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IMPROVING THE ERGONOMIC CONSTRUCTION OF KUE BALOK BAKING EQUIPMENT FUELED BY *LIQUEFIED PETROLEUM GAS* (LPG)

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Abstract

Kue Balok seller in Bandung are still using baking equipment fueled by charcoal, which have shortcomings such as long setting time for combustion, residual burning of charcoal (e.g smoke and dust) that may contain carcinogens, which is bad for health, so that the design of the Kue Balok baking equipment eco-friendly gas-fuel needs to be made, and the shortcomings from the equipment that uses charcoal must be removed in order to make it safer for the operator, consumer, and for the environment. (Novirani et al., 2017), therefore the prototype of ergonomic Kue Balok baking equipment is created, functionally tested by using FAST (Framework for the Application of System Thinking) method, and the improvement made for the baking equipment is a change for the burner and the addition of plate ontop of the burner to anticipate the wasting of heat, so the prototype resulting works better, and is expected to be used indoors such as restaurant malls and weddings.

Keyword: Baking equipment, Kue Balok, Gas, tested function, FAST, prototype

1. INTRODUCTION

Kue Balok is a traditional cake that recommended to be encouraged again by Mayor of Bandung, but Kue Balok seller in Bandung are still using baking equipment fueled by charcoal. Such equipment have shortcomings, mainly long setting time for combustion, residual burning of charcoal (e.g smoke and dust) that may contain carcinogens. The dangerous substances contained in the burning residual may mix with the Kue Balok dough, which will bring the risk of cancer to consumer. (Gyansyah et al., 2012) the design of the Kue Balok gas-fueled eco-friendly baking equipment needs to be made for these reasons, and the shortcomings must be removed in order to make it safer for the operator, consumer, and for the environment. (Novirani et al., 2017). After the prototype is made, it is tested by FAST or Framework for the Application of System Thinking. The purpose of this research is to get a better product of baking equipment for the operator, consumer, and the environment. Aside from that, it is expected to be used indoors such as in restaurant, malls and in smoke-free wedding ceremony.



2. METHODS

A problem-solving approach is used such as the Research Flow in Fig. 1. The existing equipment is observed, then analyzed by using FAST. Finally, the design improvements are made to obtain more optimized baking equipment products.

FAST (Framework for the Application of System Thinking)

The FAST method (Abdullah et al., 2013) has several phases in its application. The phases in FAST are divided into 8 phases, i.e. definition scope, problem analysis, logical design, decision analysis, physical design & integration, construction & testing, installation & delivery.

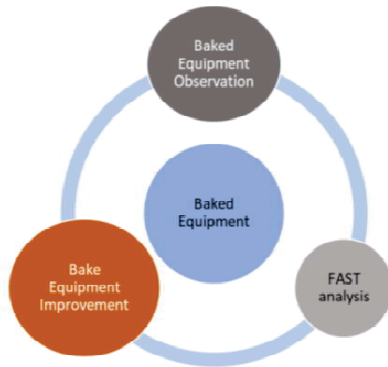


Figure 1. Research Flow

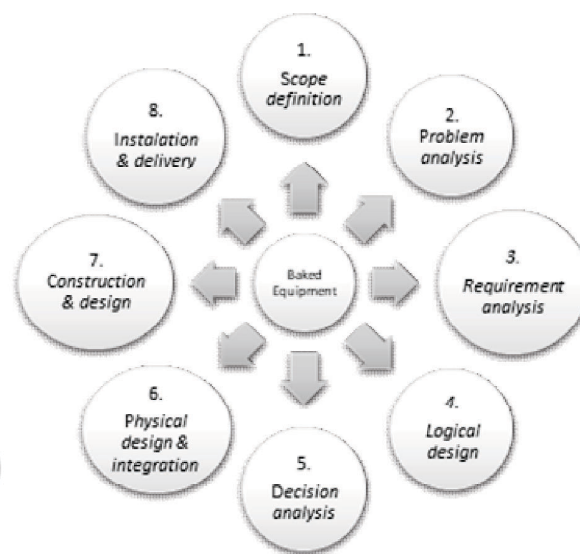


Figure 2. FAST analysis

3. RESULT AND DISCUSSION

FAST method is used to test the prototype through 8 (eight) stages as follows:

1. Scope Definition

The scope that is used to analyze the existing equipment covers two main things; the body and the burner.

- Body is compliant because it is box-shaped and has a bottom drawer with a door for gas 3 kg, and has aesthetics expected by the operator.
- The existing burner is round, consisting of top and bottom burners, each has two burners. The total burner for baking cake are four pieces. The number of burners is eligible to cook faster than using a single burner. But, for the cooking process with a round burner is not effective because the heat flows from high temperature to low temperature, so the fire is always facing upwards, while the cake is under the burner and fire. Body prototype and gas burner appliance are in figure-3.

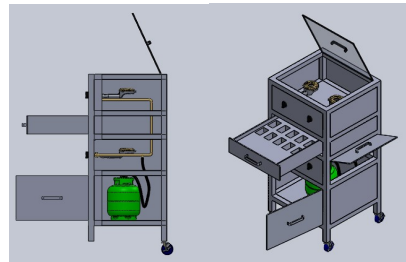


Figure 3 Existing Body and Burner

BOM TABLE			
ITEM NO.	PART	DESCRIPTION	QTY.
1	Frame Pipa	Stainless Steel	1
2	Top Cover	Stainless Steel	1
3	Coal Drawer	Stainless Steel	1
4	Side Cover	Stainless Steel	1
5	Main Gas Pipe	Copper	2
6	Pipe to Gas	Copper	1
7	Regulator	Brass	1
8	T Pipe	Copper	1
9	Hose	Rubber	1
10	Caster Wheel	Plastic	4
11	LPG case	Iron	1
12	Lighter	Iron	4
13	End of Gas Line	Alumunium	4
14	Burner	iron	4
15	Front Drower	Stainless Steel	

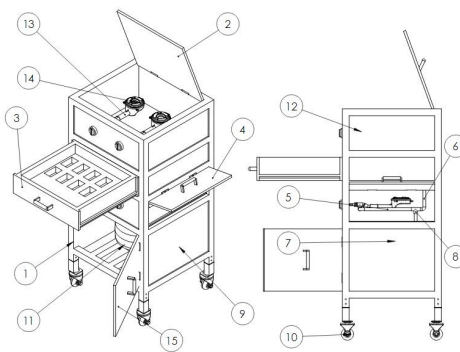


Figure 4 Bill Of Material of Existing Baking Equipment Kue Balok

2. Problem Analysis

Analyzing from the Existing design, there are some correction in the experiment.

- The burner system used is not effective because the fire is not evenly distributed throughout the Kue Balok mold. Because the fire from the burner is centered at one point.
- The top burner position is not directly in contact to the kue balok's top surface. The fire that should be baking the top surface of the cake is pointing upwards, so the heat is heating the top cover instead, resulting in longer baking time. Bill of Material *Existing* Baking Equipment Kue Balok table can be seen in Figure 4.

3. Analysis Requirement

The top round burner is not effective and efficient which cause the wasting of fuel.

4. *Logical Design dan Physical Design*

The top and bottom burner should be cylindrical instead of round to lessen the fuel usage. Proposed improvement is to change the shape of the burner into a cylinder (figure 5). The top combustion chamber is given a limiting plate to absorb the flame up, so that the heat produced can be used maximally (Figure 6). The prototype is given a handle on both sides for easy mobilization for the equipment (Omura et al., 2010).

5. *Decision Analysis*

The proposed burner design is cylindrical but, the fire produced is sideways and maintained to face upward. The cover plate will bounce the heat and cause it to expand. The room for the fire's movement needs to be decreased so the heat will be centered to the top of the kue balok. For this reason, a plate then added. The plates are made of the same material as the prototype of 304 stainless steel (Askeland et al., 2010) and (Callister et al. 2010) commonly used for foodstuffs because the carbon used is small (Ashby et al., 2007)

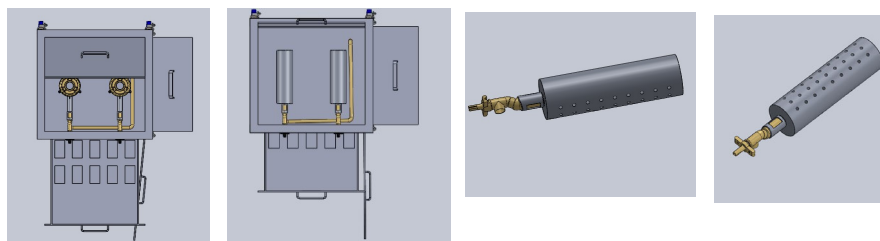


Figure 5. Round and Cylinder *Burner*

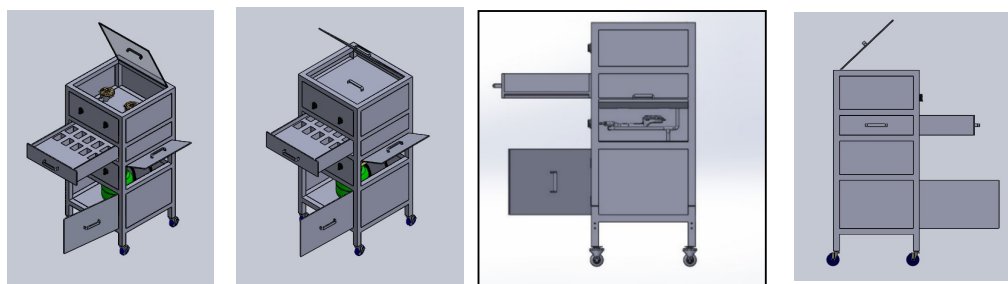


Figure 6. Equipment without and with plate, Equipment with handle

6. *Physical Design & Integration*

The following is a Bill of Material from the proposed draft improvement, with the picture of the designed part of the baking cake tool plan and its design dimensions can be seen in Figure-7

7. Contruction and Testing

Prototype testing is useful to see the functionality of the tool. Here is an observation of the prototype testing Kue Balok baking equipment.

The trial process of making kue balok. Taken 10 times using the same duration of time. The measurement parameter is the time and the baked level, assuming the scale per line on the 50 C lighters and the maximum temperature of the lighters is 100 C.

In the existing design, time and temperature factors are considered to make perfectly baked Kue Balok, i.e. at the top burner with a scale of 8-10 or 400C -500 C for approximately 3 minutes and on a bottom burner with a scale of 2 or 100C for approximately 2 minutes. In the experimental design used 2 factors, temperature and time. During the second experiment the measuring factors for measuring the results of the Cake were: not baked or defective.

BOM			
NO ITEM	PART	DESCRIPTION	QUANTITY
1	Frame pipa	Stainless Steel	1
2	Top Cover	Stainless Steel	1
3	Coal Drawer	Stainless Steel	1
4	side cover	Stainless Steel	1
5	Main Gas Pipe	Cooper	2
6	Pipe to Gas	Cooper	1
7	Regulator	Brass	1
8	T pipe	Cooper	1
9	Hose	Rubber	1
10	Caster Wheel	Plastic	4
11	LPG case	Iron	1
12	Lighter	Iron	4
13	End of Gas Line	Alumunium	4
14	Burner	Iron	4
15	Front Drower	Stainless Steel	1
16.	Cover Plate	Stainless Steel	1

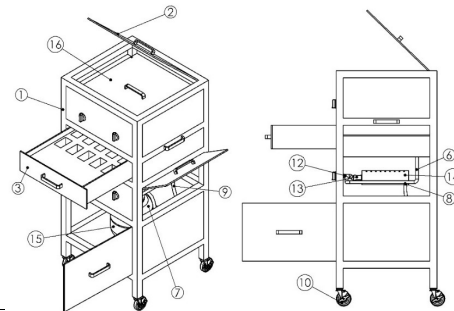


Figure 7 *Bill of Material and Proposed Kue Balok Baking Equipment design*

The mathematical model can be explained as follows

$$Y_{ij} = \mu + A_i + B_j + \varepsilon_{m(ij)}$$

Where

Y_{ij} = the number of cake defects during an experiment that is affected by temperature and time

μ = The real mean

A_i = influence of temperature

B_j = influence of time

AB_{ij} = the influence of temperature and time interaction

$\varepsilon_{m(ij)}$ = error that occurs in replication

The following is the number of cakes that are not baked or defective, testing using 2 factors namely time and temperature on the top and bottom burner. The defect data on the use of top and bottom burners can be seen in Table 1 through

Table 3. In the experimental data experiments were taken with a scale of 4,8,10 for the top burner and 2,4,6, for the bottom burner was to accommodate the criteria in the baking process experiment baking beams, ie baked and defective. Likewise the time spent on the experimental process in 2, 3, and 4 minutes, with the criteria baked and defective.

Table 1. Cake Defect Data from Top and Bottom Burners

(A) Scale	(B) Top Burner Time (min)			Total	(A) Scale	(B) Bottom Burner Time (min)			Total
	2	3	4			2	3	4	
4	6	4	3	26	2	2	2	4	14
	6	4	3			0	2	4	
8	1	1	1	5	4	2	6	6	30
	0	1	1			4	6	6	
10	2	4	6	24	6	4	8	10	44
	2	4	6			4	8	10	
Total	17	18	20	55	Total	16	32	40	88

Table 2. Recapitulation of Anova Data Calculation of Kue Balok Defects on Top Burner

Variance Source	df	ss	ms	f _{count}	F _{table}
Scale (A)	3-1 = 2	44,778	22,389	8,096	F _{2,9} =4,26
Time (B)	3-1 = 2	0,778	0,389	0,141	
Interaction AxB	4	24,889	6,222	2,250	F _{4,9} =3.63
Error	9	24,889	2,765		
Total	17	70,944	4,173		
Hypothesis test result		Result			
The temperature factor on the top burner		value $F_{count} > F_{table}$ then H_0 is rejected, there is influence from the top burner temperature factor			
time factor on the top burner		value $F_{count} < F_{table}$ then H_0 is accepted, there is no influence of the time factor on the top burner			
temperature and time interaction at the top burner		value $F_{count} < F_{table}$ then H_0 is accepted, there is no influence of time factor interaction and hot temperature at top burner			

Table 3. Recapitulation of Anova Calculation of Kue Balok Defect Data on Bottom Burner

Sumber Variasi	df	ss	ms	f _{count}	f _{table}
Scale (A)	3-1 = 2	75,111	37,556	38,025	F _{2,9} =4,26
Time (B)	3-1 = 2	49,778	24,889	25,2	
interaction AxB	4	8,889	2,222	2,250	F _{4,9} =3.63
Error	9	8,889	0,988		
Total	17	137,778	8,105		
Hypothesis test result		Result			
the temperature factor on the bottom burner		value $F_{count} > F_{table}$ then H_0 is rejected, there is influence from the bottom burner temperature factor			
time factor on the bottom burner		value $F_{count} > F_{table}$ then H_0 is rejected, there is influence of the time factor the bottom burner			
temperature and time interaction at the bottom burner		value $F_{count} < F_{table}$ then H_0 is accepted, there is no influence of time factor interaction and hot temperature at bottom burner			

There is influences from the top and bottom burner and time factor on the bottom burner, this means that Burner replacement of the round shape to the cylinder must be done and from this study also obtained the top burner temperature ratio should be greater than the bottom burner because the fire does not affect the top surface of the cake directly as the bottom burner, in general according to (Monica et al. 2016) to be fulfilled in the design is practical, light, proportional, easy maintenance, safe, and competitive pricing. Materials should be appropriate (Callister et al., 2010) in particular these equipment need to be specified in order for the operator to be safe.

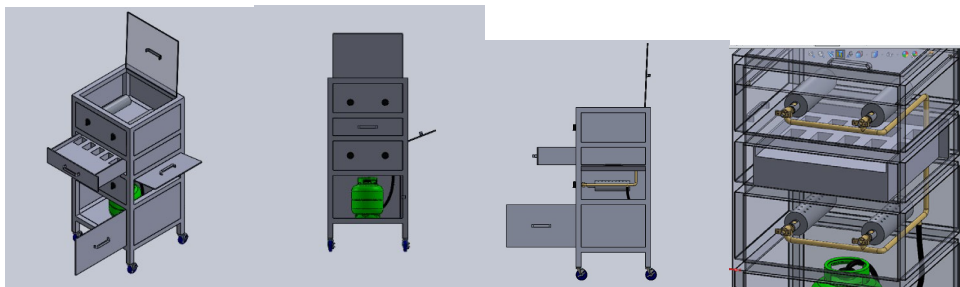


Figure 8 Proposed improvement prototype looks isometry and front view, right side view and three-dimensional burner

CONCLUSION

The proposed improvement equipment is the addition of a heat-retaining plate and changing the burner from a round shape to a cylinder, with the top burner temperature ratio must be greater than the bottom burner.

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