

MULTIFUNCTIONAL DESIGN OF MATTRESS BY USING TRIZ (*TEORIYA RESHENIYA IZOBRETATELKIKH ZADATCH*) AND QFD (*QUALITY FUNCTION DEPLOYMENT*)

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ABSTRACT

At this time the need for the design of a product is increased. Mattress is a necessity for every individual to rest. Preliminary studies of the function of the mattress stated that the use of the existing mattress found complaints (too large 72%, less attractive 40%, 80% less flexible, less comfortable 40%). Therefore, multifunctional mattress is needed. The purpose of this study is to propose a multifunctional design for a mattress. TRIZ method is used to determine the inventive principles of each attribute and QFD method is used to determine the design parameters of the mattress. Functions that can be developed from a mattress are that it can be folded, it can be a sofa / seating, into the table, flexible / easily removable and as the ironing board. The results of this study shows that the multifunctional mattress design was satisfied the customer feeling and emotion.

Keyword : *Mattress, TRIZ, QFD, Design*

1. INTRODUCTION

At this time the need for the design of a product is increased. Mattress is a necessity for every individual to rest. Preliminary studies of the function of the mattress stating that the use of the existing mattress found complaints (too large 72%, less attractive 40%, 80% less flexible, less comfortable 40%). Therefore, multifunctional mattress is needed.

The method which are used in this study are TRIZ and QFD. TRIZ is a problem solving method based on logic and data, not intuition, which accelerates the ability to solve problems creatively. QFD is an attempt by the company in designing and developing products or services in accordance with the voice of customer and combined with the voice of the engineer who is a reflection of the company's technical capabilities to meet the customer requirement.

TRIZ method is used to determine the inventive principles of each attribute and QFD method is used to determine the design parameters of the mattress. The purpose of this study is to propose a multifunctional design for a mattress.

2. RESEARCH METHOD

2.1 Survey

Paper based survey was conducted in this study to identify customer criteria of multifunctional mattress design. Questionnaires were distributed to students boarding in Yogyakarta, which is in the area around the campus which totaled 50. This questionnaire is to identify customer requirement of the mattress, determine the design of the mattress according to customer requirement and validation of the design of the mattress.

2.2 Application of TRIZ

TRIZ is a problem solving method based on logic and data, not intuition that accelerates the ability to solve problems creatively [2]. The procedure for applying

TRIZ are first, select technical problem; second, formulate a physical contradiction; third, formulate an ideal solution; fourth, find resources for the solution, making use of the capabilities of TRIZ; fifth, determine "strength" of the solution and choose the best one; sixth, predict the development of the system considered within; seven, analyze the problem and the solution process in order to prevent similar problems [4]. TRIZ is used to solve the existing problems in the design of this multifunctional mattress.

2.3 Application of QFD

QFD is an attempt by the company in designing and developing products or services in according voice of customer and combined with the voice of the engineer who is a reflection of the company's technical capabilities to meet the customer's wishes [18]. There are four stages in using QFD, first phase of product planning (house of quality), the second stage of the planning component (part deployment), the third stage of the planning process (process deployment), the fourth stage of the planning of production (manufacturing / production planning) [8]. HOQ was used for make the design parameters of the multifunctional mattress.

2.4 Development of The Virtual and Real Prototype

The objective of the development virtual prototyping is to validate physical design parameters of multifunctional mattress which satisfies user's needs. This study was done by showing the virtual design multifunctional mattress rated by users. A qualitative assessment was conducted by questionnaire to validate the virtual prototyping

2.5 Statistical Analysis

The analytical methods used in this research are TRIZ and QFD. TRIZ method is used to analyze about what needs to be done on the multifunctional mattress based on customer requirements. While QFD analyzes on the

design parameters to be used in the design of this multifunctional mattress. Analysis of the homogeneity use Stuart-Maxwell test of marginal homogeneity [16]. Final analysis of the differences between the proposed

product and the product that already exists used Wilcoxon test.

3. RESULT AND DISCUSSION

3.1 Customer Requirements

Table 4.2 5 Percentage of Customer Requirements

No.	Customer Requirements	Total	Percentage
1	Flexible/ foldable	46	92%
2	Chair	42	84%
3	Table	40	80%
4	Portable/ moveable	38	76%
5	Ironing Board	30	60%

3.2 Result of TRIZ

3.2.1 Improving Feature

Table 4.6 Improving Feature

No.	Attribute	Improving Feature
1	Flexible/ foldable	Easy Operation (33)
2	Chair	Shape (12)
3	Table	Shape (12)
4	Portable/ moveable	Volume Of Moving Object (7)
5	Ironing Board	Strength (14)

3.2.2 Worsening Feature

Table 4.7 Worsening feature

No.	Attribute	Worsening Feature
1	Flexible/ foldable	Shape (12)
2	Chair	Quantity Of Substance (26)
3	Table	Length Of Moving Object (3)
4	Portable/ moveable	Weight Of Moving Object (1)
5	Ironing Board	Stability Of The Object Compotition (13)

3.2.3 Matrix of Contradictions

Table 4.8 Contradiction Of Flexible/ Foldable

Improving Feature	Worsening Feature
	Shape (12)
Easy Operation (33)	15, 34, 28

Table 4.9 Contradiction Of Chair

Improving Feature	Worsening Feature
	Quantity Of Substance (26)
Shape (12)	36, 22

Table 4.10 Contradiction Of Table

Improving Feature	Worsening Feature
	Length Of Moving Object (3)
Shape (12)	34, 5, 4

Table 4.11 Contradiction Of Portable/ Moveable

Improving Feature	Worsening Feature
	Weight Of Moving Object (1)
Volume Of Moving Object (7)	2, 26, 40

Table 4.12 Contradiction Of Ironing Board

Improving Feature	Worsening Feature
	Stability Of The Objects Compotition (13)
Strength (14)	13, 17, 35

Table 4.13 Inventive Principles

No.	Attribute	Improving Feature	Worsening Feature	Inventive Principles
1	Flexible/ foldable	Easy Operation (33)	Shape (12)	Dynamics (15) Discarding and Recovering (34) Mechanic Subtitution (28)
2	Chair	Shape (12)	Strength (14)	Phase Transition (36) Blessing in Disguise (22)
3	Table	Shape (12)	Length Of Moving Object (3)	Discarding and Recovering (34) Merging or Combining (5) Asymetry (4)
4	Portable/ moveable	Volume Of Moving Object (7)	Weight Of Moving Object (1)	Taking Out (2) Copying (26) Composite Material (40)
5	Ironing Board	Strength (14)	Stability Of The Object Compotition (13)	The Other Way Round (13) Another Dimension (17) Parameter Changes (35)

3.2.4 Selected Inventive Principles

1. Flexible/ foldable
 - Principle 15. Dynamics
 - B. Dividing an object or system into parts that capable of cooperating against each other.
2. Chair
 - Principle 36. Phase Transition
 - Using a phenomenon that occurs during the transition period (such as changes in volume, the process of disappearing or heat absorption).
3. Table
 - Principle 34. Discarding and Recovering
 - A. Making or removing parts of objects or modify the system or directly modified during surgery.
 - Principle 5. Merging or Combining
 - A. Combining objects or systems that are identical / similar and combining the identical parts to perform parallel operations.
4. Portable/ moveable
 - Principle 26. Copying
 - A. Using an object or a system that much simpler and cheaper.
 - D. Copy the concept of creative services in different industries.
 - Principle 40. Composite Material
 - Changes some of the raw materials used.
5. Ironing Board
 - Principle 13. The Other Way Round
 - A. Reversing the appropriate actions to solve the problem.
 - Principle 17. Another Dimensions
 - C. Reorientation of the object or system or using the other parts of an object or system.

3.3 Result of QFD

3.3.1 House of Quality

Table 4.20 Correlation Matrix Of HOQ

Competitive Assessment	VOC	IR	Using additional frame	Total of fold	Using additional support	Material of frame	Length of mattress	Width of mattress	High of mattress	Additioanl of mattress	Foam of mattress
Flexible/ foldable	1	7	●	○		△					
Chair	2	7	○	○	●						○
Table	3	6	○	○	●						
Portable/ moveable	4	7	●			●	○	○	○		●
Ironing Board	5	6								●	
Target / Goal			Iron frame	3 folds	Plates	1/4 inch iron pipe	2 m	1 m	8 cm	Heat resistant up to 100 ^o C	Foam super
Kepentingan			165	60	117	70	21	21	21	54	84

Table 4.21 Competitive Assessment

Competitive assesment					Goal	Improvement Ratio	Sales Point	Row Weight	Action
1	2	3	4	5					
		○	■		5	1.25	◎	10,5	B
		○	■		5	1.25	◎	10,5	B
		○	■		4.5	1.13	◎	8,1	B
			⊙		4	1.00		7,00	C
	○		■		5	1.25	◎	9,00	B

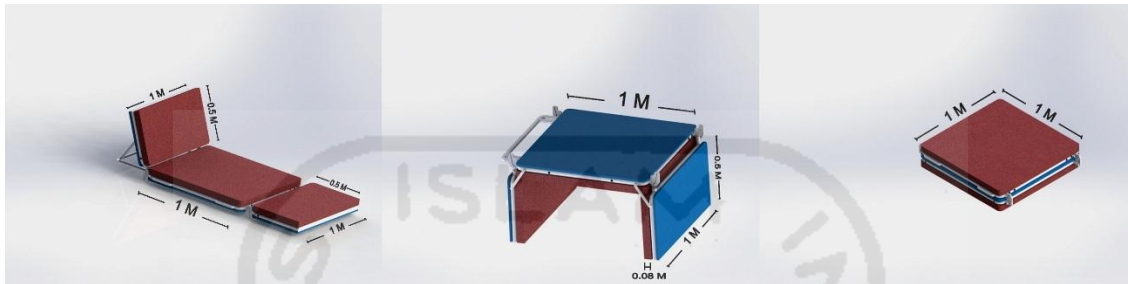


Figure 4.1 Design of Multifunctional Mattress

Multifunctional design of mattress has a size of 2m x 1m x 8cm adapted to the target of processing data using QFD. Materials used framework is ¼ inch iron pipe welded and connected with the joint so that it can be make some form. The foam which is used is the super foam that is not easily deflated and on the ironing board foam heat resistant up to 100°C so it is not easy to melt when used as an ironing board.

3.4 Result of Validation

3.4.1 Homogeneity Test

Validate of multifunctional mattress test by Stuart Maxwell test of Marginal homogeneity. The hypotheses were developed as follows:

H₀: There is no significant difference between the consumer criteria and mattress design

H₁: There is a significant difference between the consumer criteria and mattress design

Table 4.22 Result of Marginal Homogeneity

Attribute	Asymp. Sig. (2-tailed)
Flexible/ foldable	0.109
Chair	0.378
Table	0.197
Portable/ moveable	0.739
Ironing Board	0.622

In Table 4.22, it shows that Asymp column. Sig. (2-tailed) the existing number, all were above 0.05, which means that the proposed design is suitable to the customer requirements of multifunction mattress.

3.4.2 Sign Test

Wilcoxon signed-rank test was used to compare the selected design of multifunctional mattress and the common mattress.

Table 4.23 Hasil Uji Beda Wilcoxon

Attribute	Asymp. Sig. (2-tailed)
Flexible/ foldable	0.000
Chair	0.000
Table	0.000
Portable/ moveable	0.000
Ironing Board	0.000

In Table 4.23 it shows that Asymp column. Sig. (2-tailed) the existing number, all were below 0.05, which means that there is a difference between a regular mattress and mattress multifunctional. The results showed that the respondents chose a multifunctional mattress instead of common mattress.

4. CONCLUSION

Based on the result of this research, concluded as follows:

- Functions that can be developed on a mat in accordance customer requirements of multifunction mattress is flexible / foldable, chair, table, portable / moveable and ironing board.
- Inventive principles of each attribute is
 - Inventive principle which suitable with the attribute of flexible / foldable is principle Dynamics (15) with subprinsip B.
 - Inventive principle which suitable with the attribute of chair is principle Phase Transition (36).
 - Inventive principle which suitable with the attribute of table is principle Discarding and Recovering (34) with subprinsip A, principle Merging or Combining (5) and principle Asymetri (4) with subprinsip A.
 - Inventive principle which suitable with the attribute of portable/ moveable is principle Copying (26) with subprinsip A and subprinsip D, and principle Composite Material (40).

- e. Inventive principle which suitable with the attribute of ironing board is principle The Other Way Round (13) with subprinsip and principle Another Dimension (17).
- Design parameters for the design of multifunctional mattress are frame using ¼ inch iron pipe. Size of this mattress is 2m x 1m x 8 cm. Foam used is foam super quality. On the layer for ironing using foam heat resistant up to 100°C.
 - Marginal homogeneity test result shows that the designs of multifunctional mattress is suitable to the customer requirements with Asymp value. Sig. (2tailed) of the five functions are more than 0.05. Wilcoxon test results showed the difference between multifunctional mattress and common mattress with the value of Asymp. Sig. (2tailed) of the five functions are less than 0.05.

5. REKOMENDATIONS

The future research should investigate more deeply any function that can be developed on a multifunctional mattress and add economic analysis of the multifunctional mattress.

6. REFERENCES

- Al Qur'an
- Barry, K. Domb, E. & Slocum, M.S. 2006. *TRIZ, what is TRIZ?*. TRIZ Journal
- Dian, M.R., Velahyati, A. & Hartati. 2011. Desain Backpack Berdasarkan Analisis Biomekanika Dengan Pendekatan QFD dan TRIZ Untuk Pendaki Wanita. ISBN : 978-979-127255-0-6
- Diegel, O. 2004. *TRIZ*. Creative Industries Conference.
- Firdaus. 2009. Integrasi product Design and Manufacturing dengan Teknologi Informasi dan Komunikasi (TIK). *Jurnal Austenit* Vol. 1 No. 2 : 39-40
- Gadd, K. 2011. *TRIZ for engineers : enabling inventive problem solving*. Online book
- Ginting, M. 2011. Analisa Permasalahan Komponen Tempat Tidur Pasien dengan Metode QFD. *Jurnal Austenit* Vol. 3 No. 2 : 1-7
- Hamrah & Yayah, K. W. 2007. Metode QFD untuk Informasi Penyempurnaan Perakitan Varietas Melon. *Jurnal Agribisnis dan Ekonomi Pertanian* Vol. 1 No. 2 : 49-54
- Ictenbas, B. D & Erylmaz, H. 2011. Quality Function Deployment As A Strategic Planning Tool. *International Journal Of Social Sciences and Humanity Studies* Vol. 3 No. 2 ISSN : 1309-8063 : 73-76
- Ilevbare, I. Phaal, R. Probert, D. Padilla, A.T. 2011. *Integration Of TRIZ And Roadmapping For Innovation, Strategy, And Problem Solving*. Centre For Technology Management, University Of Cambridge, UK.
- Laksmi, A. Partiw, S.G. & Sudiarno, A. 2010. Perancangan Ulang Kompor Bioetanol dengan Menggunakan Pendekatan Metode *Quality Function Deployment (QFD) dan Teoriya Resheniya Izobretatelskikh Zadatch (TRIZ)*. Surabaya : Institut Teknologi Sepuluh Nopember (ITS)
- Prayogo, Y.S., Suryadhini, P.P., Iqbal, M. 2012. Usulan Peningkatan Kualitas Dengan Meminimasi Jumlah Cacat Produk Sprei Di PT Bintang Agung Dengan Menggunakan Metode *Six Sigma* dan *Theory Of Inventive Problem Solving (TRIZ)*. Bandung : Institut Teknologi Telkom Bandung
- Rahman, A. Supomo, H. 2012. Analisa Kepuasan Pelanggan pada Pekerjaan Reparasi Kapal dengan Metode Quality Function Deployment (QFD). *Jurnal Teknik ITS* Vol. 1 No. 1 ISSN : 2301-9271 : 298
- Sari, D.P., Harmawan, A. 2012. Usulan Perbaikan Kualitas Pelayanan Pada Instalasi Rawat Jalan Dengan Metode *Servqual* dan TRIZ. *J@TI Undip* Vol VII No.2
- Sari, Y. 2013. Aplikasi Metode TRIZ Dalam Upaya Perbaikan Kualitas Layanan. Surabaya : Universitas Surabaya
- Sheskin, D. J. 2004. *Handbook of parametric and nonparametric statistical procedure, third edition*. Florida : Chapman and Hall/ CRC Press
- Stratton, R. Mann, D. & Otterson, P. 2000. *The theory of inventive problem solving (TRIZ) and system-a innovation-a missing link in engineering education*. Systematic Innovation
- Sulistyo, H. 2011. Implementasi QFD dalam Meningkatkan Daya Saing Pasar Tradisional. *Jurnal Siasat Bisnis* Vol. 15 No. 2 : 158-160
- Suseno, A., Hartono, M. & Surjani, R.M. 2013. Aplikasi Integrasi *Kansei Engineering* dan Metode TRIZ Pada Layanan Villa Nunia, Bali. *Jurnal Ilmiah Mahasiswa Universitas Surabaya* Vol.2 No.1
- Wiyogo. Surachman. Soenoko, R & Setyanto, N, W. 2013. Integrasi *Servqual* dan Quality Function Deployment untuk Pengukuran Kualitas Layanan. *Jemis* Vol. 1 No. 1 ISSN : 2338-3925 : 21-22
- Zhang, Jun., Kay Chuan Tan, dan Kah Hin Chai, (2003). *40 Inventive Principles with Applications In Service Operation Management*

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