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Case Study on Fuzzy Blitz Quality Function Deployment

Eslam A. Nawar[1], Soheir H. Backar[2], Mohamed A. El-Dardiry[3]

[1]*Master's Student, Production Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt*

[2]*Assisstant Professor, Production Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt*

[3]*Emeritus, Production Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt*

Abstract

Organizations strive to develop their products in a way that fulfills customers' requirements and increases their satisfaction. The traditional Quality Function Deployment (QFD) is a popular technique for that purpose but it has some drawbacks. To tackle these drawbacks, the researchers will implement Blitz QFD a modern model of the traditional one and integrate it with fuzzy logic through a case study on the development of a cargo tricycle. This model provides a leaner approach that captures the most critical requirements of customers in order to implement them and provides more reasonable values as a result of using fuzzy logic.

Keywords

Quality Function Deployment (QFD); Analytical Hierarchy Process (AHP); Fuzzy logic; Product development

1. Introduction

Quality Function Deployment (QFD) is a mechanism that translates customer requirements into engineering characteristics (Akao & Mazur, 2003). Its objective is to better understand what customer really wants and offer a product or service that exceeds his or her expectation.

In 1972, QFD was originated at Mitsubishi's Kobe shipyard in Japan and its first guidelines was introduced by Akao in the same year. By 1977, QFD became a key procedure for Toyota and other Japanese firms used it such as Daihatsu. In 1984 the technique was introduced to the western world where many companies like General Motors and Motorola started to use it (Evans & Lindsay, 1999). It was not until 2015 when the International Organization for Standardization (ISO) published the first standard dedicated for this technique (ISO 16355-1 General principles and perspectives of Quality Function Deployment (QFD), 2015).

Researchers have reported many various advantages of the traditional QFD but the most agreed are that it is a preventive technique as it reduces the number of engineering changes required by better understanding customer requirements prior to manufacturing phase (Jaiswal, 2012). This advantage leads directly to other two advantages which are reducing product development time and lowering start-up costs. Toyota is the most famous example

for assuring these advantages. As between 1977 and 1979, Toyota's start-up costs were reduced by 20 percent, following by 38 percent reduce by 1982. Also, development time was reduced by one-third by 1982.

However the advantages of the traditional QFD, it has some drawbacks, some of the reported are that it requires a long time to be developed which is not suitable for today's rapid change of technology and therefore change of customer requirements. Also, it converts customer voice into specific rigid values which is not very suitable for human reasoning (Jaiswal, 2012).

In order to tackle these drawbacks, the researchers will propose a model built on a modern model of QFD called Blitz QFD which aims to introduce lean thinking and thus shorten the development time.

Blitz QFD was first introduced by Zultner in the mid-1990 to provide a faster approach to the traditional QFD (Zultner, 1997). The main improvements are improving efficiency and speed of analysis by tracking only a small number of the most critical customer needs and prioritizing them using some methods like Analytical Hierarchy Process (AHP) (Mazur, 2012) (Saaty, 1990).

Some researchers integrate Fuzzy Logic to the model in order to translate customer voice into more suitable values (Lie, Chen, Zhou, & Yi, 2016). Fuzzy logic was introduced by Zadeh in 1965 as a mathematical technique to deal with uncertainty and to be able to interpret human reasoning (Zadeh, 1996).

Figure 1 shows the researchers proposed model which is based on the Blitz model. This model will be the blueprint of implementing the case study and the rest of the research.

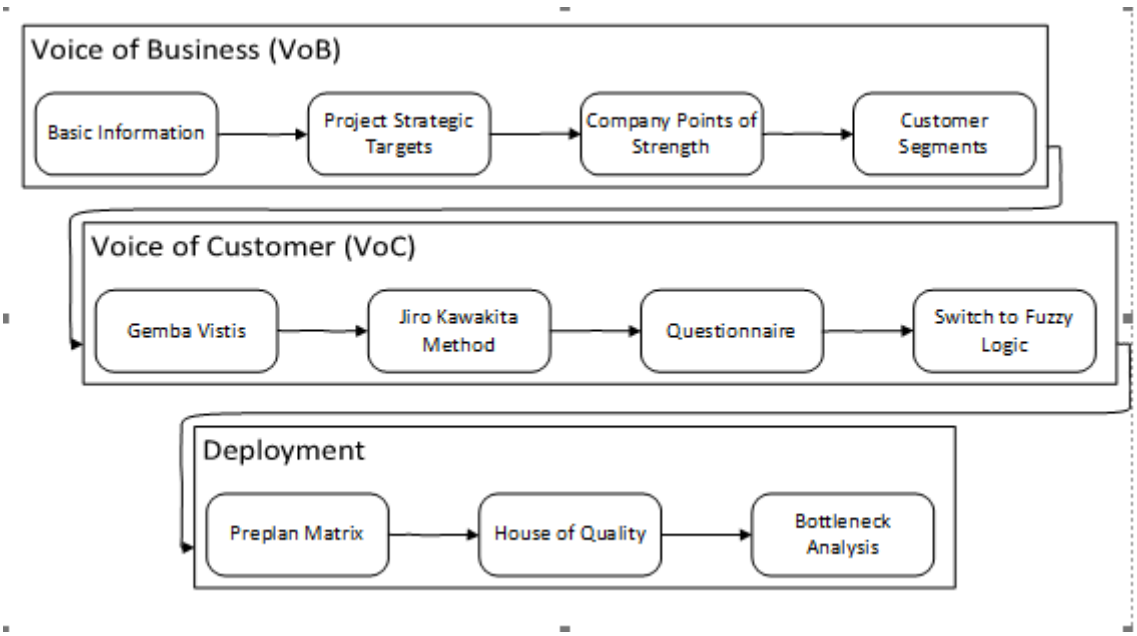

Figure 1. Proposed Blitz Quality Function Deployment Model

2. Case Study

One of the differences between the traditional QFD and the Blitz is the determination of Voice of Business (VoB) as a first step of the model which usually consists of basic information about the company and the product of study, project targets, company points of strength and customer segments (Mazur, 2012).

The steps of the integration between Blitz QFD and Fuzzy Logic are implemented through a case study taken form an Egyptian business company. The company is specialized in manufacturing automotive parts, and manufacturing and assembling tricycles.

The first step in Blitz QFD is the identifying the strategic targets as shown in Table 1. The targets were prioritized by using AHP.

Table 1 AHP strategic targets matrix

			Strategic Targets								Absolute weight	Priority
			A	B	C	D	a	b	c	d		
			Localize components	Increase capacity	Expand the market	Standardize the design	Normalized assessment					
Strategic Targets	1	Localize components	1	3	3	9	0.56	0.5	0.58	0.45	2.09	52.25%
	2	Increase capacity	0.33	1	1	5	0.19	0.17	0.19	0.25	0.8	20%
	3	Expand the market	0.33	1	1	5	0.19	0.17	0.19	0.25	0.8	20%
	4	Standardize the design	0.11	1	.2	1	0.06	0.17	0.04	0.05	0.32	8%
∑			1.77	6	5.2	20	1	1	1	1	4	100%

Types of customers are identified as: long term retailers, short term retailers, government and end user. By using ISM, customer segments were prioritized as shown in Table 3.

Table 2 Core competence matrix

			Priority	Competition strengths				Total
				A	B	C	D	
				Technical experience	Reliable suppliers	Large facility space	Standard processes	
Strategic Targets	1	Localize components	52.25%	9	3	9	1	
	2	Increase capacity	20%	3	3	9	3	
	3	Expand the market	20%	3				
	4	Standardize the design	8%	3		1	9	
Absolute weight				6.14	2.17	6.58	1.84	16.74
Strength Priority				36.70%	12.95%	39.33%	11.01%	100.00%

The next step is to identify the company's core competencies. By using Independent Scoring Method (ISM) (Maritan, 2015), the competencies were prioritized as shown in Table 2.

Table 3 Customer segment matrix

			Priority	Competition strengths				Total
				A	B	C	D	
				Long term retailers	Short term retailers	Government	End user	
Strategic Targets	1	Technical experience	36.70%	3	3	9	3	
	2	Reliable suppliers	12.95%	9	9	3	1	
	3	Large facility space	39.33%	9	3	1		
	4	Standard processes	11.01%	9	3	3	1	
Absolute weight				9.00	3.78	2.21	1.34	16.33
Priority				55.11%	23.13%	13.55%	8.21%	100.00%

The next step is to perform customer analysis. Various tools can be used to obtain qualitative information and quantitative data about customer requirements (Proctor, 2005). In this model, we used Gemba interviews as a qualitative tool, then used questionnaire as a quantitative one.

A small group of selected customers have been interviewed to capture customers' opinions, suggestions and requirements in their language and expressions. These customer requirements have been rewritten in sticky notes according to Jiro Kawakita (JK) recommendations (Kawakita, 1981) as shown in Figure 2, then Grouped into categories of up to two level as shown in Figure 3.

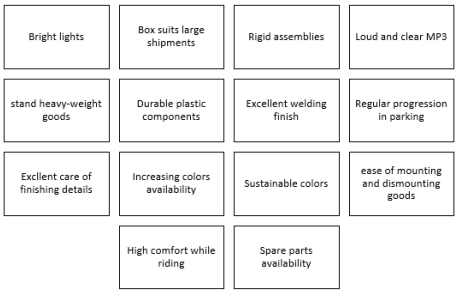

Figure 2. Collecting the sticky notes

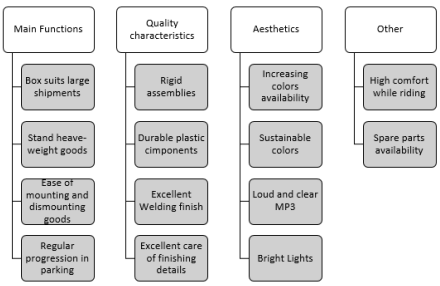

Figure 3. Affinity diagram, the result of JK method

After that, the questionnaire has been designed to ask about the importance and bench marking for each requirement.

All the answers from questionnaires are summarized in order to be easily. Then the crisp values are converted into fuzzy values (Chen & Hwang, 1992). Preplan matrix is constructed while the complete House of Quality (HoQ) matrix is constructed as well using the same relations of traditional QFD (Cohen, 1995) but considering the mathematics of fuzzy logic (Bede, 2013). The fuzzy values of relative importance design characteristics are converted back to crisp values using Centre of Gravity method (Chen & Hwang, 1992).

Help Us Developing the Best Tricycle for You

Please take 5 minutes to complete this questionnaire to help us developing the best tricycle.

Guidelines:
The questionnaire consists of two sections, "Section a. evaluating characteristics" and "Section b. personal information". In "Section a", for each characteristic, please choose how importance this characteristic for you (1 = not important at all: 5 = extremely important), also for each characteristic, evaluate how each company satisfy this characteristic (1 = very bad : 5 = very good). In "Section b", answer only the questions represent you either you are a retailer or a consumer.

Section a

#	Characteristics	Importance					Benchmarking															
							Our Tricycle					Competitor #1					Competitor #2					
	Example: Character X	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	Box suits large shipments	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2	Stand heavy-weight goods	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3	Ease of mounting of dismounting goods	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4	Regular progression in parking	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	Rigid assemblies	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6	Durable plastic components	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7	Excellent welding finish	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8	Excellent care of finishing details	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9	Increasing colors availability	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10	Sustainable colors	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11	Loud and clear MP3	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
12	Bright lights	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13	High comfort while riding	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
14	Spare parts availability	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Section b

If you are a retailer, please answer these questions.	If you are a consumer, please answer these questions.
How old is your business?	How old are you?
Which city do you sell?	Which city do you live?
What is the most brand you sell?	What is the main good you transfer?
How much would you pay to buy a tricycle?	How much would you pay to buy a tricycle?
Do you have any words to us?	Do you have any words to us?

Figure 4 Questionnaire Form

Table 4 Summary of questionnaire responses

	Importance				Benchmarking											
					Our Tricycle				Competitor #1				Competitor #2			
Question / Customer	W_1	W_2	…	W_{14}	W_1	W_2	…	W_{14}	W_1	W_2	…	W_{14}	W_1	W_2	…	W_{14}
1	5	2		5	3	4		2	5	2		4	4	3		1
2	5	5		5	4	5		4	4	1		4	2	2		3
3	4	4		3	3	3		1	5	2		4	2	3		3
4	4	5		5	2	2		4	3	4		3	4	4		2
5	5	4		4	4	4		2	1	1		1	4	3		3
…																
50	5	4		2	1	5		2	5	3		4	4	4		1

Table 5 Converting questionnaire responses into fuzzy values

	Importance			Benchmarking								
				Our Tricycle			Competitor #1			Competitor #2		
Question / Customer	W_1	…	W_{14}	W_1	…	W_{14}	W_1	…	W_{14}	W_1	…	W_{14}
1	8,9,9		8,9,9	4,5,6		2,3,4	8,9,9		6,7,8	6,7,8		6,7,8
2	8,9,9		8,9,9	6,7,8		6,7,8	6,7,8		6,7,8	2,3,4		2,3,4
3	6,7,8		4,5,6	4,5,6		1,1,2	8,9,9		6,7,8	2,3,4		6,7,8
4	6,7,8		8,9,9	2,3,4		6,7,8	4,5,6		4,5,6	6,7,8		4,5,6
5	8,9,9		6,7,8	6,7,8		2,3,4	1,1,2		1,1,2	6,7,8		4,5,6
…												
50	8,9,9		2,3,4	1,1,2		2,3,4	8,9,9		6,7,8	6,7,8		4,5,6
AVG	6.7,7.7,8.2		5.7,6.7,7.4	4.6,5.5,6.4		3.2,4,5	5.4,6.4,7.1		3.6,4.4,5.2	4.3, 5.0,5.9		5.6,6.6,7.3

Table 6 Preplan Matrix

What	Importance	Benchmarking			Plan		Weight	
		Us	Comp 1	Comp 2	Target	Rate of improvement	Absolute	Priority
W_1	(6.8, 7.8, 8.2)	(4.7, 5.6, 6.4)	(5.5, 6.4, 7.1)	(4.3, 5.1, 5.9)	(6.1, 7.1, 8.1)	(1, 1.3, 1.7)	(6.4, 9.9, 14.3)	(0.3, 0.5, 0.8)
W_2	(6.4, 7.4, 8)	(5.7, 6.6, 7.3)	(4.2, 5, 5.8)	(3.5, 4.4, 5.3)	(6.3, 7.3, 8.3)	(0.9, 1.1, 1.5)	(5.6, 8.2, 11.8)	(0.3, 0.4, 0.6)
W_3	(6.5, 7.5, 8)	(4.5, 5.3, 6.1)	(4.3, 5, 5.8)	(4.3, 5.2, 6)	(5.1, 6.1, 7.1)	(0.8, 1.2, 1.6)	(5.5, 8.7, 12.8)	(0.3, 0.5, 0.7)
$W_{…}$								
W_{14}	(5.7, 6.7, 7.4)	(3.2, 4, 5)	(3.7, 4.4, 5.3)	(5.6, 6.6, 7.3)	(6.3, 7.3, 8.3)	(1.3, 1.8, 2.6)	(7.2, 12.3, 19)	(0.4, 0.6, 1)

Table 7 Complete HoQ Matrix

What	Weight	Box Dimension	Box Material	Packing easiness	Barking Distance	Inspection	Plastic Material	Sound Welding	Painting Process	MP3 Quality	Light Efficiency	Seat Design	No. of Outlets
W_1	(0.3, 0.5, 8)	(4, 9, 9)	(1, 3, 5)	(4, 9, 9)	(0, 1, 2)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_2	(0.3, 0.4, 0.6)	(1, 3, 5)	(4, 9, 9)	(1, 3, 5)	(1, 3, 5)	(0, 0, 1)	(0, 0, 1)	(1, 3, 5)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_3	(0.3, 0.5, 0.7)	(1, 3, 5)	(0, 1, 2)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 1, 2)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_4	(0.3, 0.5, 0.8)	(0, 1, 2)	(0, 1, 2)	(0, 0, 1)	(4, 9, 9)	(0, 1, 2)	(0, 0, 1)	(0, 1, 2)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_5	(0.2, 0.4, 0.6)	(0, 1, 2)	(0, 1, 2)	(0, 1, 2)	(0, 0, 1)	(1, 3, 5)	(0, 0, 1)	(1, 3, 5)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_6	(0.3, 0.4, 0.6)	(0, 0, 1)	(0, 1, 2)	(0, 0, 1)	(0, 0, 1)	(0, 1, 2)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_7	(0.3, 0.5, 0.8)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 1, 2)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_8	(0.3, 0.4, 0.7)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_9	(0.2, 0.4, 0.6)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_{10}	(0.2, 0.4, 0.6)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 1, 2)	(1, 3, 5)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_{11}	(0.2, 0.4, 0.7)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)
W_{12}	(0.3, 0.5, 0.7)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)	(0, 0, 1)
W_{13}	(0.2, 0.3, 0.5)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)	(0, 0, 1)
W_{14}	(0.4, 0.6, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(0, 0, 1)	(4, 9, 9)
Importance	Absolute	(1.94, 8.29, 22.3)	(1.51, 7.28, 20.4)	(2.8, 10.5, 24.2)	(1.63, 6.7, 19.6)	(1.33, 6.99, 20.2)	(1.41, 5.02, 16.9)	(1.87, 8.17, 22.1)	(1.78, 6.83, 19.4)	(0.98, 3.76, 15.1)	(1.1, 4.08, 15.3)	(0.81, 2.93, 13.8)	(1.53, 5.82, 17.6)
	Relative	(0.08, 0.34, 0.92)	(0.06, 0.3, 0.84)	(0.12, 0.43, 1)	(0.07, 0.28, 0.8)	(0.06, 0.29, 0.84)	(0.06, 0.21, 0.7)	(0.08, 0.34, 0.92)	(0.07, 0.28, .8)	(0.04, 0.16, 0.63)	(0.05, 0.17, 0.63)	(0.03, 0.12, 0.57)	(0.06, 0.24, 0.73)
	Crisp Value	0.34	0.3	0.43	0.28	0.29	0.21	0.34	0.28	0.16	0.17	0.12	0.24
Difficulty		4.5	2	3	4	1	1	2.5	2	1.5	1	3.5	3.5

Figure 5 shows a chart to trade off between the importance of the technical requirements and their difficulty to implement. Development team should start implementing the lower right part as it represents high importance and easy implementing characteristics. The lower left part represents low importance but easy implementing characteristics, so the team could implement them too. The higher left part is the last section to consider as it

includes low importance and difficult to implement characteristic. The last part is the higher right part which is considered as the challenging part where it contains high importance but difficult to implement characteristic, so the team have to spend much time in order to introduce innovative thinking to implement these characteristics.

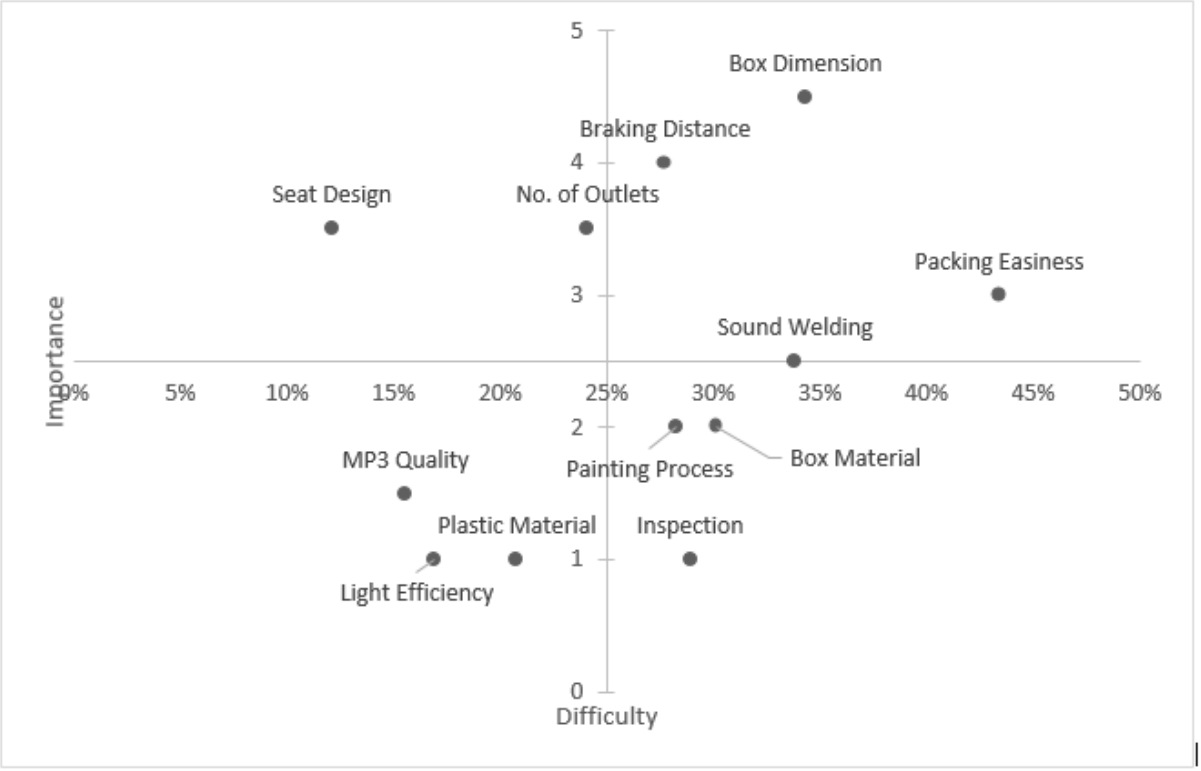

Figure 4. Bottle neck analysis

3. Conclusions

Blitz QFD offers a leaner and faster way than the traditional one in a way that helps organization shorten the cycle time of product development and identifying the most important requirements to customers. The integration of fuzzy logic through the model helps to obtain more suitable way to reduce the ambiguity of VoC.

The most benefits obtained from this case study by applying the proposed model are the clear identification and communication of each steps between the development team enhanced by the use of visual tables, focusing on the most critical requirements for both VoB and VoC, not complicated calculations and suitable to use by small organizations and increasing customer satisfaction by correctly implementing his or her requirements.

Although the model can be implemented on wide range of applications, the researchers suggest testing and comparing other tools for each step like the use of focus groups in customer analysis, Analytical Network Process (ANP) in prioritizing customer requirements and Chen's approach for converting fuzzy numbers to crisp values in order to obtain the most suitable for any specific application.

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