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# Design of Ergonomic Biomass Stove Using Ergonomic Function Deployment (EFD) Method

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**Abstract— Increased energy use is caused by population growth and depletion of world oil reserves. Emissions from fossil fuels give problems to every country to immediately use alternative energy. Briquette is one of the methods used to convert biomass energy sources. Other biomasses such as coconut shells, wood charcoal, rice husks, and sawdust can be made into briquettes. Biomass stoves are stoves used specifically for the use of non-fossil fuels. The current problem is the design of biomass stoves used by respondents, one of which is biomass stove that is not ergonomic and difficult to control the size of the fire. So this research was conducted to design an ergonomic biomass stove using the Ergonomic Function deployment (EFD) method which is a development from Quality Function Deployment (QFD). The conclusion of the research design of an ergonomic biomass stove using the Ergonomic Function Deployment (EFD) method is a specification of the results of the design of a biomass stove needed, namely: a biomass stove that is safe, easy to use, a size that is comfortable to use, a lightweight and durable material , easy to set fire and easy to ignite. Then the anthropometric data used are the dimensions of the width of the palm of the hand measuring 8.62 cm, the dimension of the palm of the hand 4, cm.**

***Keywords—Alternative Fuels, Ergonomic Function Deployment, Biomass Stove***

## I. INTRODUCTION

At present the increase in energy use is caused by population growth and depletion of world oil reserves. Other problems such as emissions from fossil fuels make a nation immediately use alternative energy. Biomass is a biological resource that can be converted into renewable energy sources. Coverage of biomass energy comes from organic materials such as plants or animals, whether formed from the results of their production, metabolic waste, or derived from the waste they produce.

Based on the data from the Ministry of Energy's Statistics Indonesia, 2018 focuses on the use of stoves or daily cooking activities. From these activities can be utilized by the conversion of energy into biomass. Biomass that can be used includes coconut shells, rice husks, sawdust, sawdust and other biomass waste. Making briquettes is not too difficult, the tools used are also not too complicated (Usman, 2014). Another problem arising from this energy conversion is related to the design of the stove that does not pay attention to ergonomic factors. Considered more efficient but enough complaints are found that will later be corrected to be superior products.

Popular research has been made by Rahman J. (2015) in his journal "Pollution-free Biomass Stove Design" is different from this research. One of the methods used is not in accordance with ergonomic aspects. Other research was also made by Sulistiyaningsih (2015) in her journal "Designing a Square Biomass Stove with Matlab Modeling and Matching Different Methods" variation with this study is wrong, the method used is not in accordance with ergonomics.

Regarding complaints felt by biomass stove users are: Experiencing low back pain, Causing a lot of smoke, Trying to cook a stove, Working out the size of the fire, Feeling the heat caused when using the stove. So that biomass fuels and biomass stoves can be used by the community using the Ergonomic Fumction (EFD) method.

## II. RESEARCH METHOD

Ergonomic Function Deployment (EFD) is a development of Quality Function Deployment (QFD) (Ulrich & Eppinger, 1995) by adding a new relationship between consumer desires and the ergonomic aspects of the product. This relationship will complete the House of Quality matrix form which also translates into desired Ergonomic aspects. The House of Quality matrix used in the Ergonomic

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Function Deployment (EFD) was developed into the House of Ergonomic (HOE) matrix.

The first step of this method is the identification of needs variables by designing open questionnaires, determining samples and distributing questionnaires, ending with determining the needs variables. Then proceed with the identification of the level of importance in the form of designing open questionnaires, determining samples and distributing questionnaires, ending with a test of validity and reliability. The determination of the needs variable is based on the ENASE rule, which is (Effective, Comfortable, Safe, Healthy and Efficient). Then after the level of importance is obtained, it is continued with the formation of the House of Ergonomic which contains the needs and desires of consumers as a reference for the creation of new products according to consumer desires. The last stage is product design as an effort to meet the wants and needs of consumers.The flow of this research is arranged in the form of Flowchart as follows:

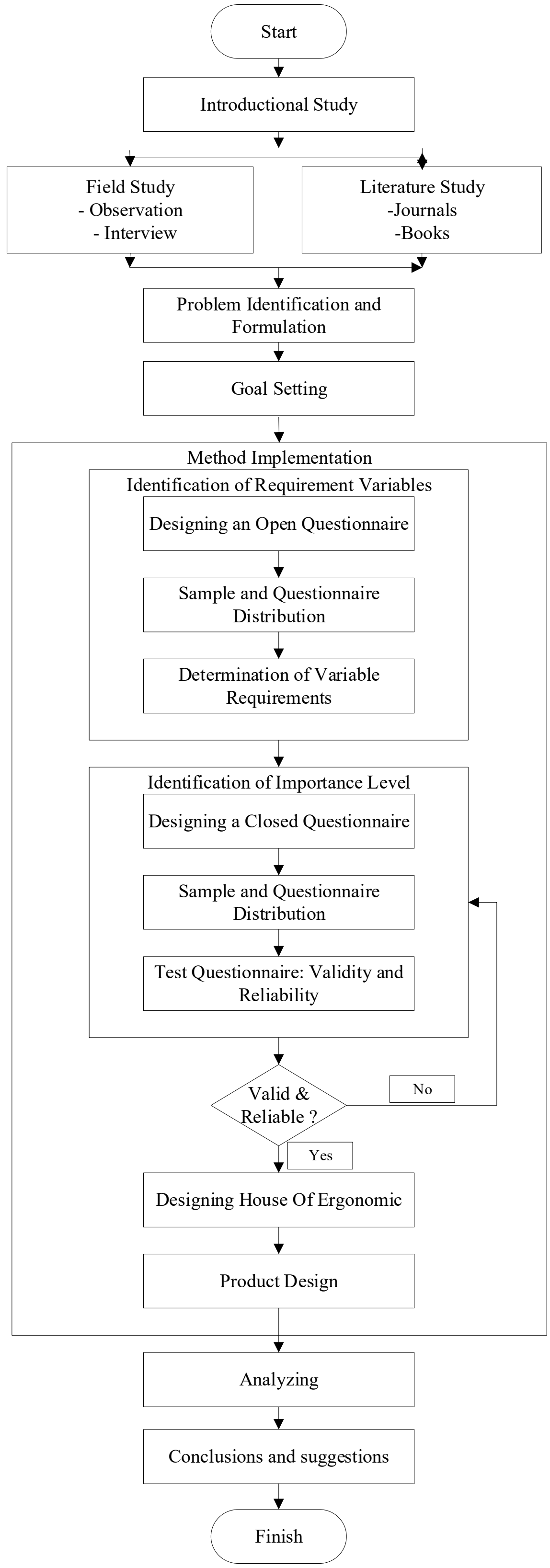


Figure I. Research Methodology Flowchart

Source: Data processed in 2019

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## III. RESULTS AND DISCUSSION

### *A. Respondent Identification*

TABLE I. Variable of consumers' needs

| Aspect | Code | Variable of Needs | Description |
|---|---|---|---|
| Effective | V1 | Easy to set fire and easy to ignite | Biomass stove design can easily adjust the level of fire |
| | V2 | Light and durable material | The biomass stove material is lightweight, inexpensive, easy to carry and durable |
| | V3 | Easy to use | The design of the biomass stove is easily understood by users |
| Comfortable | V4 | The stove size is comfortable to use | The dimensions of the biomass stove are in accordance with Indonesian anthropometric body measurements |
| Safe | V5 | Safe when used | The design of the biomass stove makes the user safe from accidents such as there is not much smoke, no pungent odor, and does not explode easily |
| Healthy | V6 | Doesn't cause back pain | Biomass stove design can reduce back pain |
| Efficient | V7 | Economical in usage | A fuel-efficient biomass stove is easily available |

Source: Data Processing, 2019

### *B. Level of Consumer Interest*

TABLE II. Level of Consumer Interest

| No | Variable | STP | TP | CP | P | SP | Total | Performance value |
|---|---|---|---|---|---|---|---|---|
| 1 | Easy to set fire and easy to ignite | | | | 4 | 6 | 46 | 4,6 |
| 2 | Light and durable material | | | | 5 | 5 | 45 | 4,5 |
| 3 | Easy to use | | | | 6 | 4 | 44 | 4,4 |
| 4 | The stove size is comfortable to use | | | | 4 | 6 | 46 | 4,6 |
| 5 | Safe when used | | | | 4 | 6 | 46 | 4,6 |
| 6 | Doesn't cause back pain | | | | 6 | 4 | 44 | 4,4 |
| 7 | Economical in usage | | | | 4 | 6 | 46 | 4,6 |
| Total | | | | | | | 317 | 31,7 |

Source: Data Processing, 2019

### *C. Level of Consumer Satisfaction*

TABLE III. Level of Consumer Satisfaction

| No | Variable | STP | TP | CP | P | SP | Total | Performance value |
|---|---|---|---|---|---|---|---|---|
| 1 | Easy to set fire and easy to ignite | | 5 | 5 | | | 25 | 2,5 |
| 2 | Light and durable material | | 6 | 4 | | | 24 | 2,4 |
| 3 | Easy to use | | 6 | 4 | | | 24 | 2,4 |
| 4 | The stove size is comfortable to use | | 5 | 5 | | | 25 | 2,5 |
| 5 | Safe when used | | 5 | 5 | | | 25 | 2,5 |
| 6 | Doesn't cause back pain | | 6 | 4 | | | 24 | 2,4 |
| 7 | Economical in usage | | 5 | 5 | | | 25 | 2,5 |
| Total | | | | | | | 172 | 17,2 |

Source: Data Processing, 2019

### *D. Goal*

TABLE IV. Goal Setting

| No | Variable | Goal |
|---|---|---|
| 1 | Easy to set fire and easy to ignite | 5 |
| 2 | Light and durable material | 5 |
| 3 | Easy to use | 5 |
| 4 | The stove size is comfortable to use | 5 |
| 5 | Safe when used | 5 |
| 6 | Doesn't cause back pain | 5 |
| 7 | Economical in usage | 5 |

Source: Data Processing, 2019

### *E. Determine Technical Response*

TABLE V. Technical Response

| No | Variable | Technical Response |
|---|---|---|
| 1 | Easy to set fire and easy to ignite | Product Design |
| 2 | Light and durable material | Material component |
| 3 | Easy to use | Product Design |
| 4 | The stove size is comfortable to use | Product dimension |
| 5 | Safe when used | Product Design |
| 6 | Doesn't cause back pain | Product dimension |
| 7 | Economical in usage | Material component |

Source: Data Processing, 2019

### *F. Uniformity Test, Data Sufficiency and Percentile value*

TABLE VI. Recapitulation of Anthropometric Data Uniformity Test calculation

| No | Dimension code | Body dimension | σ | BKA | BKB | Description |
|---|---|---|---|---|---|---|
| 1 | D12 | Dimension of the width of the palm | 0,52 | 8,61 | 6,59 | Similar |
| 2 | D16 | Dimension of the | 0,26 | 4,27 | 3,23 | Similar |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | thickness of the palm | | | | |

Source: Data Processing, 2019

TABLE VII. Recapitulation of Anthropometric Data Sufficiency Test calculation

| DATA | N | N' | Description |
|---|---|---|---|
| D12 | 10 | 6,4 | Adequate |
| D16 | 10 | 6,8 | Adequate |

Source: Data Processing, 2019

TABLE VIII. Selected Percentile value

| No | Dimension Code | Body Dimension | Selected Percentile |
|---|---|---|---|
| 1 | D12 | Dimension of the width of the palm | P 95 (8,62) |
| 2 | D16 | Dimension of the thickness of the palm | P 95 (4,26) |

Source: Data Processing, 2019

Product dimensions are based on anthropometric measurements. The anthropometric data used were the width dimension of the palm (D12) of 8.62, and the dimension of palm thickness (D16) of 4.26.

## G. House of Ergonomics

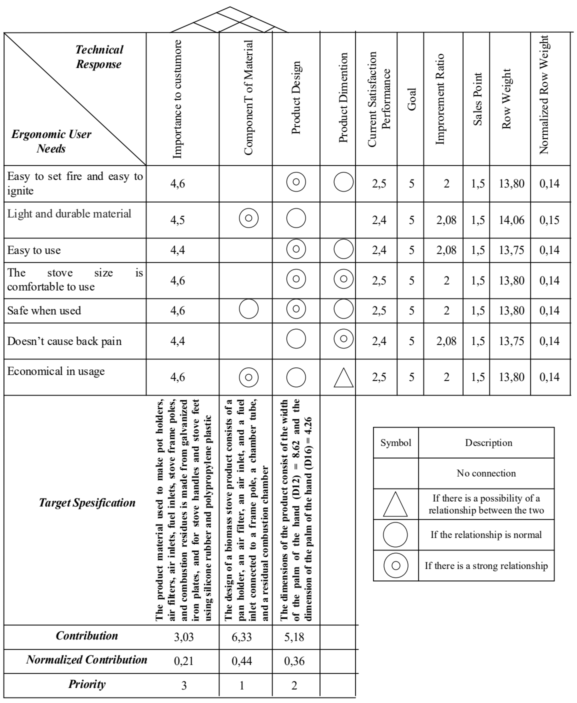


Figure II. House Of Ergonomic

Source: Data Processing 2019

HOE functions to unite all data into 1 picture that explains all EFD processing that forms a house image. HOE consists of consumer needs, technical responses, the relationship between customer needs and technical responses, the relationship between technical responses, the level of importance, level of satisfaction, Goal, Imitation Ratio, Sales Point, Raw Weight, Normalized Raw Weight, Target Specification, contribution value, normalized contribution and priority order.

## H. Design of Ergonomic Biomass Stove

Figure III. Design of Ergonomic Biomass Stove

Source: Data Processing 2019

The design of the stove consists of filters, air holes, fuel inlet, frame poles, tubes and ash disposal sites connected and can use galvanized iron plate material, and there is a handle to hold or dispose of ash and add ash disposal in the design of biomass stoves which is resistant from fire.

## I. Material Cost Calculation

| Material | Size Description | Size used | Per unit | Price | Price Per unit |
|---|---|---|---|---|---|
| Galvanized iron plate | 75 x 75 x 2,7mm | 150 x 85mm | 9 | $ 35,66 | $ 2,80 |
| | | 165 x 196mm | 7 | | $ 1,10 |
| | | 110 x 20mm | 8 | | $ 16,21 |
| | | 122 x 70mm | 12 | | $ 4,18 |
| | | 150 x 50mm | 20 | | $ 4,76 |
| | | 245 x244mm | 12 | | $ 3,96 |
| Polypropylene plastic + silicon rubber | 2 kg | 3 x 30 x x100mm | 9 | $ 14,21 | $ 15,79 |
| Service | | | 1 | $ 7,10 | $ 7,10 |
| Total | | | | | $ 34,58 |

Source: Data Processing, 2019

The manufacture of one biomass stove needs galvanized iron plate materials, with a total price of Rp.486,792,- per unit.

## J. Benchmarking

| Product Type | Product Design | Product Material | Product Specification | |
|---|---|---|---|---|
| Product on the market |  | Iron | 1 | Material can rust |
| | | | 2 | Size doesn't adjust to body dimension, which can be seen from (Palm thickness, and palm width) |
| | | | 3 | No handle |
| | | | 4 | No ash shelter |
| | | | 5 | The price is $ 27,00 |

| | | | | |
|---|---|---|---|---|
| Product Design |  | Galvanized iron plate, Silicon rubber, Polypropylene plastic | 1 | Rust and fire resistant material |
| | | | 2 | Size is based on the body dimension of stove user, which can be seen from (Palm thickness, and palm width) |
| | | | 3 | It has handle to carry the stove |
| | | | 4 | It has a place to accommodate the rest of the burnt or ashes |
| | | | 5 | The price is $ 34,58 |

Figure IV. Benchmarking
Source: Data Processing 2019

At this stage many differences are found in terms of the materials and components available on the biomass stove. In the proposed design, this biomass stove uses galvanized iron plate material because it has a material that is lightweight and resistant to fire, and so that users are more comfortable in using the stove, and can easily create a shelter or ash disposal after burning. In addition, silicone rubber has stable properties, non-reactive, and has the ability to survive in extreme environmental conditions and still be able to maintain its properties and functions.

## IV. CONCLUSION

The conclusions of the research design of an ergonomic biomass stove using the Ergonomic Function Deployment (EFD) method are as follows:

1. The required biomass stove design specifications based on the results of the distribution of questionnaires to users or users of biomass stoves are stoves that have a lightweight and durable material, and the size of a stove that is comfortable when used, does not cause back pain, is easy to use, safe when used, and can set fire easily and easy to ignite.
2. From the data processing, an ergonomic biomass stove design with anthropometric data is obtained, namely the dimensions of the width of the palm of the hand measuring 8.62 cm, the dimension of the palm of the hand 4, cm.

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