

# Ergonomic Design for Tempe Production Tool Based on User Voice

E W Asih<sup>1</sup>, A Mawadati<sup>1</sup> and N Lestari<sup>1</sup>

<sup>1</sup>Industrial Engineering Department, Faculty of Industrial Technology, AKPRIND Yogyakarta Institute of Science & Technology, Jl. Kalisahak 28 Yogyakarta

Corresponding e-mail: endang.akprind@gmail.com

**Abstract.** The process of tempe production in small industry are considering not optimal yet. The process does not consider the ergonomic aspects and is not environment friendly. It causing complaint at some body parts and pollution. For the solution, this research aims to design a multifunctional tool that considering ergonomic and eco- friendly aspect. The design will be based on Ergonomic and the Quality Function Deployment (QFD) methods. Based on evaluation using the Nordic Body Map, it shows that body parts with the most complaints are the waist, back, neck, right and left shoulder, wrist and leg. Complaints on these body parts are caused by wrong postural when doing work which is not ergonomic. And by using Quality Function Deployment (QFD) the tool designed by considering user expectation and desire. it was found that the user expect for the tool to be made based on worker anthropometry, moved with a semi-manual machine and the tool model is suitable for work. Overall the design shows that the Ergonomic Tempe Maker Tool is a multifunctional tool that easy, flexible, safe and comfortable to be operated which focused on anthropometric size, uses a semi-manual machine and can be arranged up or down.

## 1. Introduction

In one of small industry that produce tempe, the production process performance and work environment are considering not optimal yet. It has low productivity and efficiency. The reason is that production process is not ergonomic and unhealthy. The non-ergonomic production process can be seen at the process of breaking soybeans and overall they have to go back and forth from one process to another, also their waste management process is not environmentally. In the process of breaking soybeans, workers work by bending and squatting (can be seen in Figure 1). Tools used in the process of breaking soybeans are also not in accordance with the dimensions of the body of the worker, so workers must bend to do their work. It can cause pain in the back and neck, as well as the risk of muscle and spinal back disorders.

At the washing and cracking process include a repetition and back and forth process. This process starts by cooking the soybean, then after being boiled in the kitchen the soybean taken to the well for washing, after being washed, then brought back to close to the kitchen for the soybean cracking process. In the process, workers need to go back and forth from the kitchen to the well then returning back to the kitchen, this is done 5 times a day, because for boiling 20 kg they divided it into 5 washing parts, so that the production process becomes long, and cause the results are not optimal (low worker productivity).

In this small industry it also can be seen that the work environment is not environmentally friendly, where the disposal of waste from the washing process is disposed to sewers and river (see Figure 2),



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

which polluting the environment. As a result of environmental pollution, causing air odor, sewers or streams become smelly, and the soil becomes muddy. Pollutants are the amount of pollutant weight in a certain time unit, which is the result of the multiplication of pollutant levels with liquid waste discharge [1]. The parameters used to measure the content of pollutants include BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand),.

To increase the productivity of small-scale industries and reduce the impact of waste, these influential factors must get serious attention from small industry owners, especially factors such as; ergonomic risk factors, awkward posture while working and work layout [2]–[3] and waste. Previous studies have shown that workers in small industries are susceptible to disease due to work posture errors [4–8]. In addition to potentially causing disease, this non-ergonomics work posture and work environment also has the potential to cause productivity to decline. Surely this can affect the output of the business. The problem of increasing productivity is done as an effort to get alternative ways of working that are good, effective, efficient, healthy, comfortable and safe.

A good, efficient and comfortable alternative for small industries Rasimun is making a multifunctional tool that considering the ergonomic and eco friendly aspect [9]. This tool is designed so can be used for washing and cracking the soybeans and the residual liquid can be stored in the container so that can be processed into something useful. For this reason, it is necessary to design a multifunctional tool that can be used for washing, splitting and filtering (to separate soybeans from liquid waste) while being ergonomic and environmentally friendly.



**Figure 1.** Process of cracking soybeans.



**Figure 2.** Disposal of waste in a ditch.

## 2. Methodology

### 2.1 Ergonomics

Ergonomics comes from the word ergo which means work and nomos which means rules, principles or rules. So the word ergonomics means a study of the relationship between humans and their work. In its development, the notion of ergonomics is a term that is widely used in terms of human engineering or human factor, which is a study of interface devices and forms of interaction between humans and objects used with the work environment. By using a more comprehensive approach, ergonomic is carried out through three main things, namely; focus, purpose and ergonomics [10]. The focus of ergonomics is humans and their interactions with products, equipment, facilities, procedures and work environments and daily life. The goal of ergonomics is to increase the effectiveness and efficiency of work, improve safety, reduce fatigue and stress, increase comfort, receive greater user acceptance, improve job satisfaction and improve quality of life. The approach taken in ergonomics is a systematic application of relevant information about abilities, limitations, characteristics, behavior and motivation humans to product design and procedures used for the environment in which they are used.

Based on the above approach, Chaffin summarizes the definition of ergonomics as a science that explores and applies information about behavior, abilities, limitations, and other human characteristics

to design equipment, machinery, systems, jobs and environments to improve productivity, safety, comfort and the effectiveness of human work [11].

Ergonomics also can be define as a systematic branch of knowledge to utilize information about the nature, abilities and limitations of humans to design a work system so that people can live and work in the system by both achieving the desired goals through work effectively, safely and comfortably [12]. In ergonomics, one of the principles that must always be used is the principle of fitting the task / job to man. This implies that work must be adapted to the capabilities and limitations of humans, so that the results achieved can be better. The absence of ergonomist can result in undesirable product design [13]. For the example the tools that be used by the worker in Rasimun. The machine is not made based on the anthropometry and biomechanics of the body of the worker. Thus, there are many complaint regarding pain in the back and neck. In this paper, we develop a new design of tempe production tool that minimize physical discomfort and risk of of muscle and spinal back disorders.

## 2.2 *Quality Function Deployment (QFD)*

Quality Function Deployment (QFD) is a methodology used by companies to anticipate and prioritize consumer needs and desires, and combining the needs and desires of consumers in the product or service provided to consumers [14]. The use of QFD in the product design process will help the management to gain competitive advantage through the process of creating the characteristics and attributes of quality products or services that can increase customer satisfaction. In addition, the implementation of the QFD methodology is also able to guarantee that information on consumer needs obtained in the initial stages of the planning process is applied to all stages of the product cycle, from the design concept, component planning, process and production planning, to the product for consumers.

The key to competitive ability is the ability to respond to challenges in producing a product and / or service quickly [15]. But there are some obstacles for companies to produce products and / or services quickly, such as: low understanding of customer needs, strategic mistakes in determining priorities, the desire to take risks that can be returned, there is a tendency towards the use of designs that are not developing or unable to provide services, determination of specifications that are too high, and the wrong testing scenario in determining the main error. QFD is used for three reasons: to focus on customer need and satisfaction, to save development and design time, also to improve communication in all parts of the organization [16].

Many research has done using QFD as their tool to develop a new product [17–20] or for evaluation of system [21–23]. The use of QFD has also been carried out in research on the design of ergonomic products [13,24,25]. In this study QFD is used to identify the desires and needs of worker regarding the tool they will use at tempe production.

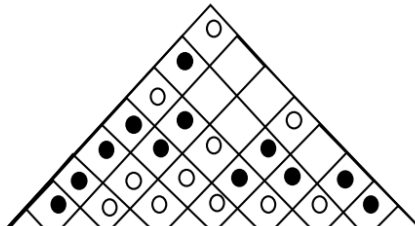
## 3. **Results and Discussion**

This study begin by collecting initial data (qualitative data), was carried out with a questionnaire on workers and home industry owners, with the aim of obtaining questionnaire attributes. Attributes related to the use of tools in the production process, that are ergonomic and environmentally friendly. The questionnaire is divided into 3 parts, namely; section 1 contains the satisfaction of workers on the existing tools used for the production process, part 2 contains the importance of the tool and part 3 contains the complaints of the biomechanical workers on the existing tools. The questionnaires distribut to 25 workers and tempe industry owners.

The results of the questionnaire were calculated using the Importance to Customer value and satisfaction level. This data processing reflects the level of interest of workers on existing indicators based on the questionnaire. Measuring the level of customer satisfaction of product users is obtained based on the results of a questionnaire regarding how far the workers feel satisfied with the quality of the tempe production tool used at this time. Determination of the level of importance and level of satisfaction of worker indicators based on the average value of the weight or answers of respondents in processing the questionnaire.

Ergonomics is a verbal discussion of consumers which is then classified into the primary level. From the primary language, the ergonomic meaning is translated into the level of secondary language, which is easy, flexible, safe, comfortable and of appropriate size. Tertiary language is a sorting and secondary language translation which is a detailed result of the wishes of workers.

The final result of the QFD method is a product development plan. The development plan can be seen in the target value located at the bottom of the House of Quality (HOQ). The QFD method includes complete processes ranging from identifying problems to achieving targeted development projects through the birth of design specifications. For details of the overall results of House of Quality seen in Figure 3.

													
			Technical respond										
			Customer need	Machine	Material Weight	Material Strength	material quality	according to anthropometry	can be move up and down	suitable to work	security		
ERGONOMICS	Easy	Easy to be operated	20	4	16	20	20	12	20				
	Flexible	The ability to be used variously	25		15	15	25	20	25				
		The rotation speed can be adjusted	20	12	16	16	12		16				
		To work standing or sitting	20		12	12	25	25	15				
		Use inside or outside the room	9	15	9	9	15		19				
	Right Size	Easy to be moved (lightweight)	12	15	9	9	15		3				
		match size with body dimensions	25		15	15	25	20					
	Secure	The condition of the tool when used is clean	20		15	15	25		15	25			
		security of equipment when used	12		9	9	9	9	20	20			
	Comfort	Comfort to be used	20			12	25	25	25	15			
Total		183	26	132	132	187	111	148	60				

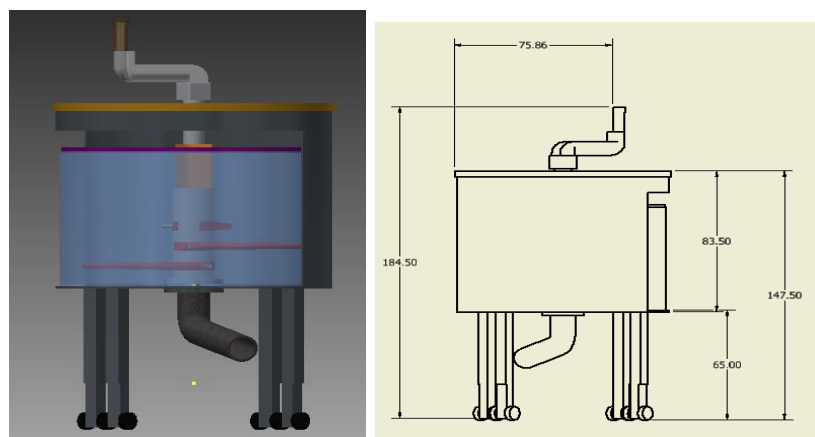
**Figure 3.** House Of Quality .

From the HOQ matrix (house quality) can be known the level of the relationship between the attributes of workers' needs and the characteristics of the technique. Technical characteristics are used to measure or quantify consumer needs that are still qualitative. From the level of importance, it can be seen that the characteristics that have a value of 5, show that the most important thing is that the tool has the ability to use various processes, the condition of the equipment when used cleanly, and its measurement tools according to the dimensions of the human body. The level of importance with a value

of 4, shows that it is very important for workers that the Tempe maker is easy to operate or control and security of use. It is important for consumers that the tool can be used inside or outside the room (can be moved),

In the relationship matrix between the needs of workers with technical characteristics shows workers prefer the tool to be easy to operate, the tool can be used in a variety of tempe making processes namely to wash, break and filter soybeans, convenient tools to use, tools can be used to work standing and or sitting, inside the meaning of the tool can be adjusted worker's work when standing by using a semi-manual machine and the tool can be used comfortably. This can be seen in the largest number found in the relationship matrix. From the target value of Figure 4. HOQ shows that the characteristics of the measurement technique with anthropometry, that is, the size of the tool made by Tempe is based on the anthropometry of workers, has the greatest value. The second biggest characteristic is that the tool is moved by a semi-manual machine and the tool model is in accordance with the work. This shows that the tool that makes ergonomic Tempe is an easy, flexible, safe and comfortable tool when operated focused on anthropometry size, the tool uses a semi-manual machine and the tool can be raised and lowered.

After House of Quality, the next step is design planning. The design phase of the ergonomic Tempe maker design tool starts from the largest target value generated from HOQ (House of Quality). Based on the target value, the order of the technical characteristics that are the top priority is the size of the tool in accordance with anthropometry, the tool is operated by the machine, the equipment can be raised and lowered, the tool must be made of strong material, good quality material and the seat is in accordance with tools and work. At this design, the ergonomic Tempe maker has many functions, such as washing, breaking and filtering soybeans based on priority characteristics as in Figure 3. And the drawing of the design based on QFD can be seen in Figure 4.

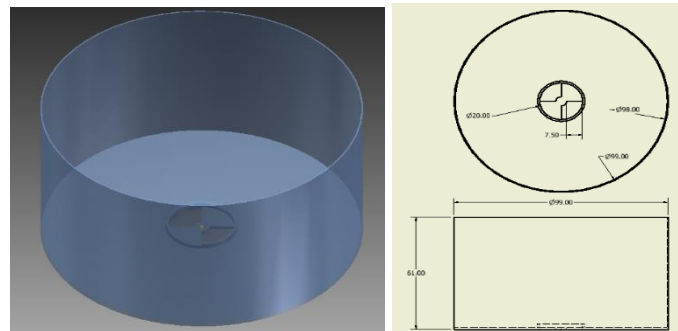


**Figure 4.** Cicahring Tool Design based on HOQ results

Figure 3 is a complete picture of the design product which we called is Cicahring. The design of Cicahring had considered several aspects of ergonomics so that the product is comfortable to be operated. The anthropometric measurement used in this design adjusts the body posture of Indonesian men, Javanese, and age ranges from 20-50 years.

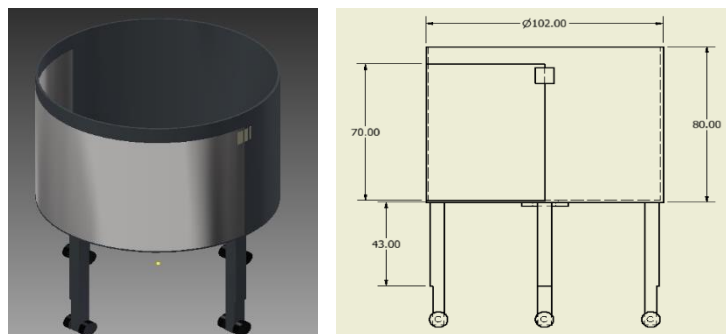
This product consists of 1 core component, 3 subcomponents, and 1 supporting component. Each component is divided again into several components. The core component is a tub component that functions as a container of soybeans and water to be ground. Material used for this component is mild steel so it is easy to move. The diameter for the tub is 98 cm, which is the body dimension of the reach of the hand going forward. This tub has a hole that has function as a drainage center for soybeans after being ground. After the epidermis is separated and the washing water has been

removed, the tub can be removed and the results of the mill are taken. This core component can be seen in Figure 5.



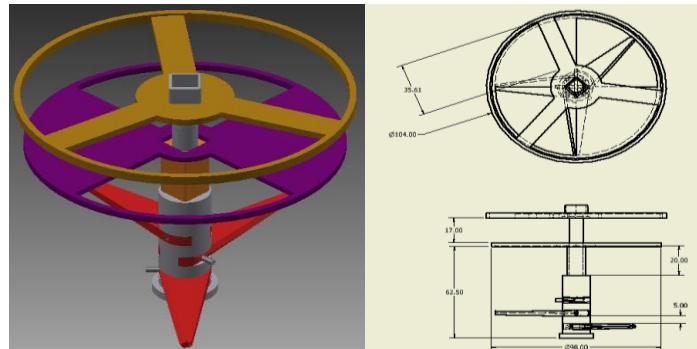
**Figure 5.** Core Component

The subcomponents consist of subcomponent 1, subcomponent 2 and subcomponent 3. Sub component 1 is a container and its grinding blade. In this component there are legs to support the engine load, also wheels so the product could be move easily. The wheel is equipped with a lock to prevent the product from move around being used. This subcomponents 1 can be seen at Figure 6.



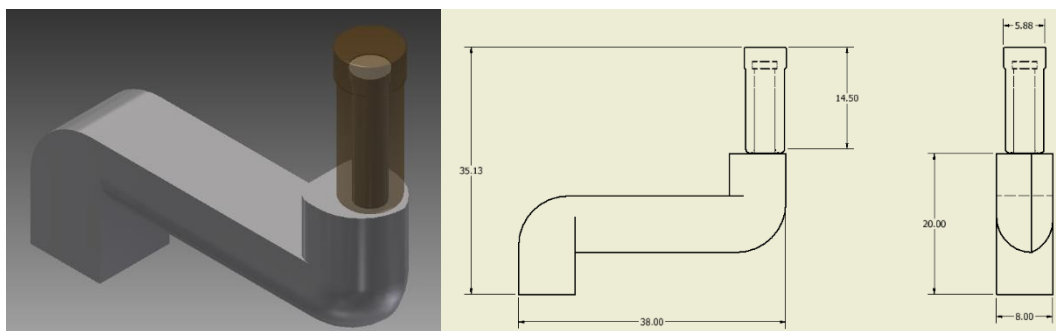
**Figure 6.** Sub Component 1

Sub component 2 is a combination of several components, such as the base of the blade, blade, bolt, filter, filter holder, and cover. At the base of the blade equipped with a rubber that serves as a lock and water barrier to prevent leakage. The blade is adjusted to the height of the filter, which later can be opened after the grinding process is complete. The filter can be opened and closed. During the grinding process the filter is opened, after finished the filter is closed to remove the soybean husk. Then the head of the blade base can be removed thus the blade and filter can be removed. This component can be seen at Figure 7.



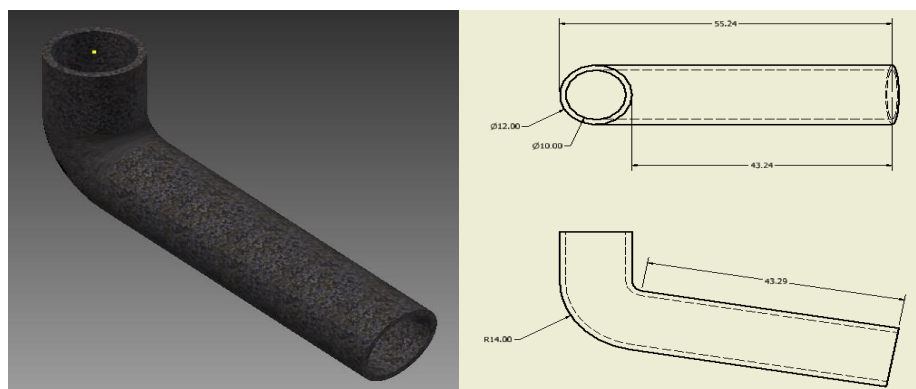
**Figure 7.** Sub Component 2

Sub component 3 is a component that functions as a blade grinder lever. For the length of the grinder lever uses body dimensions shoulder-hand length forward = 61cm, which is the total addition of the radius of the tub plus the length of the lever body. The lever consists of two components, namely the main lever and the hand handle. This subcomponent can be seen at Figure 8.



**Figure 8.** Sub Component 3

Supporting component is additional components used to dispose the disposal water so it does not splatter. This component has a pipe that functions to close and open the channel through the tap. The design of this supporting component can be seen at Figure 9.



**Figure 9.** Additional Component



#### 4. Conclusion

Based on previously discussed outcomes, it can be concluded that:

- i. The results of the questionnaire with Nordic Body Map are that most respondents (85%) stated that work tools can affect work performance. For work posture 76% stated that work posture can affect work performance
- ii. The body parts that have the most complaints are the waist, back, neck, right and left shoulder, wrist and leg. Complaints on the waist and back are caused by postural errors when doing work.
- iii. From the results of the QFD through HOQ the tool designed is a multi-functional tempeh process tool for various processes, namely the process of washing, breaking and filtering ergonomic Cicahring with an easy, flexible, safe and comfortable tool when focused on anthropometric measurements. machine tools, can be used for a variety of processes and tools can be raised and lowered

#### References

- [1] Anon 1999 Surat Keputusan Gubernur no 61
- [2] Asih E and Oesman T 2015 Usulan Perancangan Fasilitas Kerja Yang Ergonomis Guna Meningkatkan Kinerja Pekerja Industri Kecil Mozaik *Proceeding 11th Natl. Conf. Indones. Ergon. Soc.*
- [3] Asih E W, Parwati C I, Widyastuti N, Industri J T, Sains I, Teknologi & and Yogyakarta A 2015 Analisis Produktivitas Pada Proses Penyepuhan dengan Metode Green Productivity *Prosiding IENACO* (Surakarta: Universitas Muhammadiyah Surakarta)
- [4] Mulyati Invironmental Politeknik Kesehatan Kementerian Kesehatan Bengkulu Bengkulu S 2019 *The Relationship Between Work Posture And Musculoskeletal Disorders (Msds) In Laundry Workers In The Area Of Puskesmas Sukamerindu Bengkulu*
- [5] Gde I K, Suarbawa J, Adiputra N, Pangkahila A, Dewa I, Sutjana P, Ketut I and Suarbawa G J 2016 Work Posture Improvement Using Ergonomic Approach Decreases Subjective Disorders of Perapen Workers on the Process of Nguwad Gamelan in Bali *Int. Res. J. Eng.*
- [6] Splittstoesser R E, Yang G, Knapik G G, Trippany D R, Hoyle J A, Lahoti P, Vatan Korkmaz S, Sommerich C M, Lavender S A and Marras W S Spinal loading during manual materials handling in a kneeling posture
- [7] Gangopadhyay S, Ghosh T, Das T, Ghoshal G and Das B 2010 Effect of Working Posture on Occurrence of Musculoskeletal Disorders among the Sand Core Making Workers of West Bengal Postural *Cent Eur J Public Heal.* **18** 38–42
- [8] Vandergrift J L, Gold J E, Hanlon A and Punnett L 2012 Physical and psychosocial ergonomic risk factors for low back pain in automobile manufacturing workers *Occup. Environ. Med.* **69** 29–34
- [9] Asih E W 2009 Perancangan Alat Pemecah Kedelai Yang Ergonomis Dengan Pendekatan Integrasi Model Kano & Quality Function Deployment
- [10] Sanders M and McCormick E 1987 Human factors in engineering and design
- [11] Don B. Chaffin, Gunnar B. J. Andersson B J M 2006 *Occupational Biomechanics* (England: John Wiley and Son Ltd)
- [12] Sitalaksana I, Anggawisastra R and JH Tjakraatmadja 1970 *Teknik tata cara kerja* (Bandung: Jurusan Teknik Industri ITB)
- [13] Marsot J 2005 QFD: A methodological tool for integration of ergonomics at the design stage *Appl. Ergon.* **36** 185–92
- [14] Mazur G 2003 Voice of the customer (define): QFD to define value *Proc. 57th Am. Qual.*
- [15] Cohen L *Quality Function Deployment: How to Make QFD Works for You* (Michigan: Addison Wesley-Publishing Company)
- [16] Akbar R, Noor S and Shah W 2010 Qfd As a Tool for Improvement of Car Dashboard *J. Qual. Technol. Manag.* **VI** 1–22
- [17] Wu X, Hong Z, Li Y, Zhou F, Niu Y and Xue C 2020 A function combined baby stroller design



- method developed by fusing Kano, QFD and FAST methodologies *Int. J. Ind. Ergon.* **75** 102867
- [18] Kuijt-Evers L F M, Morel K P N, Eikelenberg N L W and Vink P 2009 Application of the QFD as a design approach to ensure comfort in using hand tools: Can the design team complete the House of Quality appropriately? *Appl. Ergon.* **40** 519–26
- [19] Moghimi V, Jusan M B M, Izadpanahi P and Mahdinejad J 2017 Incorporating User Values into Housing Design through Indirect User Participation using MEC-QFD Model *J. Build. Eng.* **9** 76–83
- [20] Kurtulmuşoğlu F B and Pakdil F 2017 Combined analysis of service expectations and perceptions in lodging industry through quality function deployment *Total Qual. Manag. Bus. Excell.* **28** 1393–413
- [21] Pramanik D, Halder A, Mondal S C, Naskar S K and Ray A 2017 Resilient supplier selection using AHP-TOPSIS-QFD under a fuzzy environment *Int. J. Manag. Sci. Eng. Manag.* **12** 45–54
- [22] Cebi S, Ozkok M and Demirci E 2014 Evaluation of Design Parameters for Vessel Engine Room by Using A Modified QFD Technique *J. Mult. Log. Soft Comput.* **23** 559–87
- [23] Bulut E, Duru O and Huang S T 2018 A multidimensional QFD design for the service quality assessment of Kansai International Airport, Japan *Total Qual. Manag. Bus. Excell.* **29** 202–24
- [24] Hashim A M and Dawal S Z M 2012 Kano Model and QFD Integration Approach for Ergonomic Design Improvement *Procedia - Soc. Behav. Sci.* **57** 22–32
- [25] Zadry H R, Rahmayanti D, Susanti L and Fatrias D 2015 Identification of Design Requirements for Ergonomic Long Spinal Board Using Quality Function Deployment (QFD) *Procedia Manuf.* **3** 4673–80