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Research Paper

Application of Quality Function Deployment in Customer Oriented Footwear Development Process

Hailu Beyecha Deti*, Habtamu Beri, Biftu Hailu, Kemal Temam

Mechanical Engineering Department, School of Mechanical, Chemical & Materials Engineering, Adama Science and Technology University, P.O. Box: 1888, Adama, Ethiopia

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Abstract

The main purpose of this study was to develop the house of quality in footwear development process. The study was conducted using quantitative research method. Both primary and secondary data sources were used. The primary data sources were sampled using purposive sampling method. The tools used for collecting the data were informant interview and questionnaire. The secondary data were collected from previous research outputs that are related to the application of quality function deployment in footwear development process. The collected data were analyzed using Microsoft Excel 2016 and QFD Capture Professional Edition 4.2.20. The analysis results revealed that the footwear produced by Ethiopian companies fared below par in comparison to the footwear produced by Chinese and European companies in terms of customer and technical perspectives. Therefore, Ethiopian footwear manufacturing companies shall use the prioritized customer and technical requirements in order to develop customer oriented footwear.

1. Introduction

Nowadays, manufacturing industries, particularly footwear manufacturing industries are operating in a very competitive and dramatically changing environment (United Nations, 2018; Alina and Alexandra, 2018). In order to survive in such an environment, the industries have to develop a better-quality product with a reasonable cost and faster delivery time (Alina and Alexandra, 2018). For improving quality, reducing cost and shortening delivery time of a product, manufacturing industries were using different quality techniques (Radej et al., 2017). Among the techniques, Quality Function Deployment (QFD) was the one that was used by many industries throughout the globe in order to enhance customer satisfaction (Eshan, 2012; Alina and Alexandra, 2018; Chatree et al., 2012). According to Niguss Haregot and Kassu Jilcha (2019), firms can improve quality of products, minimize costs and shorten product development time through the introduction of QFD.

QFD is an engineering method used to improve quality by considering the voice of the customer (or customer requirements) in the product development process, according Akao (1990), the founder of QFD. Moreover, QFD is a method used to transform customer demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process (Eshan, 2012). Additionally, QFD is a technique

*Corresponding author, e-mail: beyechahailu@yahoo.com

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used to improve quality of a product by focusing on the requirements of the customer. QFD is further used to translate customer requirements into technical requirements of the product by considering benchmarks and regulatory standards (Fiorenzo and Domenico, 2018). QFD is also considered as a method that is used by applying a graphic model named as House of Quality, HoQ (Akao, 1990; Karin and John, 1996; Anusha, 2010; Sanchit and Vivek, 2015). The HoQ is a type of conceptual map that offers the means for inter-functional planning as well as communications during the product development process (Praveen, 2016). Moreover, HoQ is a QFD tool that is used to identify customer requirements and determine technical requirements in order to satisfy customer requirements.

On the contrary, QFD has not been well introduced to the Ethiopian industries yet (Niguss Haregot and Kassu Jilcha, 2019). As a result, the industries are less competitive in the local and global markets due to poor product quality and high product cost (Niguss Haregot and Kassu Jilcha, 2019). Therefore, this is the rationale for delving into the study as it is high time to introduce customer oriented footwear development process through the application of QFD.

2. Methodology

In this study, a quantitative research method had been employed. Both primary and secondary data were collected and used in order to conduct the study. The primary data were collected through informant interview and questionnaire. The informant interview was used to identify customer requirements with regard to footwear from potential customers and lead sellers at different areas of Adama city such as 'Amede', 'Franko' and 'Mebrat Hail'. The questionnaire was used to determine the importance to customer and customer competitive assessment from the respondents' point of view. The respondents were selected purposively based on their experiences of using footwear made in Ethiopia, China and Europe. Additionally, the secondary data were collected so as to account for the regulatory standards of footwear development process. The secondary data were obtained from different literatures and previous research outputs such as journals, periodicals and articles.

The scale used for the design of the questionnaire is the Likert Scale (Ankur et al., 2015) with the range from one (1) to five (5); one (1) stands for the very low importance and five (5) for the very high importance. The questionnaire was distributed to the purposively selected permanent workers of Adama Science and Technology University (ASTU). Currently, there are about 2,222 permanent workers in ASTU (IRCCD, 2020). Therefore, the sample size of the respondents was determined by using simple random sampling method with the Slovin's formula (Equation 1) (Thomas, 2013):

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

where, n = sample size, N = total population and e = sampling error at 90% level of confidence.

Therefore, $n = \frac{2,222}{1+2,222(0.1)^2} = 96$

As a result, 120 questionnaires were distributed to the respondents and finally 99 questionnaires were properly filled and returned from the respondents. Thus, the response shows that the data were strongly reliable at 90% level of confidence.

With regard to the demographic characteristics of the respondents, nearly 96% of the respondents were male respondents and the remaining 4% were female respondents. Additionally, the age range of the respondents was varying from 26 – 59 years of age with their education level of 35%, 54% and 11% that stand for first degree, second degree and third degree, respectively.

Then after, the data obtained from the questionnaire were analyzed and presented by using the House of Quality (HoQ) technique, the main analytical technique used in the QFD (Yoji Akao, 1990). In HoQ, customer requirements are translated into technical requirements by considering the regulatory standards of footwear development process. Therefore, QFD Capture Professional Edition 4.2.20 was used to construct the results of the study based on the steps that required for the development of the HoQ (Praveen, 2016; Alina and Alexandra, 2018). Additionally, Microsoft Excel 2016 was used to determine the average and percentage results of the study through descriptive statistical analysis method.

3. Results and discussion

3.1. Determination of Customer Requirements

Four primary and twenty secondary customer requirements were generated based on the responses of the customers and lead sellers of footwear that were made in Ethiopia, China and Europe. Furthermore, the average importance to customer and customer competitive assessment were determined from the responses of the respondents by approximating the digits below 0.5 to the lower full number and higher 0.5 to the next full number with the range from 1 to 5. The comparative percentage of the primary customer requirements was also determined among the primary customer requirements and the competitors as shown in Table 1.

Table 1 shows the list of customer requirements with the average results of the importance to customer and customer competitive assessment of footwear that were made in Ethiopia, China and Europe. In the importance to customer, the primary customer requirements such as performance, comfort, appearance and availability weighs the value of 25.71%, 25.58%, 24.36% and 24.36%, respectively. In the customer competitive assessment, European footwear weighs the highest value in most of the primary customer requirements such as comfort, appearance and performance with 40.00%, 39.58% and 37.50%, respectively. However, Chinese and Ethiopian footwear weigh the same higher value in the case of availability with 34.78%. Moreover, Ethiopian footwear weighs higher value (33.65%) in the case of performance when compared with the Chinese footwear that weighs lower value (28.85%).

Table 1: Customer requirements, importance to customer and customer competitive assessment

#	Customer requirements		Average importance to customer (1 – 5)	Average customer competitive assessment		
	Primary	Secondary		Ethiopia (1 – 5)	China (1 – 5)	Europe (1 – 5)
1	Comfort	Soft and flexible	4	3	4	5
2		Allow free movement	4	4	4	5
3		Good fit on foot	5	4	4	5
4		Thermal comfortability	4	3	3	5
5		Light weight	4	3	4	4
Comparative percentage			25.58%	28.33%	31.67%	40.00%
6	Performance	Durable	4	4	3	5
7		Good adhesion of outsole	4	4	3	5
8		Not fabric fungi problem	5	4	3	5
9		Not make skin irritation	5	3	3	4
10		Protection against hazards	4	4	3	4
11		Slip resistance	4	4	3	4
12		Easy to lock and unlock	4	4	4	4
13		Easy to don/doff	4	4	4	4
14		Easy to polish	4	4	4	4
Comparative percentage			25.71%	33.65%	28.85%	37.50%
15	Appearance	Fashionable	4	3	4	5
16		Good look	4	3	4	5
17		Nice finish	4	4	4	5
18		Wide colour range	4	3	4	4
Comparative percentage			24.36%	27.08%	33.33%	39.58%
19	Availability	Wide size range	4	4	4	4
20		Reasonable price range	4	4	4	3
Comparative percentage			24.36%	34.78%	34.78%	30.43%

Table 2: Target value and sales point of customer requirements

#	Customer requirements		Target value (1 – 5)	Sales point (1 – 2)
	Primary	**Secondary**		
1	Comfort	Soft and flexible	4	2
2		Allow free movement	5	2
3		Good fit on foot	5	2
4		Thermal comfortability	4	2
5		Light weight	4	2
Comparative percentage			24.13%	27.38%
6	Performance	Durable	5	2
7		Good adhesion of outsole	5	2
8		Not fabric fungi problem	4	1.5
9		Not make skin irritation	4	2
10		Protection against hazards	4	1.5
11		Slip resistance	4	2
12		Easy to lock and unlock	5	1
13		Easy to don/doff	4	1
14		Easy to polish	4	1
Comparative percentage			23.77%	21.29%
15	Appearance	Fashionable	5	2
16		Good look	5	2
17		Nice finish	5	2
18		Wide colour range	5	2
Comparative percentage			27.42%	27.38%
19	Availability	Wide size range	5	2
20		Reasonable price range	4	1.5
Comparative percentage			24.68%	23.95%

The target value of customer requirements was determined by approximating the digits below 0.5 to the lower full number and higher 0.5 to the next full number with the range from 1 to 5. Moreover, the sales point of customer requirements was also determined with the range from 1 to 2. The comparative percentage of the primary customer requirements was also determined among the primary customer requirements as shown in Table 2.

Table 2 shows the results of the target value and sales point of customer requirements that determined by considering the need of customers. This table also shows that the primary customer requirements such as appearance, availability, comfort and performance weighs the percentage target value of 27.42%, 24.68%, 24.13% and 23.77%, respectively. Moreover, the primary customer requirements such as appearance, comfort, availability and performance weighs the percentage sales point of 27.38%, 27.38%, 23.95% and 21.29%, respectively.

3.2. Determination of Technical Requirements

Customer requirements were properly translated into technical requirements through brainstorming and reviewing different literatures of footwear development process (Siriphan and Nopadon, 2012; Suzana et al., 2020; Adul and Thanin, 2020; Lucie et al., 2020; Salto, 2016; Bitlisli et al., 2013; Muhammed et al., 2012). Accordingly, three primary and twenty secondary technical requirements were generated. Moreover, the average degree of difficulty, target value and technical competitive assessment were determined by approximating the digits below 0.5 to the lower full number and higher 0.5 to the next full number with the

range from 1 to 5. The comparative percentage of the primary technical requirements was also determined among the primary technical requirements and the competitors as shown in Table 3.

Table 3 shows the technical requirements and the results of the degree of difficulty, target value and technical competitive assessment of footwear that made in Ethiopia, China and Europe. The degree of difficulty for the primary technical requirement such as manufacturing, materials and design weighs 34.01%, 33.33% and 32.65%, respectively. The target value for the primary technical requirement such as manufacturing, materials and design weighs 34.60%, 33.20% and 32.16%, respectively. In the case of technical competitive assessment, European footwear weighs the highest value for the primary technical requirement such as design, materials and manufacturing with 44.87%, 44.78% and 41.67%, respectively. Chinese footwear weighs the intermedium value for the primary technical requirement such as design, materials and manufacturing with 37.18%, 35.82% and 33.33%, respectively. Ethiopian footwear weighs the lowest value for the primary technical requirement such as manufacturing, materials and design with 25.00%, 19.40% and 17.95%, respectively.

3.3. Development of QFD Model

QFD model of footwear development process was developed using QFD Capture Professional Edition 4.2.20 based on the results of the customer and technical requirements of the study as discussed in the Figures 1 to 4.

Table 3: Technical requirements, degree of difficulty and technical competitive assessment

#	Technical requirements		Degree of difficulty (1 – 5)	Target value (1 – 5)	Technical competitive assessment		
	Primary	Secondary			Ethiopia (1 – 5)	China (1 – 5)	Europe (1 – 5)
1	Design	Lasting and sewing design	3	4	3	4	5
2		Sewing pathway design	4	3	2	3	5
3		Locking system design	3	4	3	4	5
4		Style and colour design	3	4	2	5	5
5		Shape and size design	3	4	2	5	5
6		Sole tread design	4	3	1	4	5
7		Water and air permeability design	4	4	1	4	5
Comparative percentage			32.65%	32.16%	17.95%	37.18%	44.87%
8	Materials	Upper materials	3	4	3	4	5
9		In-sock materials	3	4	2	4	5
10		Insole materials	3	4	2	4	5
11		Outsole materials	4	3	1	4	5
12		Lining materials	4	4	3	4	5
13		Adhesive materials	4	4	2	4	5
Comparative percentage			33.33%	33.20%	19.40%	35.82%	44.78%
14	Manufacturing	Preparation	3	4	3	4	5
15		Coupling and moulding	3	4	3	4	5
16		Tacking and trimming	4	4	3	4	5
17		Scouring and roughing	4	4	3	4	5
18		Ironing and lasting	3	4	3	4	5
19		Gluing and attaching	4	4	3	4	5
20		Finishing	4	4	3	4	5
Comparative percentage			34.01%	34.60%	25.00%	33.33%	41.67%

Figure 1 shows that there was a strong, moderate and weak relationship between the customer and technical requirements.

Standard 9-3-1		Lasting and sewing design	Sewing pathway design	Locking system design	Style and colour design	Shape and size design	Sole tread design	Water and air permeability design	Upper materials	In-sock materials	Insole materials	Outsole materials	Lining materials	Adhesive materials	Preparation	Coupling and moulding	Tacking and trimming	Scouring and roughing	Ironing and lasting	Gluing and attaching	Finishing
Strong ● 9.0		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Moderate ○ 3.0																					
Weak △ 1.0																					
Soft and flexible	1	○	●	●	△			○	●	○	○	●	△			●					○
Allow free movement	2	△		○		○	△		○	△	△	○				○				○	○
Good fit on foot	3	○	○	△	○	△				△	△	○			○		○		●		
Thermal comfortability	4	△						●		△	△	●				△	○	△			
Light weight	5					△	△	△		△	○	△			●		△	○			
Durable	6		△		○		○		●		●		●							●	●
Good adhesion of outsole	7	●	●											●						○	○
Not fabric fungi problem	8				△			○						△							
Not make skin irritation	9	○				●		○		○		○									
Protection against hazards	10		△	○	○		△	○	●		△		●				○				○
Slip resistance	11		△			△	●	○												○	
Easy to lock and unlock	12	●		●	△	△												○			
Easy to don/doff	13	○		○	○	△				△											
Easy to polish	14	△	△			△			○		△	○		△	○				○		●
Fashionable	15	●	●	○	●	●	○	○		○					○	○		○			
Good look	16	●	●	○	●	●	○	○		○					○	○		○		△	
Nice finish	17	●	●	○	○		○	○		○		○	○	○	○	○		○	○		●
Wide colour range	18				●				●			●				●					
Wide size range	19				△	●					△	○									
Reasonable price range	20	△	△		△	△	△			○	△										

Figure 1: QFD results of relationship matrix, where, the (●) symbol stands for strong relationship, the (○) symbol stands for moderate relationship, the (Δ) symbol stands for weak relationship and the blank space stands for insignificant relationship between customer and technical requirements.

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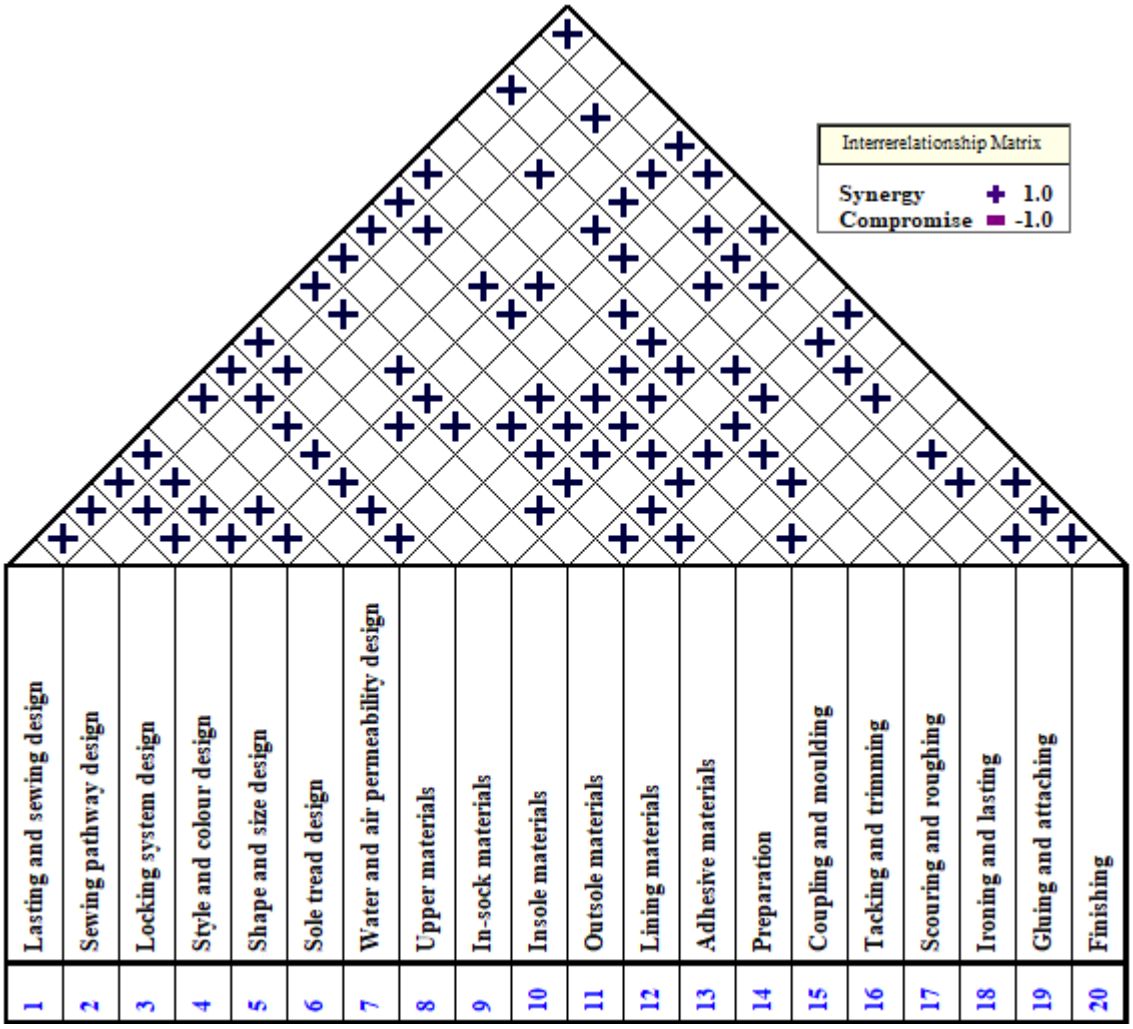

Figure 2: QFD results of interrelationship matrix, where, the (+) sign stands for synergetic interrelationship, the (-) sign stands for compromise interrelationship and the blank space stands for insignificant interrelationship between technical requirements.

Figure 2 shows that there was almost a synergy interrelationship between the technical requirements.

Figure 3 shows the results of customer competitive assessment. Customer requirements (WHATs) such as good fit on foot, not make skin irritation, fashionable, good look and wide color range weighs the highest percent of importance rate with 6.9%, 6.9%, 6.4%, 6.4% and 6.4%, respectively.

		Importance of the WHATs	Ethiopia	China	Europe	Target Value	Improvement Factor	Sales Point	Overall Importance	Percent Importance	Max = 6.9 Percent Importance Min = 2.3	
		1	1	2	3	4	5	6	7	8		
Soft and flexible	1	4.0	3.0	4.0	5.0	4.0	1.2	2.0	9.6	5.5		1
Allow free movement	2	4.0	4.0	4.0	5.0	5.0	1.2	2.0	9.6	5.5		2
Good fit on foot	3	5.0	4.0	4.0	5.0	5.0	1.2	2.0	12.0	6.9		3
Thermal comfortability	4	4.0	3.0	3.0	5.0	4.0	1.2	2.0	9.6	5.5		4
Light weight	5	4.0	3.0	4.0	4.0	4.0	1.2	2.0	9.6	5.5		5
Durable	6	4.0	4.0	3.0	5.0	5.0	1.2	2.0	9.6	5.5		6
Good adhesion of outsole	7	4.0	4.0	3.0	5.0	5.0	1.2	2.0	9.6	5.5		7
Not fabric fungi problem	8	5.0	4.0	3.0	5.0	4.0	1.0	1.5	7.5	4.3		8
Not make skin irritation	9	5.0	3.0	3.0	4.0	4.0	1.2	2.0	12.0	6.9		9
Protection against hazards	10	4.0	4.0	3.0	4.0	4.0	1.0	1.5	6.0	3.4		10
Slip resistance	11	4.0	4.0	3.0	4.0	4.0	1.0	2.0	8.0	4.6		11
Easy to lock and unlock	12	4.0	4.0	4.0	4.0	5.0	1.2	1.0	4.8	2.7		12
Easy to don/doff	13	4.0	4.0	4.0	4.0	4.0	1.0	1.0	4.0	2.3		13
Easy to polish	14	4.0	4.0	4.0	4.0	4.0	1.0	1.0	4.0	2.3		14
Fashionable	15	4.0	3.0	4.0	5.0	5.0	1.4	2.0	11.2	6.4		15
Good look	16	4.0	3.0	4.0	5.0	5.0	1.4	2.0	11.2	6.4		16
Nice finish	17	4.0	4.0	4.0	5.0	5.0	1.2	2.0	9.6	5.5		17
Wide colour range	18	4.0	3.0	4.0	4.0	5.0	1.4	2.0	11.2	6.4		18
Wide size range	19	4.0	4.0	4.0	4.0	5.0	1.2	2.0	9.6	5.5		19
Reasonable price range	20	4.0	4.0	4.0	3.0	4.0	1.0	1.5	6.0	3.4		20

Figure 3: QFD results of customer competitive assessment

Figure 4 shows the results of technical competitive assessment with maximize direction of improvement. In the case of percent of importance, the technical requirements (HOWs) such as lasting and sewing design, sewing pathway design, shape and size design, style and color design, and outsole materials weighs the highest rate 9.6%, 9.1%, 8.1%, 7.9% and 7.7%, respectively.

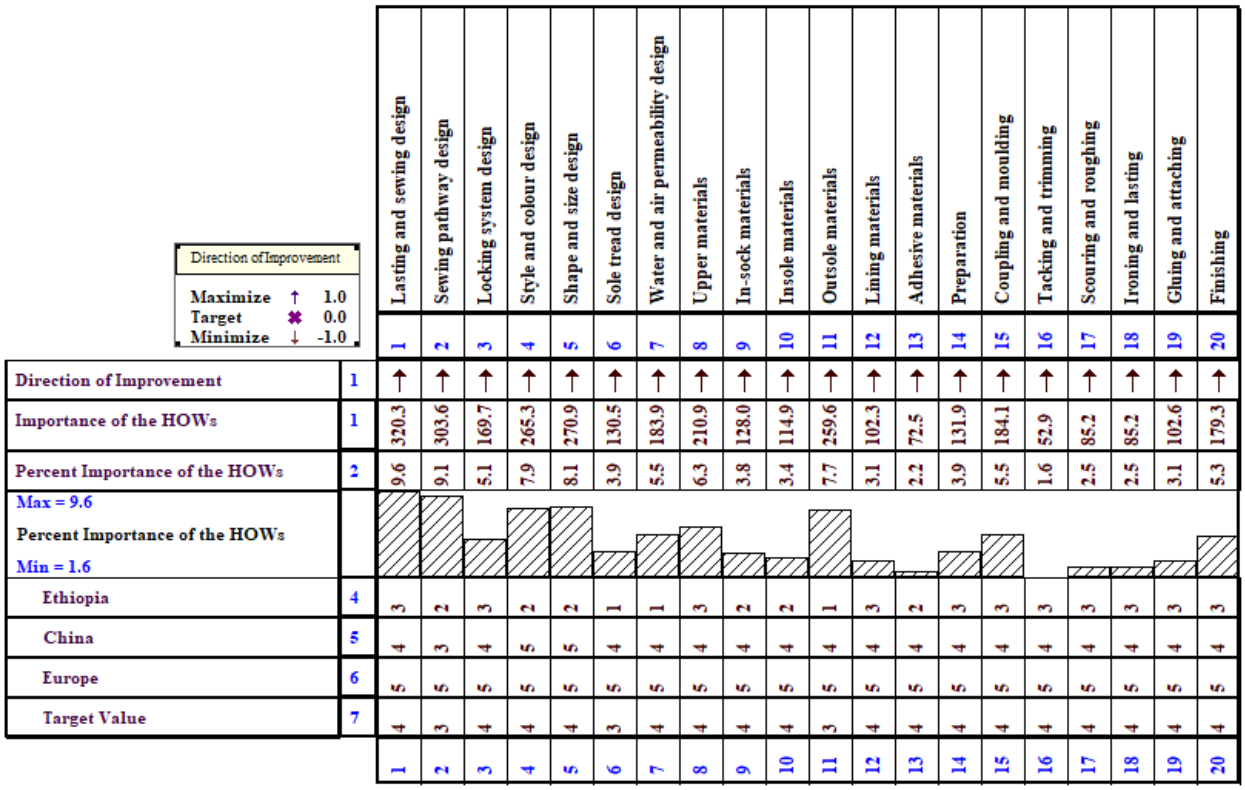

Figure 4: QFD results of technical competitive assessment

4. Conclusion

This study deals with footwear development process using quality function deployment to meet customer requirement. The findings of this study made it evident that quality function development is a superb technique that can help to deal with every aspect of footwear development process. Thus, several customer and technical requirements were generated with regard to footwear development process based on the data collected from the respondents and different literatures. Additionally, potential values such as customer competitive assessment, importance to customer, target value, sales point, degree of difficulty and technical competitive assessment were determined.

The result of the analysis of the customer and technical requirements show that the footwear that were made in Ethiopia had lower value when compared with the value of the footwear that were made in China and Europe except in the case of performance and availability. In the case of QFD model, the customer and technical requirements with the higher percentage of importance (6.9% and 9.6%, respectively) demand higher attention in the development process of footwear in comparison with that of the lower percentage of importance (2.3% and 1.6%, respectively).

As such, the study shows that Ethiopian footwear needs quality improvement in order to satisfy both the customer and technical requirements. As a result, Ethiopian footwear manufacturing companies shall strive more in order to cope up with Chinese and European footwear manufacturing companies. Therefore, the researchers would like to recommend the introduction of quality function deployment, which has been a proven technique for maintaining the quality of footwear development process. Hence, concerned stakeholders shall use the prioritized customer and technical requirements in customer oriented footwear development process.

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