipe heat source at the top and bottom of the roasting chamber. The control system uses programmable logic controllers (PLC) and Raspberry Pi-type microcontrollers, raspberry Pi 3 is the third generation of raspberry products that enhance the features of the second generation [22]. The gas distribution system is controlled using a solenoid valve and is equipped with a switch, the rack used is a non-permanent rack.

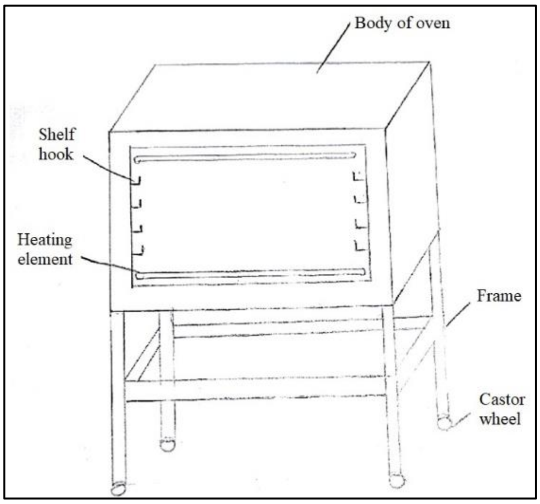

Figure 5. The 3rd Concept

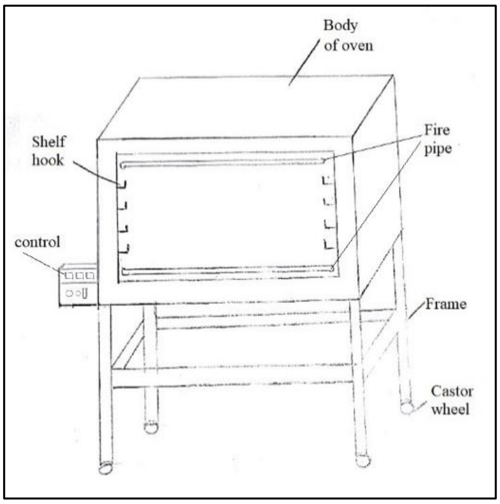

Figure 6. The 4th Concept

The essential decision matrix of the oven concept is presented in Table 4, where the scoring criteria, (+) is equal to 1; S is equal to 0; and (-) is equal to -1.

Based on the decision-making matrix (see Table 5), the fourth product concept got the highest score. The fourth product concept was further developed into a multifunctional food oven product design. The product (4th) concept selected is followed by the product design or embodiment process. Figure 7 is a 3-dimensional model of the 4th concept. While the bill of materials of the oven is presented in Table 6.

Table 5. Oven concept basic decision matrix

Criteria	**Weight**	**Concept**			
		1	**2**	**3**	**4**
Width less than 80 cm	8	REFERENCE	S	S	S
Height (approximately 150 cm)	8		-	-	S
Use nuts and bolts	5		S	S	S
Use a microcontroller	5		S	S	S
Use a retractable shelf	3		S	S	S
Spare parts are easily available in the market	5		S	S	+
Easy to maintain	5		S	S	S
Ease of assembly	5		S	S	S
Use castor wheels	4		-	-	S
Max capacity of 40 kg	4		S	S	S
Able to roast and dry of food like bread, pastries, eggs, and others	8		-	-	+
frame material is strength and light	9		S	S	S
refractory, corrosion resistant, food grade	10		-	-	+
Food roaster (bake) and dryers	6		S	S	S
Total +		-	0	0	8
Total S		-	12	12	13
Total -		-	4	4	0
Total Score		-	-30	-30	23

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Table 6. Bill of material of the oven

No.	Part name	Material	No.	Part name	Material
1	Body	A6061, steel galvanized	13	Rack	Al 6061
2	Fire pipe	AISI 1018	14	Castor wheels	Thermoplastic Resin
3	Frame	Steel angle ASTM A36	15	Hose to solenoid	ETFE Gas Hose
4	Door	Steel galvanized	16	Divider hose	ETFE Gas Hose
5	Handle	Stainless steel 304	17	Gas hose	ETFE Gas Hose
6	Nozzle pipe	AISI 1018	18	Box panel	Steel plate coated
7	Table frame	Steel AISI 1018	19	Thermostat	Universal
8	Fireplace door	Steel galvanized	20	Switch	Universal
9	Solenoid valve I	normally-closed	21	Cable	PBT Plastic
10	Solenoid valve II	normally-closed	22	Electric socket	Universal
11	Gas cylinders	Steel	23	Connecting hose	Polyurethane
12	Gas Regulator	Universal			

3.3 Stress analysis on the Table of Oven

The loading applied to the table frame is shown in Figure 8-b, wherein the load 1737.44 N has been calculated by equation 2. The temperature applied to the table frame, $\mathbf{T_m}$ is 640C, as shown in Figure 8-a. The load's data is present in Table 1. The material uses a steel angle with the dimension of 40x40x4 (mm).

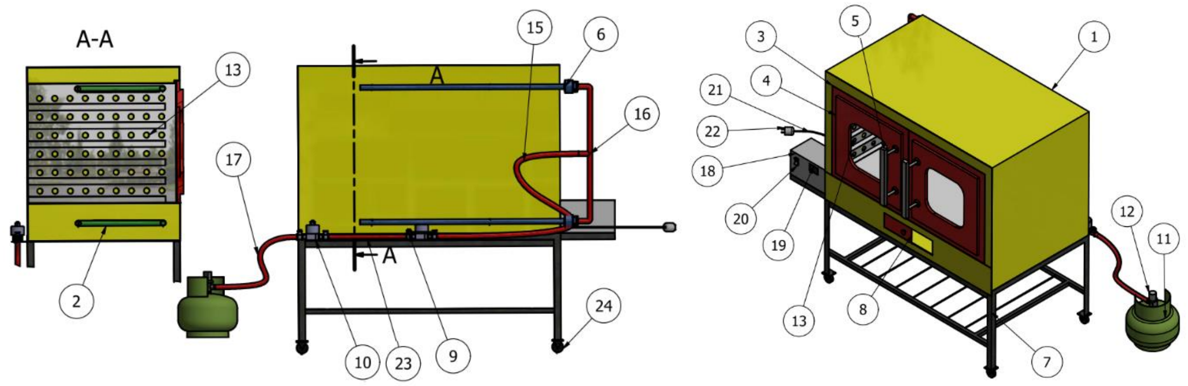

Figure 7. The 3D model of oven

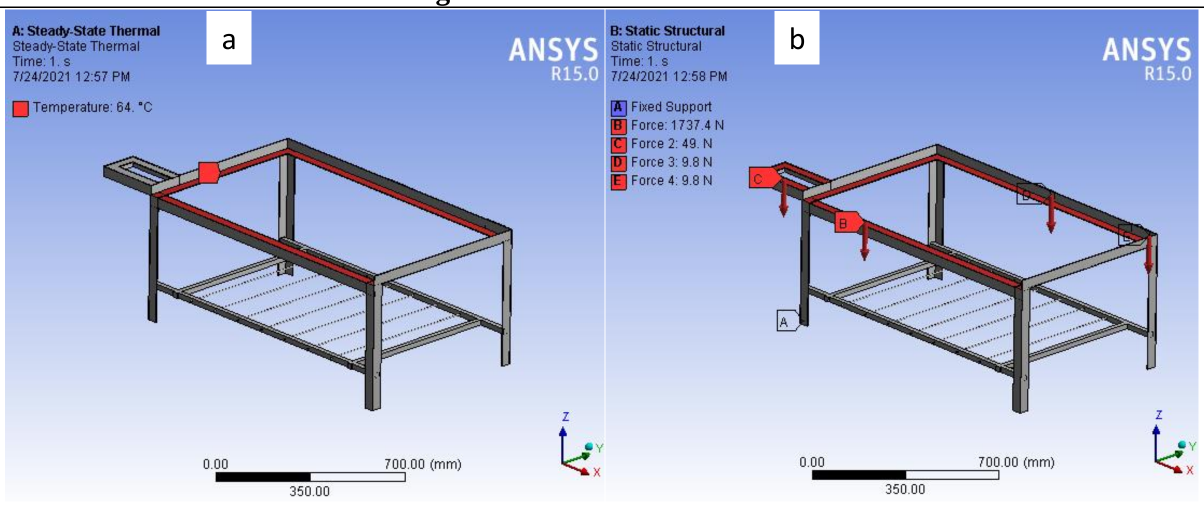

Figure 8. Loads and boundary condition of oven table (a and b)

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Table 7. The loads on the table frame

	W_{b1} (N)	W_{b2}(N)	W_m(N)	W_{lo} (N)	W_p(N)	W_t(N)	W_o(N)	T_m(^{0}C)
Value	406.57	19.05	1737.44	78.204	55.664	46.67	1131.132	64

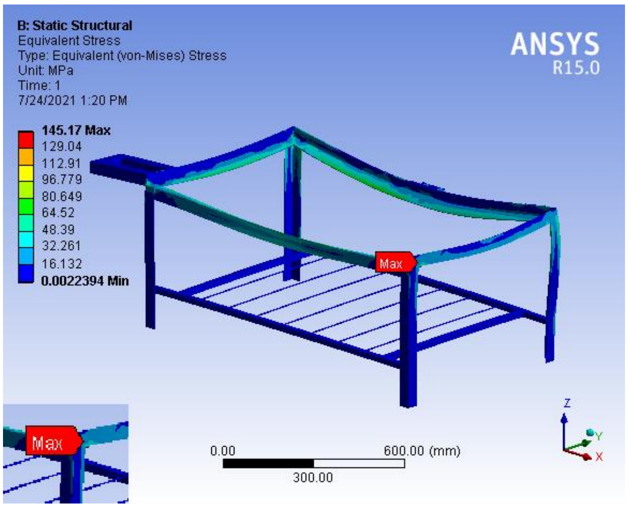


Figure 9. The Von mises stress of table frame

The maximum of the von mises stress is 145.17 MPa which is in the red area in Figure 9. The safety factor of the table frame is 1.55, which was calculated use Equation 6, with the yield strength of the material ASTM A36 (200MPa). The table frame design is declared safe because the *SF* (1.55) is more than the acceptance criteria *SF*> 1.25. Furthermore, the table frame material is declared strong at maximum operating loading conditions.

3.4 Design Validation

The designs made have been assessed by lecturer of engineering design field in Universitas Negeri Semarang, Indonesia as design experts and engineering in the Metal and Wood Industry Centre, Department of Industry and Trade, Central Java Province, Indonesia as manufacture experts. Validation by users is carried out by the owner of the OTARA SMEs in Semarang, Indonesia. The validation results are shown in Table 8. Validation is done assessing the feasibility of the design refers to meeting user needs regarding Table 5 (in criteria column). The results of expert validation indicate that the design can meet the user's need so that the product continues to be made.

Table 8. Design Validation Results

Validator	Conformity value (%)
Design expert	90
Manufacturer experts	100
Users	100

3.5 Product Manufacturer

The manufacture of oven products is carried out at the Mechanical Engineering Laboratory, Semarang State University, and partner workshop in Semarang. The production of the product is done by sheet metalworking and welding joints with SMAW and GTAW. The multifunction oven prototype is shown in Figure 10.

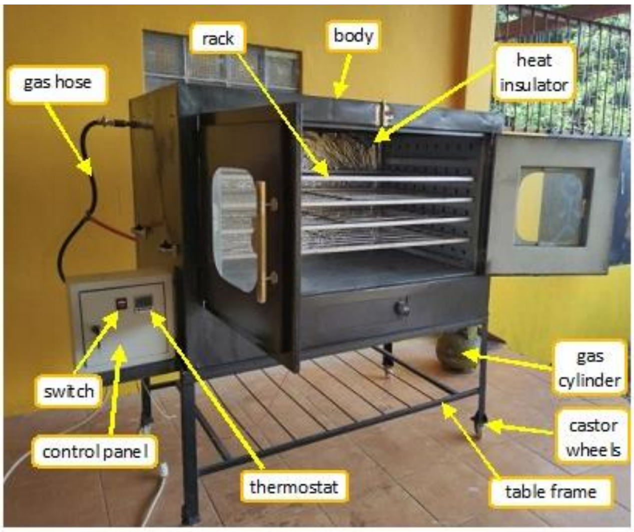


Figure 10. Prototype of multifunction Oven

3.6 Control manufacturer

The control system in multifunctional food ovens regulates several working steps in the oven such as switching on-off the switch, temperature control, and baking time. Figure 11 depicts the oven controller's work scheme, whereas Figure 12 depicts the control program.

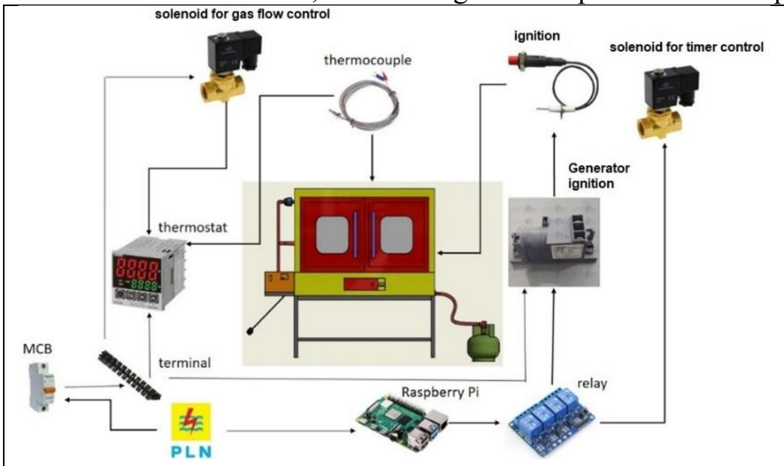
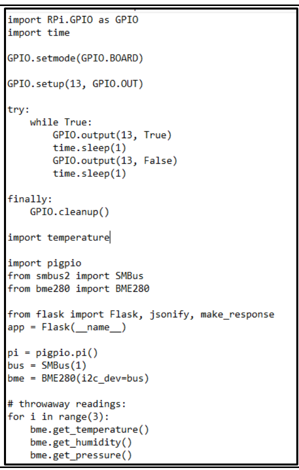


Figure 11. Controller work scheme



```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BOARD)

GPIO.setup(13, GPIO.OUT)

try:
    while True:
        GPIO.output(13, True)
        time.sleep(1)
        GPIO.output(13, False)
        time.sleep(1)

finally:
    GPIO.cleanup()

import temperature

import pigpio
from smbus2 import SMBus
from bme280 import BME280

from flask import Flask, jsonify, make_response
app = Flask(__name__)

pi = pigpio.pi()
bus = SMBus(1)
bme = BME280(i2c_dev=bus)

# throwaway readings:
for i in range(3):
    bme.get_temperature()
    bme.get_humidity()
    bme.get_pressure()
```

Figure 12. Control Program

Figure 13. Controller program on smartphone

The control system was tested in two stages, namely before and after the control system was assembled on the oven unit. The controller work scheme is shown in Figure 13. The microcontroller is connected to an internet connection and can then be controlled with a smartphone using a GPIO web server connection.

3.7 Product feasibility test

The experimental test of oven with a baking process using brownie bread was controlled using a microcontroller with a temperature variation of 100˚C and 120˚C with a time of 30 minutes and 45 minutes. The results of the water content (MC) test and the level of doneness (DL) are shown in the Figure 14.

Description: *X1* is baked at 100˚C for 30 minutes; *X2* is baked at 100˚C for 45 minutes, *X3* is baked at 120˚C for 30 minutes, *X4* is baked of 120˚C for 45 minutes, and K is control product with the Brownies "Cinta" brand. The test results show that the higher temperature and time of baking the product decrease the water content.

The test water content on several variations of temperature and time shows that the variations of *X2* and *X3* have the same value with the control product. Variation *X1* is higher than the water content of other variations by 3.7%. At the same water content results, the bake time can be shortened by increasing the temperature as on *X3*, while the temperature increased by 10˚C and the time is shortened by 15 min from *X2*. This is in accordance with research [24-25] that the higher the drying temperature the shorter the drying time.

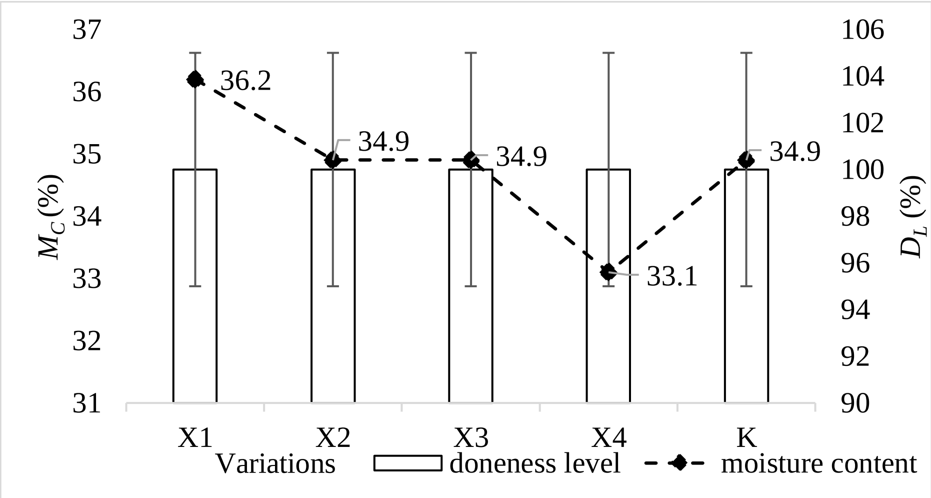


Figure 14. Test results of moisture content and doneness level

The level of doneness is seen from the dark brownie colour, dry outer texture, and moist inner textured. The doneness level examination was carried out by a culinary expert at the State University of Semarang, Indonesia.

Energy use in the oven in baking for 30 minutes is calculated using Equations 7 and 8. The power and energy usage of the oven in the present study is presented in Table 9.

Table 9. Power and energy usage of Oven

	I [kWh]	P_r [kWh]	P_o [kWh]	P_s [kWh]	P_{tot} [kWh]	E [kJ]
Value	2.45	0.0037	0.15	0.22	3.0437	10,957.32

The energy consumption of an electric oven with a similar capacity within 30 minutes is 7.5 kW x 0.5 hours = 3.25 kWh or 11,700 kJ. The comparison of energy use in multifunctional food ovens and electric ovens on the market shows that multifunctional food ovens have a saving value of 6.8%.

4. Conclusion

Ovens with multifunctional features, large capacity, using gas fuel, automatic ignition, energy-saving, and controlled using a smartphone have been designed and manufactured. The oven has the following specifications: (1) a volume of 400L, a length of 1200 mm, a width of 700 mm, a height of 800 mm, (2) an oven using gas fuel, (3) can be used for baking and drying various foodstuffs, (4) operation using a smartphone, (5) the table frame is equipped with wheels, (6) the capacity of food ingredients is 400 Kg, (7) can be used to roast numerous food, (8) the inner cover body use aluminium, outer cover uses steel galvalume coated, and the oven rack uses an aluminium material that is by user needs. The characteristics of the processed products are close to those of the products on the market. The results of the design validation tests from design experts, manufacturing experts, and users found that the design was feasible. Furthermore, the feasibility test of the oven prototype also found that the moisture content of the baking process was close to the control product (brownies with marketing authorization) was around 34.9% as well as the doneness level was 100%. The energy use of the oven present is 10957.32 kJ compared to an electric oven similar capacity with an energy consumption of 1170000 kJ, is a saving of 6.8%. Based on design validation and product feasibility test, calculation of oven energy consumption, the conclusions that the oven can meet the needs of small and medium enterprises (SME) users.

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