

# Development of Prototype Ergonomic Reflexology Vest (ERV) for Improving the Quality and Performance Features

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**Abstract**—Product prototype Ergonomic reflexology vest is an ergonomic intervention recommendation, which serves to reduce or minimize Musculoskeletal disorders such as aches, stiffness, and pain as well as fatigue in the body area of the back, waist, shoulders, and neck of the user. This product features a vertical massaging motor, a vibrator, and its control, a timer, a rechargeable battery, which was designed to be practically foldable and ergonomic because it uses the Indonesian anthropometric dimensions. This product with a number of features was expected to make the body points relax after tired work or activities all day long so that it makes users feel comfortable and able to reactivate. Usability testing of prototype products has been carried out where the result is that prototypes are still lacking and need improvement and development. For this reason, it is necessary to improve and develop the design and features of the vest in order to have better quality. Then the aim of this research is to develop an ergonomic reflexology vest prototype using the method Quality Function Deployment (QFD), through the development of the House of Quality (HoQ), which is the first level of QFD, and to apply ergonomic principles that are effective, safety, healthy, comfortable and efficient. House of Quality (HoQ) aims to translate customer requirements directly to the technical requirements of the products produced. The respondents of this study were drivers car on-line and students were selected based on predetermined characteristic criteria. The results of this study are that there are 15 items Product Attributes as consumer needs and 7 technical requirements. Based on the results of the priority of weights and relative weights, the priority order for 7 items was set: (1) redesigning features, (2) developing and improving design patterns, (3) improving the quality of vest products that are more ergonomic (effective, safety, healthy, comfortable and efficient), (4) quality material selection, (5) testing the ability of vest prototype, (6) warranty service & periodic service, (7) price adjustment with production costs.

**Keywords**—Product Design, Customer Requirements, QFD, HOQ

## I. INTRODUCTION

One sector of work that is at high risk of developing musculoskeletal disorders is transportation. Transportation workers such as drivers are exposed to various risk factors that can cause health problems. Driving a two-wheeled or four-wheeled vehicle is a job done with a static body posture that is sitting in a certain period of time and doing repetitive activities throughout the trip, including holding the steering wheel, moving gears, stepping on the brakes, gas and clutch and require a high enough concentration to focus on the front, back, left and right sides of the road. This considerable physical and mental activity were carried out within a certain time duration, with exposure to vibrations and low enough

temperatures and other pollution it can cause health problems, including musculoskeletal disorders, fatigue, and sleep disorders, which have an impact on driving performance.

The first and second stages of applied research have been carried out, namely the development of an ergonomic reflexology vest product prototype, which has the function to reduce or minimize Musculoskeletal disorders such as aches, stiffness, and pain as well as fatigue in areas of the back, waist, shoulders and neck of the user, which features a vertical massaging motor, vibrators and controls, a timer, a rechargeable battery, which were designed to be practically foldable and ergonomic, because it uses Indonesian anthropometric dimensions. Ergonomic reflexology vests with several features are expected to make the body points become relaxed after being tired from work or activities all day so that makes users feel comfortable and can reactivate.

After the prototype of the ergonomic reflexology vest was made, the next research is to conduct usability testing and evaluation on real environmental conditions to get initial feedback about the concepts and parameters that determine the functional design. Some parameters will be used as an evaluation and the basis for the next phase, improvement, where testing will involve the end-user, improvements will be made based on the experience of the end-user when using it.

Based on the results of the study of ability, the respondent (user) stated that this ergonomic reflexology vest prototype product was still lacking so it had to be improved and developed again.

Quality function deployment (QFD) is a structured methodology that can be used in the process of product planning and development to determine the specifications of the needs and desires of consumers, as well as systematically evaluating the capabilities of a product to meet the needs and desires of consumers [1][2][3][4].

Some previous studies using the method quality function deployment (QFD), Patil et al [1] conducted a study on helical spring design, where the result was that researchers had to reduce production costs by optimizing the type of material. Tsai et al designed aids in moving a wheelchair, Power-assisted wheelchair (PAW), where the results of this study, stated that QFD can be used to improve design quality, taking into account the desires and satisfaction of consumers. This tool can increase the efficiency of a manual wheelchair, making it easier for patients to move the wheel and not cause injuries due to continuous use.

Based on the background that has been explained, the purpose of this study is to improve and develop an ergonomic reflexology vest prototype using the method Quality Function Deployment (QFD), through the development of the House of Quality (HoQ), which is the first level of QFD, and to apply ergonomic principles, namely effective, safety, healthy, comfortable and efficient.

II. METHOD

The steps of this study:

A. Field observations and interviews

Methods of data collection by conducting observations/direct observations on the object of research. In this study conducted initial observations about the

development of reflexology vest products, with the aim of getting the specifications needed by the user and evaluating the capability of the system in the hope of being able to meet the needs of the user (driver car).

B. Determining Variable Questionnaire

Characteristics user needs and desires of the reflexology vest product development that will be used for the preparation of the questionnaire in the study so that the attributes that will be used for the questionnaire [5]. The statement attributes shown in table 1. The results of Focus Group Discuss (FGD) user needs are done through the distribution of open questionnaires in order to obtain 15 underlying attributes in Product development shown in table 2.

Table 1. Statement Attributes

No.	Variable	Dimension	No. Item	Statement Attribute	Measurement Scale	Measurement Instrument
1	Measurement Product Quality (Garvin, 1998 & Tjandjaja, 2009)	Performance	1	Vest products can able to function (massage) well	Interval	Quantitative
			2	Some car massage and vibrator can be felt enough		
			3	Massage can reduce symptoms of aches and pains		
		Features	4	Complete massage operation features		
			5	Battery vest products are easy to charge		
			Durability	6		
2	Product Price (Kadir & Anwar, 2008)	7		Prices of affordable vest products	Interval	Quantitative
		8		Prices of vest products are in accordance with its quality &		
		Product Design	9	Vest product designs are easy to fold and ergonomic		
	10		Vest products are easy to wear			
	11		Easy to remove vest products			
	Product Quality	12	Good product quality when used			
13		Forms of good quality vest product designs				
14		Comfortable material when used				
3	Customer Satisfaction (Ellmer, 1998 & Satrio, 2012)	Customer Satisfaction	15	The results of massage can reduce symptoms	Interval	Quantitative

Table 2. Attribute Identification Results

Number Item	Statement Attribute Identification Results
1	Vest products can function properly when used by the driver (car driver)
2	The massage can be felt by the user body (driver car)
3	Massage can reduce pain and pain in the user (driver car)
4	Complete features (servo arms, vibrators, charge devices, timer button switches & speedups) on massaging vests and easy to operate by the user (driver car)
5	Multi-function vest battery cable (can be charged anywhere)
6	Age of usage of vest products lasts long
7	Affordable product prices among users (cash/credit)
8	Price of vest products according to the quality and benefits of vest products
9	The design of the vest product is easily folded and ergonomically user (driver car)
10	Easy to use vest products for users (driver car)
11	Vest products are easy to open after being used by the driver (car driver)
12	Good quality car driver products
13	Vest product design is easy to fold and ergonomically by the user (driver car)
14	Comfortable vest material when worn by the driver
15	fatigue experienced by the user (driver car) can be overcome

### C. Distribution of Questionnaires

Questionnaires are data collection techniques through forms that contain questions that are posed written on a person or group of people to get answers or responses and information needed by researchers [6]. The questions in the questionnaire was made using a scale of 1-5 adapted from the Likert scale to examine how strongly the subject agreed/satisfied or disagreed/dissatisfied with the question on a 5 point scale with the following arrangement: very important (5), important (4), ordinary (3), unimportant (2), very unimportant (1) and or: very satisfied (5), satisfied (4), ordinary (3), dissatisfied (2), very not satisfied (1) [7]. Questionnaire data collection was carried out to obtain responses from several populations of car drivers in Jakarta by translating different specifications regarding the development of vest products.

### D. Build a House of Quality (HOQ)

Planning product House of Quality (HOQ) is a product plan that will be developed and adapted to the technical response based FGD among a team of researchers with the driver.

## III. RESULT

### A. Building a House of Quality (HOQ)

Planning product House of Quality (HOQ) which is a product plan that will be developed and adapted to the technical response based FGD among a team of researchers with the driver car. This House of Quality (HOQ) stage consists of user requirements (Customer Requirements or What's) and technical responses (Technical Responses or How's) obtained from the recapitulation of the questionnaire.

### B. Consumer Needs (HoQ part A)

There are 15 customer requirements (Customer Requirements or Whats) are the attribute statements required by consumers are (1) product are able to function (massage) properly, (2) servo arm massage and vibration can be felt strongly, (3) massage can reduce complaints of aches and pains, (4) completeness of the operating features of the massage, (5) the vest product battery is easy to charge, (6) the life of the vest product usage is able to last a long time, (7) the price of the vest product is affordable, (8) the price of the vest product is in accordance with the quality & benefits, (9) the design of the vest product is easy to fold and ergonomic, (10) the vest product is easy to wear, (11) the vest product is easily removable, (12) the product quality is good when worn, (13) the design of the vest product is of good quality, (14) the comfort of the vest material when in use, (15) the massage results can overcome complaints.

### C. Determination of the Planning Matrix (HoQ part B)

The Planning Matrix (HoQ part B) is the level of assessment (average value) of the comparison between respondents' satisfaction and expectations of the vest product. Based on the recapitulation of the questionnaire and FGD. The planning matrix shown in table 3.

**Table 3. Planning Matrix**

Number	Characteristics Consumer Needs	Competitive Analyze (0= Worst, 5 = best)	
		Satisfaction	Expectation
1	Vest products can function properly when used by the driver (car driver)	3.667	4.933
2	The massage can be felt by the user body (driver car)	3.600	4.800
3	Massage can reduce pain and pain in the user (driver car)	3.400	4.667
4	Complete features (servo arms, vibrators, charge devices, timer button switches & speedups) on massaging vests and easy to operate by the user (driver car)	2.800	4.800
5	Multi-function vest battery cable (can be charged anywhere)	2.533	3.667
6	Age of usage of vest products lasts long	2.400	4.400
7	Affordable product prices among users (cash / credit)	3.533	3.733
8	Price of vest products according to the quality and benefits of vest products	2.600	4.600
9	The design of the vest product is easily folded and ergonomically user (driver car)	2.867	3.933
10	Easy to use vest products for users (driver car)	3.400	3.600
11	Vest products are easy to open after being used by the driver (car driver)	3.067	3.733
12	Good quality car driver products	2.667	4.733
13	Vest product design is easy to fold and ergonomically by the user (driver car)	2.600	4.667
14	Comfortable vest material when worn by the driver	2.733	4.533
15	fatigue experienced by the user (driver car) can be overcome	3.533	4.867

D. Technical Response (HoQ part C)

Technical Response (Technical Responses or How's) is a translation of customer needs into technical based on FGD. Substitute Quality Characteristics (SQCs) have a direction of improvement that was used to show performance in the process of planning the product vests to be achieved according to customer needs. Symbol towards improvement shown in Table 4 and technical responses are shown in Table 5.

Table 4. Symbol of Repair

Symbol	Information
▼	Poor target
▲	The target is getting better
X	The best target

Table 5. Technical Response (The How's) and Direction for Improvement

Number	Characteristics of Technical Response	Symbol
1	Improving the quality of vest products that are more ergonomic (effective, safe, healthy, comfortable and efficient)	▲
2	Develop and improve vest product design patterns that can be adjusted by the user	▲
3	Redesigning features (servo arms, vibrators, charge devices, timer button switches & speedups) and electronic circuits needed	▲
4	Selection of quality material	x
5	Price adjustment with production costs	x
6	Testing the use of vest-type prototype	▲
7	Periodic service & warranty services	▲

E. Determination Matrix Relations (HOQ part D)

Matrix relationship (Relationship Matrix) is a reciprocal relationship between the needs of consumers (in Software QFD Language: DEMANDED Quality or Whats) with technical response (in Software QFD Language: Quality Characteristics or Hows) based FGD among researchers with the car driver. The relationship matrix symbol was shown in table 6, the results of the relationship matrix shown in Figure 1.

Table 6. Symbol of Relationship Matrix

Symbol	Information	Value
Blank	Not related	0
▲	A little related	1
O	Related	3
⊖	Very related	9

Results for the determination of the weight value (weight) and Relative Weight value (Relative Weight) based on FGD and support Software QFD. The relative weight and weight values table shown in table 7.

Table 7. Relative Weight and Weight Value

No.	Characteristics of Technical Response	Weight	Relative Weight
1	Improving the quality of vest products that are more ergonomic (effective, safe, healthy, comfortable and efficient)	556.6	18.0
2	Develop and improve vest product design patterns that can be adjusted by the user	560.4	18.1
3	Redesigning features (servo arms, vibrators, charge devices, timer button switches & speedups) and electronic circuits needed	598.0	19.3
4	Selection of quality material	456.2	14.7
5	Price adjustment with production costs	253.6	8.2
6	Testing the use of vest-type prototype	383.1	12.4
7	Periodic service & warranty services	290.5	9.4

F. Determination of Correlation

The technical correlation matrix is a policy determination on the correlation between technical responses based on FGDs and assistance Software QFD. The technical correlation matrix symbol was shown in table 8, the results of determining the strength of the correlation matrix shown in Figure 2.

Table 8. Symbols of the Correlation Matrix

Symbol	Information
++	Strong positive influence
+	Positive effect
-	Negative effect
▼	Strong negative influence

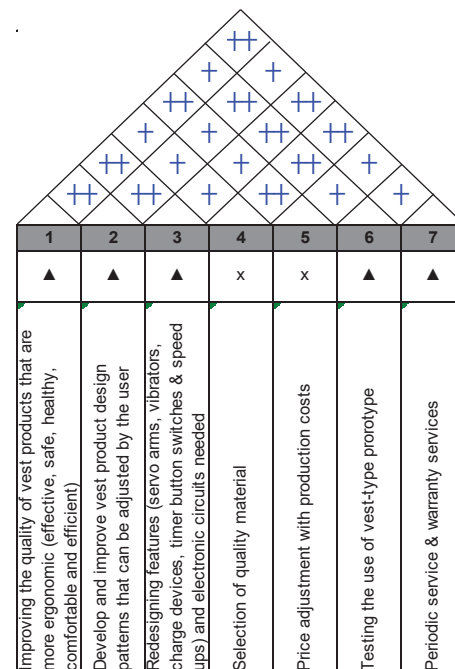


Figure 2. Results of the Correlation Matrix



### G. Determination of Matrix Interest

Matrix technical interest is the result of the determination of the level of difficulty and the target in the process of achieving the technical requirements. Level of difficulty (Difficulty Level) generated from the weights and relative weights. Difficulty level values between 1-5 include: (1) = focus is low, (2) = focus is low enough, (3) = focus is high, (4) = focus is very high (5) = the focus achieved is absolutely high. The difficulty level is shown in table 9 and the target technical response characteristics shown in table 10 are:

**Table 9. Level of Difficulty**

Difficulty (1=Easy to Accomplish, 5=Extremely Difficult)	5	5	5	4	2	3	2
Max Relationship Value in Column	9	9	9	9	9	9	9
Weight / Importance	556.6	560.4	598.0	456.2	253.6	383.1	290.5
Relative Weight	18.0	18.1	19.3	14.7	8.2	12.4	9.4

**Table 10. Target Characteristics of Technical Response**

Number	Characteristics of Technical Response	Target
1	Improving the quality of vest products that are more ergonomic (effective, safe, healthy, comfortable and efficient)	Adjust to ISO 9001 standards for vest product quality
2	Develop and improve vest product design patterns that can be adjusted by the user	Test the creation of several vest product design options at the customer's request and apply the vest product design to AutoCAD software to be comfortable to use
3	Redesigning features (servo arms, vibrators, charge devices, timer button switches & speedups) and electronic circuits needed	Selection of quality features and electronic circuits
4	Selection of quality material	Choose quality materials at competitive prices
5	Price adjustment with production costs	The minimum number of orders is determined as well as the selection of materials at competitive prices
6	Testing the use of vest-type prototype	Conduct testing of the ability on the prototype before production to determine the quality and input of the user
7	Periodic service & warranty services	Providing periodic warranty & service to keep the product quality of the vest good

The Development Results of the House of Quality (HoQ) shown in Figure 3.

## IV. CONCLUSION

From the results of research conducted on the design of the product development of this vest can be concluded is Quality Function Deployment (QFD) -House of Quality (HOQ) produces 15 items of Product Attributes as consumer needs and 7 technical requirements. The results of priority weights and relative weights, then priority order was set on 7 items based on the value of the weight generated FGD between researchers and the driver (driver car), namely: redesigning features (weight value: 598), developing and improving design patterns (weight value: 560.4), improve the quality of a more ergonomic vest product (weight value: 556.6), quality material selection (weight value: 456.2), test the ability to use vest prototype (weight value: 383.1), warranty service & periodic service (weight value: 290.5), adjusting prices with production costs (weight value: 253.6). The whole series in the process of refining the reflexology vest prototype was adjusted based on the FGD between the researcher and the driver (driver car).

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<div style="display: flex; justify-content: space-between; padding: 5px;"> <div style="width: 45%;"> <b>Demanded Quality</b>                      (a.k.a. "Customer Requirements" or "Whats")                 </div> <div style="width: 55%; text-align: right;"> <b>Quality Characteristics</b>                      (a.k.a. "Functional Requirements" or "Hows")                 </div> </div>	Improving the quality of vest products that are more ergonomic (effective, safe, healthy, comfortable and efficient)	Develop and improve vest product design patterns that can be adjusted by the user	Redesigning features (servo arms, vibrators, charge devices, timer button switches & speed ups) and electronic circuits needed	Selection of quality material	Price adjustment with production costs	Testing the use of vest-type prototype	Periodic service & warranty services
Vest products are able to function (massage) well	○	○	○	○	▲	○	▲
Servo arm massage and vibration can be felt strongly	○	○	○	○	▲	○	▲
Massage can reduce complaints of aches and pains	○	○	○	○	▲	○	▲
Complete massage operation features	○	○	○	○	○	○	○
Battery vest products are easy to charge	○	○	○	○	▲	○	○
Age of use of vest products can last a long time	○	○	○	○	▲	○	○
Prices of affordable vest products	○	○	▲	○	○	○	○
Prices of vest products are in accordance with the quality & benefits	○	○	○	○	○	○	○
Vest product designs are easy to fold and ergonomic	○	○	○	▲	▲	○	○
Vest products are easy to wear	○	○	○	○	○	○	▲
Easy to remove vest products	○	○	○	○	○	○	▲
Good product quality when used	○	○	○	○	○	○	○
Forms of good quality vest product designs	○	○	○	○	▲	○	▲
Comfort of vest material when used	○	○	○	○	▲	○	▲
The results of massage can resolve complaints	○	○	○	○	▲	○	▲

**Figure 1. Results of the Relationship Matrix**

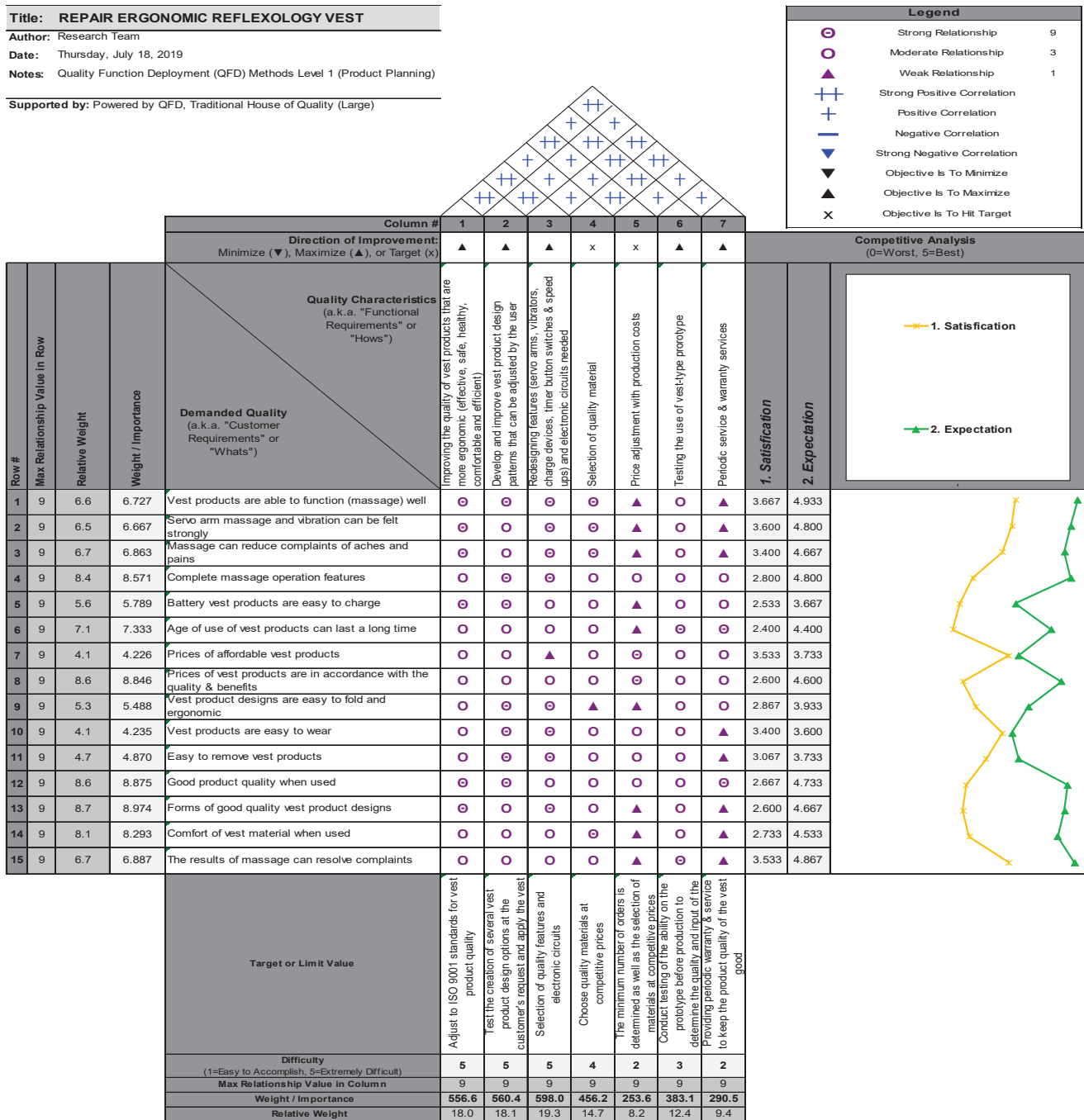


Figure 3. Development Results of the House of Quality (HoQ)