Product Development of Mini Chamber with Ergonomic Function Deployment (EFD) Method

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Abstract: Corona Virus Disease-19 (Covid-19) pandemic is still ongoing until now. The spread of this virus is very dangerous because it can spread through droplets or the particles that come out from the nose and mouth. Based on these sentences, the spread of the virus has become risky, one of the activities is shopping online. Virus transmission can occur through delivery and receive stuff activities. The habit that occurs in public, often the stuff arrived at home indirectly sterilized. The purpose of the research is to develop a product that can sterilize the stuff with disinfectant automatically. This research for product development with Ergonomic Function Deployment (EFD) Method. In this method, the product concept is designed based on customer needs (voice of customer). Data of customer needs is obtained from the result of 100 respondents with an age range of 20-40 years who frequently online shopping. The product designed refers to the method used with the ergonomic principle after data is processed. The recommendation of product development from this research is a mini chamber. This product is a development of the chamber but its function is for spraying stuff from the outside of house. The procedure of this product is works automatically so the application of this product for customer can be easier.

Keywords: Ergonomic function deployment, anthropometry, house of ergonomic, mini chamber, Covid-19

1. Introduction

At the end of 2019, China was recorded as the county with first virus cases suspected the virus has similarity with the pandemic was occurred in 17 years ago is SARS (Severe Acute Respiratory Syndrome). SARS is a case of the acute respiratory syndrome [1]. The virus is called Corona Virus Disease-19 or Covid-19. According to World Health Organization (WHO) in 2019, Covid-19 is an infectious virus caused by new viruses are SARS-CoV-2. This virus was transmitted by droplets or the particles form mouth that was produced when an infected has cough, sneezing, or exhales. These droplets are too heavy and cannot stay in the air, until dropped quickly stick on the floor or other surface. Corona Virus Disease-19 has many dangerous is a complication of respiratory tract. Patient death rate as result of this virus is showing exponential graphic.

In 2020 was reported have many countries had many efforts to avoid spreading this virus, including Indonesia. The severity rate showing that the risk suffered is high risk of death. The Ministry of Health of the Republic Indonesia issued the decision to implement health protocol. Many preventive efforts have promoted by Ministry of Health are maintaining distance, wearing a mask, washing the hand, and doing activities from home [2].

The goal of activities from home is to reduce of people crowding. The activities such as studying, working, and shopping form home. According to the Directorate-General of Post and Information (PPI) Ministry of Information and Communication, online sales in 2020 this pandemic is increased drastically until 400% [3]. People interest for online shopping are increase drastically, but the people often have less aware of the stuff they bought before. Box of packaging was bought from online store are not guaranteed to clean. Viruses, which are the microorganisms, it can stick on the surface the boxes. The viruses can stay on the air for three hours until two days on the box and plastic.

To minimize that statement, many products are using to support Adaption of New Habit (AKB). For example, the product was designed from Faculty of Computer Science Mulia University Students is automatic hand sanitizer with robotic technology [4]. Furthermore, the innovation product from Malang State University Students is portable sink, both of products have same goals are making easier for people to apply new habit [5]. In this research, the product designed is product development of chamber. Using of chamber have pro and contra because the disinfectant effect for the users or people and the environment. However, the product developed for this research is mini chamber that is specifically to customer for spray the disinfectant

automatically the stuff from house outside area. Customer can move mini chamber to the desired place and effective for using this product so there are no droplets are left on the stuff.

The existence of this product is helping to customer for avoid Covid-19 by stuff sterilizing process form the house outside area with disinfectant automatically. Working sensor will make it easier for customer to using this product and make it easier for customer to move the desired place. The product design based on Ergonomic Function Deployment (EFD) Method. This method is product development method that consider aspects ergonomic. The attributes for this research based on customer needs (voice of customer). With this research, is hope can be contributed to reduction spread rate of Covid-19. This product can also reference many people in effort to Adaptation of New Habit.

2. Literature Review

2.1. Ergonomic

Ergonomic is the study of human relation by seeing all the limitations that the people have goal for increasing productivity of works [6-7]. The aspects of ergonomic to achieving ENASE (Effective, Comfortable, Safety, Healthy, and Efficient). The explanation about ergonomic aspects are:
1. Effective, this aspect put forward the goal have been planned before.
2. Comfortable, this aspect stated that the condition to avoid the anxiety.
3. Safety, this aspect put forward free from risk or the things can be injured by people.
4. Health, this aspect is the condition who avoid from disease or health problem.
5. Efficient, this aspect is the achievement a goal has been planned before by considering all sides, from costs, power, and time spent.

2.2. Product Development

Product development is very important at the time that considering many products have made without pay attention the product function. The goal of product development is to make easier jobs and increasing in works both in the home environmental and in company environmental. The steps to starting product development are [8]:
a. Doing product planning
b. Identify about customer needs by doing collecting data according to the product want to design.
c. Give the decision for product specification so product designed can determine the components in this product.
d. The preparation of product concept must be seen form the design until work system that will use on customer.
e. The aim of concept product is to see and reassess product concept have been planned before based on customer needs.
f. Concept testing is carried out so customer needs have been planned before are fulfilled.
g. The design of product architecture is carried out based on product function that has made and makes the components of product.
h. The industry design applied ergonomic aspects to avoid from injury until the sense of secure to use this product.
i. The aim of design for a manufacture process has made is supporting the product has been designed before so that the product created can provide benefit or value to customer.
j. Creating a prototype, as a product description before the product will be manufacturing with dimension or actual size.
k. Economic analysis is very important to make decision whether the product is useful or not.

2.3. Ergonomic Function Deployment (EFD)

Ergonomic Function Deployment or EFD is development of the Quality Function Deployment (QFD) Method by applying from ergonomic aspect which is will develop the product [9]. EFD Method is used to give a decision for product development by connecting the attributes based on the product being designed [10]. The attribute elements used based on customer needs. The attribute designed must be contain ENASE elements (Effective, Comfortable, Safety, Health, and Efficient). The application of EFD Method is usually in industry, both of small scale and large scale, for example in company.

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The step in processing data for EFD Method have using the matrix, which is to connecting all of the other attributes. The matrix used to EFD Method called the House of Ergonomic (HOE). This is following the structure of House of Ergonomic (HOE) [11].
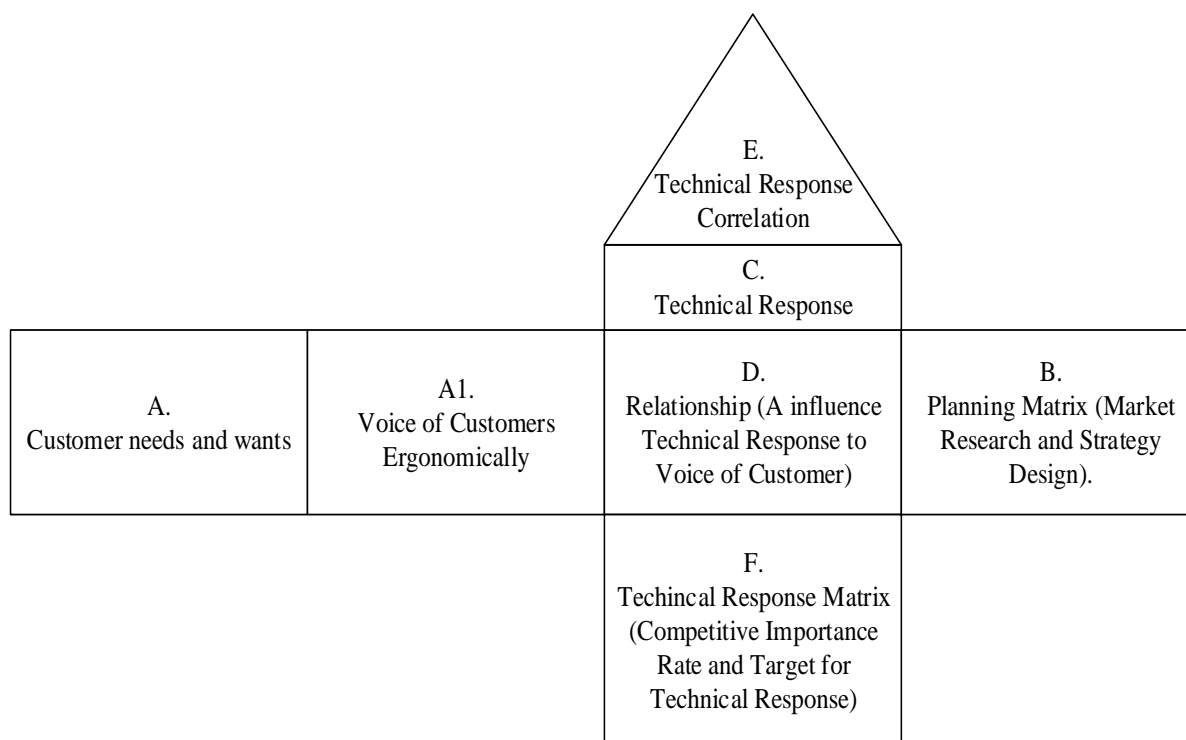

Figure 1. House of ergonomic (HOE)

2.4. Anthropometry

The term of Anthropometry comes from Greek with two words "Anthropos" is human and "metros" is measure [10]. Anthropometry is one of Method in Ergonomic to study the dimension of human body [12]. The implementation of Anthropometry in company is usually for designing or developing the product. The use of Anthropometry for products so avoid the users get injury, provide sense of secure and comfort when the user uses it. The dimension measure of human body is varying from other, but there are factors can affect dimension of human body. The factors on dimension of human body can be from age, gender, ethnic, body position, thickness or thinness clothes worn by human, disability, and pregnancy [13]. The data collection of Anthropometry based on product to designed.

3. Methodology

The Method used for this research is Ergonomic Function Deployment (EFD) Method with Anthropometry Method. This research is using primary data and secondary data. The collection data for Ergonomic Function Deployment (EFD) Method with primary data is a questionnaire. The questionnaire made contains have 15 statements with range in age 20 until 40 years old. The statements for a questionnaire contains ergonomic aspects are ENASE (Effective, Comfortable, Safety, Health, and Efficient). The respondents are required 100 respondents minimum. The parameter used with Likert Scale. In measurement, the form for opinion or agreement have five choices, are strongly disagree, disagree, neutral, agree, and strongly agree. The data is notated a number and then it processed. Next step is creating of House of Ergonomic (HOE) with connecting the attributes has been made by researcher and filled with respondents as customer. House of Ergonomic (HOE) finds out what the customer needs for product to be designed. After knowing what the customer needs, the determining of planning matrix and prioritization. After determining priorities, the next step is product design. The measure of the product based on Anthropometry dimension. Anthropometry Method is one of Method in Ergonomic id using for finds out product size based on dimension of human body. Determination of product is using with secondary data, is looking at https://antropometriindonesia.org/ and product sizes was designed based on percentile on each body dimension. Product planning made with software AutoCAD.

4. Results and Discussion

4.1. Data collection

Product development currently needed for increasing productivity in a job. Product development planning is started form identifying customer needs (voice of customer) with a questionnaire was given to 100 respondents sample. Form the result obtained 15 attribute of customer needs. This is following is the voice of customer recapitulation:

Table 1. Voice of customer recapitulation

No.	Questions	Scale				
		1	2	3	4	5
1	The mechanism of this product when it spraying the stuff automatically	1	1	13	28	57
2	The spray right on the stuff so it can kill the virus	1	2	9	17	71
3	The product have place to put the stuff for spraying process easily	1	0	10	27	62
4	Product is designed based on dimension of human body size	0	1	18	25	56
5	Have handle and wheels for customers to move a mini chamber easily	0	1	8	33	58
6	The design of mini chamber with eye catching colour	0	1	19	33	47
7	Product material made from harmless material	0	0	4	20	76
8	There are not have sharp sides and corners in product	0	0	7	26	67
9	Have lock valve in the refill to avoid leakage when refilling the disinfectant	0	1	10	27	62
10	Spaying the disinfectant to stuff can reduce the dangers of droplets from the outside house area	0	0	13	27	60
11	Disinfectant liquid just spreading in a mini chamber	1	4	17	28	50
12	Have a great residue steam sewer	1	0	14	23	62
13	Product design is simple so the product can stored in everywhere	0	2	8	25	65
14	The spraying is carried out in a short times	1	4	10	28	57
15	Product is designed can be charged with charger	1	3	14	27	55

4.2. Data processing

4.2.1. Data adequacy test

Data Adequacy Test is needed in this research for make sure the data has collected and presented adequacy on objective measurement.

$$N' = \left[\frac{k/s\sqrt{N\Sigma X^2 - (\Sigma X)^2}}{\Sigma X}\right]^2 = \left[\frac{40\sqrt{100(30582) - 44488900}}{49.78}\right]^2$$

N' < N = 49.78 < 1500, so the data is adequate.

4.2.2. Validity and reliability

Validity is an accuracy test of an instrument in research [14]. The data obtained form 100 respondents is n or the amount of data in research. Validity uses Pearson correlation coefficient (r table) as a valid limit or not. The validity test is presented in Figure 2.

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	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
VAR00001	129.0100	238.717	.695	.745
VAR00002	128.8500	239.644	.663	.746
VAR00003	128.9100	241.113	.657	.748
VAR00004	129.0400	241.837	.582	.749
VAR00005	128.9200	241.428	.713	.748
VAR00006	129.1400	244.243	.492	.752
VAR00007	128.6800	245.957	.653	.753
VAR00008	128.8000	242.364	.748	.749
VAR00009	128.9000	239.303	.781	.745
VAR00010	128.9300	240.147	.743	.746
VAR00011	129.1800	240.412	.546	.748
VAR00012	128.9500	237.644	.757	.744
VAR00013	128.8700	239.165	.773	.745
VAR00014	129.0400	239.231	.620	.746
VAR00015	129.0800	238.276	.653	.745

Figure 2. Validity test with SPSS software

The corrected item-total correlation value above is the calculation r-value which is greater than DF value (degree of freedom). The result of r value is 0,1966 based on significance test is 0.05. The calculation r-value is greater than table r, so the result is valid. The goal of reliability test is to determine the consistency whether the measure tool uses can be dependable and consistent.

Cronbach's Alpha	N of Items
.920	15

Figure 3. Reliability test with SPSS software

In this research, the data is processing and the result 0,920, which is base of making decision based on Cronbach's Alpha is 0,6. It is because Cronbach Alpha is greater than 0,6 so the data is reliable or consistent [15].

4.2.3. Drafting of the house of ergonomic

The drafting of House of Ergonomic is determined by making Planning Matrix are [16]:
1. Importance to Customer (ITC)
    Importance to Customer is level of importance in each of attribute. The calculation of ITC with mode or the value has appeared frequently. In this research, the respondents are fulfilled the attribute with strongly agree opinion so the value has appeared frequently is 5,00.

2. Current Satisfaction Performance (CSP)
    Current Satisfaction Performance is the rating of satisfaction level from product development planning. The satisfaction level of customer can be calculated with formula:

Weight Average Performance= $(\sum i[(\text{Number of respondents at performance value i).i)}])/((\text{Total number of respondents}))$
Weight Average Performance = (439/ 100) = 4,39

3. Goal
    The goal determination from researcher discussion based on an Importance to Customer. This assessment is based on subjective assessment which is the researcher was made target value will be achieved. Goal assessment scale shown from the below table:

Table 2. Goal scale

Scale	Explanation
1	Very unsatisfying
2	Unsatisfying
3	Neutral
4	Satisfying
5	Very Satisfying

4. Improvement Ratio (IR)

The Improvement Ratio is showing the amount of changing or improvement will be doing. In the mathematics form, value of Improvement Ratio is:

Improvement Ratio = Goal/Current Satisfaction Performance
Improvement Ratio = 5/4,39 = 1, 14

The value is means for improvement; the explanation of meaning is:

Table 3. Scale improvement ratio

Value	Meaning
< 1	No improvement
1,0 – 1,5	Moderate improvement
> 1,5	Improvement completely

5. Sales Point (SP)

Sales Point is the amount of selling of product or consumption value in product development planning. Sales Point value shown from the below table:

Table 4. Sales point scale

Value	Meaning
1	No sales point
1,2	Moderate sales point
1,5	Intense sales point

Sales Point selected is the subjective value of chosen based on the attributes, which is have highly sell rate.

6. Raw Weight (RW)

This step uses are showing the amount of improvement in customer need criteria. In the mathematics form, determine of value is:

Raw Weight = Importance to Customer x Improvement Ratio x Sales Point
Raw Weight = 5,00 x 1,14 x 1,5 = 8,54

7. Normalized Raw Weight (NRW)

NRW is the value from Raw Weight that is has made form 0-1 scale, can be calculating with formula:

Normalized Raw Weight = (Raw Weight) / (Raw Weight Total)
Normalized Raw Weight = 8,54/104,81 = 0,082

8. Relationship Matrix

This matrix used for showing the relation of cause and effect between customer needs and technical response. In mathematics form, the determined of Relationship Matrix is:

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Relationship Matrices = Raw Weight Value * Rating Weight of Relationship Level

Relationship Matrix rated based on the subjective value to show the intense relationship until weak between customer needs and technical response. The determination to show the relationship between each of customer needs and technical response shown from the below table:

Table 5. Relationship value

Symbol	Numeric Value	Meaning
△	1	Relationship probably
○	3	Moderate relationship
●	9	The relationship very intense

The drafting for House of Ergonomic presented from the below table:

Table 6. Planning matrix drafting

No.	Question	ITC	CSP	GO	IR	SP	RW	NRW
1	The mechanism of this product when it spraying the stuff automatically	5	4,39	5	1,14	1,5	8,54	0,082
2	The spray right on the stuff so it can kill the virus	5	4,55	4	0,88	1,2	5,27	0,050
3	The product have place to put the stuff for spraying process easily	5	4,49	4	0,89	1,2	5,35	0,051
4	Product is designed based on dimension of human body size	5	4,36	4	0,92	1,5	6,88	0,066
5	Have handle and wheels for customers to move a mini chamber easily	5	4,48	5	1,12	1,5	8,37	0,080
6	The design of mini chamber with eye catching colour	5	4,26	4	0,94	1,2	5,63	0,054
7	Product material made from harmless material	5	4,72	5	1,06	1,5	7,94	0,076
8	There are not have sharp sides and corners in product	5	4,6	5	1,09	1,5	8,15	0,078
9	Have lock valve in the refill to avoid leakage when refilling the disinfectant	5	4,5	5	1,11	1,5	8,33	0,080
10	Spaying the disinfectant to stuff can reduce the dangers of droplets from the outside house area	5	4,47	5	1,12	1,5	8,39	0,080
11	Disinfectant liquid just spreading in a mini chamber	5	4,22	4	0,95	1,2	5,69	0,054
12	Have a great residue steam sewer	5	4,45	4	0,90	1,2	5,39	0,051
13	Product design is simple so the product can stored in everywhere	5	4,53	4	0,88	1,2	5,30	0,051
14	The spraying is carried out in a short times	5	4,36	5	1,15	1,2	6,88	0,066
15	Product is designed can be charged with charger	5	4,32	5	1,16	1,5	8,68	0,083

From the data was processed above, the House of Ergonomic matrix with Ergonomic Function Deployment Method. The results of Planning Matrix above are input to House of Ergonomic later. The value of Importance to Customer (ITC) shown on the left side table.

While, the value of Customer Satisfaction Performance, Improvement Ratio, Sales Point, Raw Weight, and Normalized Raw Weight shown on the right side table. In the middle of the table filled with Relationship Matrix, which is marked with symbols based on between customer needs and technical response. For top triangle on the House of Ergonomic Diagram filled with technical response correlation. In the bottom side, have integrity and priority levels. Priority level determined from the result is highest until lowest.
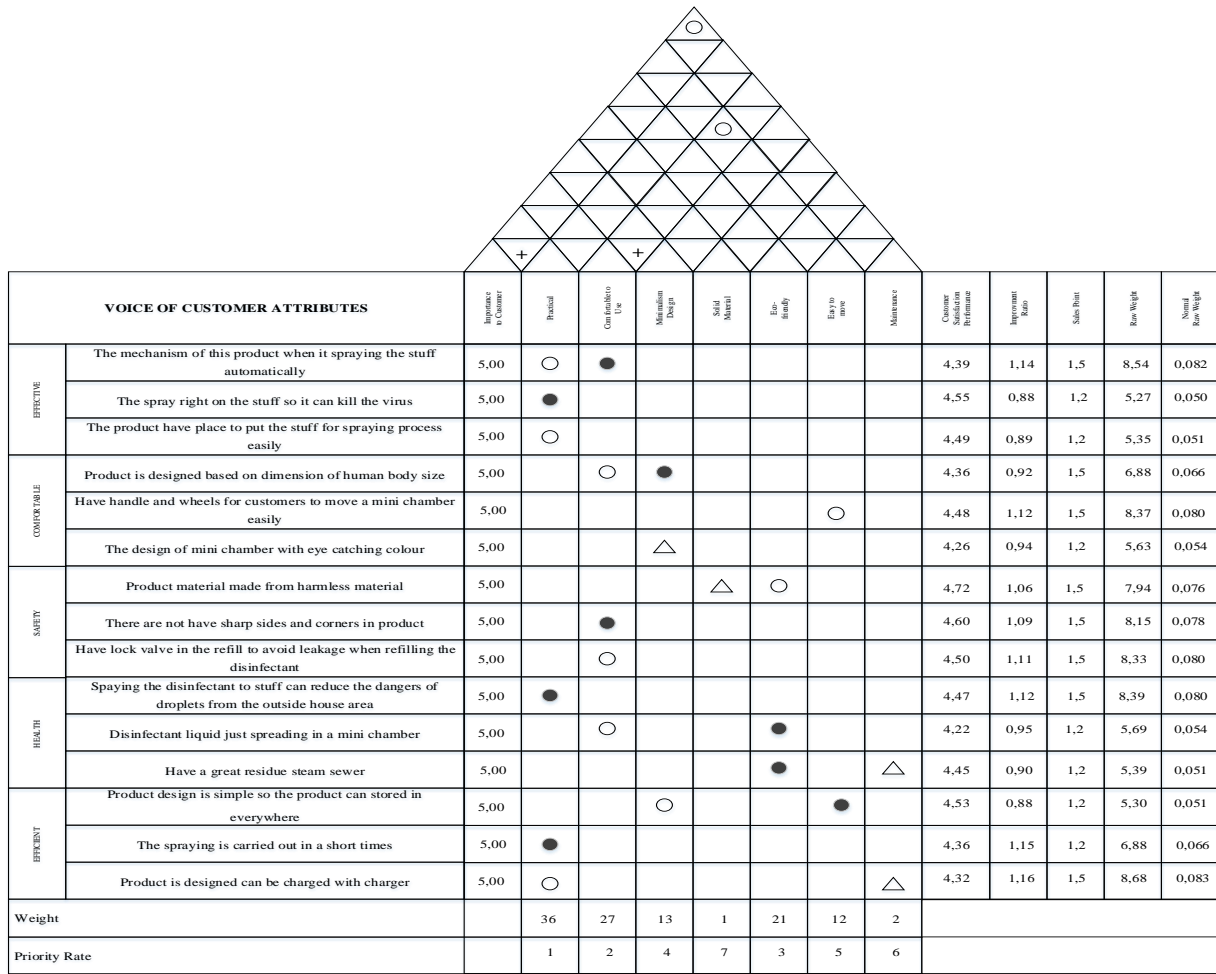
	VOICE OF CUSTOMER ATTRIBUTES	Importance to Customer	Practical	Comfortable to Use	Minimalism Design	Solid Material	Eco-friendly	Easy to move	Maintenance	Customer Satisfaction Performance	Improvement Ratio	Sales Point	Row Weight	Normal Row Weight
EFFECTIVE	The mechanism of this product when it spraying the stuff automatically	5,00	○	●						4,39	1,14	1,5	8,54	0,082
	The spray right on the stuff so it can kill the virus	5,00	●							4,55	0,88	1,2	5,27	0,050
	The product have place to put the stuff for spraying process easily	5,00	○							4,49	0,89	1,2	5,35	0,051
COMFORTABLE	Product is designed based on dimension of human body size	5,00		○	●					4,36	0,92	1,5	6,88	0,066
	Have handle and wheels for customers to move a mini chamber easily	5,00						○		4,48	1,12	1,5	8,37	0,080
	The design of mini chamber with eye catching colour	5,00			△					4,26	0,94	1,2	5,63	0,054
SAFETY	Product material made from harmless material	5,00				△	○			4,72	1,06	1,5	7,94	0,076
	There are not have sharp sides and corners in product	5,00		●						4,60	1,09	1,5	8,15	0,078
	Have lock valve in the refill to avoid leakage when refilling the disinfectant	5,00		○						4,50	1,11	1,5	8,33	0,080
HEALTH	Spaying the disinfectant to stuff can reduce the dangers of droplets from the outside house area	5,00	●							4,47	1,12	1,5	8,39	0,080
	Disinfectant liquid just spreading in a mini chamber	5,00		○			●			4,22	0,95	1,2	5,69	0,054
	Have a great residue steam sewer	5,00					●		△	4,45	0,90	1,2	5,39	0,051
EFFICIENT	Product design is simple so the product can stored in everywhere	5,00		○				●		4,53	0,88	1,2	5,30	0,051
	The spraying is carried out in a short times	5,00	●							4,36	1,15	1,2	6,88	0,066
	Product is designed can be charged with charger	5,00	○						△	4,32	1,16	1,5	8,68	0,083
Weight			36	27	13	1	21	12	2					
Priority Rate			1	2	4	7	3	5	6					

Figure 4. House of ergonomic

4.2.4. Anthropometry

In design, the product is needed to human body dimension in related with product specification. In anthropometry concept, percentile used as the base of measure for product [17]. The specification for P5 is used because the design of product specification, a critical for people who have small body posture. The product specification for P5 are handle width, width of a mini chamber product, height of a mini chamber product, length and weight of disinfectant refill. Meanwhile, P95 is critical for people who have a large body. The product specification for P95 are handle length, length of a mini chamber product, and height of disinfectant refill.

Table 7. Anthropometry dimension

Specification	Dimension	Percentile	Size
Handle length	D29 (Hand width)	P 95	15,87 cm
Handle width	D28 (Hand length)	P 5	14,85 cm
Length of a mini chamber product	D17 (Shoulder width)	P 95	50,89 cm
Width of a mini chamber product	D23 (Forearm length)	P 5	31,00 cm
Height of a mini chamber product	D15 (Knee height)	P 5	44,11 cm
Length of disinfectant refill	D23 (Forearm length)	P 5	31,00 cm
Width of disinfectant refill	D28 (Hand length)	P 5	14,85 cm
Height of disinfectant refill	D29 (Hand width)	P 95	15,87 cm

From anthropometry data processing, so the researcher is designing a product with AutoCAD software as shown below:

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Figure 5. Mini chamber

5. Results and Discussion

Based on the result of research has been done, the data can see in Table 1 is voice of customer. From 100 respondents, the data shown as many as 60%, the opinions are very agreeing of 15 voice of customer attributes have been given. Then, the data is processed and tested of adequacy data with validity and reliability. The data from 100 respondents is adequate. Likewise, validity and reliability test were the data collected and processed are valid and reliable.

After that, the data processed to planning matrix. The planning matrix is a base for processing a House of Ergonomic. One of the goal of House of Ergonomic is to know the voice of customer priority. Priority rate has seen in the bottom of House of Ergonomic. The first of priority rate is practical. In this priority, there are three voice of customers are the spray right on the stuff so it can kill the virus, spaying the disinfectant to stuff can reduce the dangers of droplets from the outside house area, and the spraying is carried out in a short time. The spraying carried out in 90 seconds, which is the nozzle was set in 30 seconds slowly for spraying the product [18].

The second priority is comfortable to use. This attribute has two voice of customers are the mechanism of this product when it spraying the stuff automatically and there are not have sharp sides and corners in product. The mechanism of this product when it spraying the stuff automatically because the product uses with sensor system is Arduino sensor. The namely of this sensor is Sensor Motion PIR HCSR501 Detector Infrared which is when there is movement form hand to put the stuff in a Mini Chamber, the disinfectant is spraying with nozzle automatically. The sensor installed on the top of product, it shown in Figure 6.

Figure 6. Sensor motion PIR HCSR501 detector infrared

The next voice of customer is there are not have sharp sides and corners in product. The shape of mini chamber designed is the corner of this product not to 90° angle. This manifested by curving corner in product [19]. The principal applied of designing process give a 3 cm radius curves in the corner of product. The slight contouring in the corner of product have to increase of comfortable and aesthetic form the product.
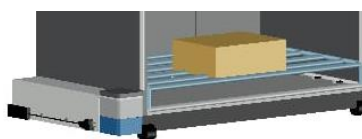

Figure 7. Disinfectant refill

The next priority is eco-friendly because the product made has pro and contra about the disinfectant. In Figure 7 shown disinfectant refill. The disinfectant liquid used in this product with the electrolyzed salt ion

antiseptic (anolyte). Dr. Muji said the anolyte liquid can be sterilized in nose and throat during inhalation without difficulty breathing and skin irritation [20]. The salinity levels in 1-2% salt can be optimized the disinfectant function [21].

Then, the needs for the product can moved easily. The product design was designed with additional handle and wheels so the product can be moved depends the customer. The other priorities used as a complement of product conceptual.

After determining the priorities, then production planning is designing with AutoCAD software. The size for a product while the product is designing with dimension of human body, it from Anthropometry Method in 20-40 years old. The size is using 5 percentile (P5) and 95 percentile (P95). P5 indicated the smallest size and P95 indicated the largest size. The goal of Anthropometry is the product assessment to maintain ergonomic principle in design or work system. With Ergonomic Function Deployment (EFD) Method, the design process of product conceptual used, ergonomic work system can be optimal based on voice of customer [22].

6. Conclusion

From the final result of research, the conclusion is voice of customers for a mini chamber can be applied ENASE principles are practical, comfortable to use, minimalist design, solid material, eco-friendly, easy to move, and maintenance. The data obtained from result of 100 respondents recapitulation. The product design based on result of House of Ergonomic Matrix. The size determined for product development is a range of 20-40 years with Ergonomic principle, which the goal is for designing ergonomically product in work system. With Ergonomic Function Deployment (EFD) Method, the design process of product can be optimal based on voice of customer.

Acknowledgment

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