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Product Improvement with Quality Function Deployment (QFD) Technique

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Abstract. The purpose of this paper is to improve a new part for the natural gas sector using Quality Function Deployment (QFD) technique. QFD methodology was chosen for the product improvement process at IGDAS (Istanbul natural gas distribution company), the biggest natural gas distribution firm in Turkey. Experts from engineers were selected to determine customer expectations. Application of QFD to pipe strangling equipment is described step by step. The results show that when developing a new product or improving a product both customer expectations and product requirements are evaluated at the same time pleasing both parties for a successful result.

Introduction

New product development (NPD) process may consider different issues. Some authors take into consideration controlled management of the processes used in NPD [1]. Others have emphasized the collection and use of customer ‘‘wants and needs’’ [2]. Yet, others have emphasized the collection of primarily financial data [3]. This is then analyzed to minimize risks and hence speed up time to market [4].

When combining NPD and quality approach it is seen clearly that one should determine customers` needs as the most important factor. Responding to customers’ demands for more and better products, businesses worldwide are revitalizing the process of new product development, to ensure that the right product gets to the market quicker, at the right time, and at the right price [5]. Yelkur and Herbig (1996) also stated that to be successful, global new product development cannot be a rigid step-by-step process, it has to be dynamic and simultaneous [5]. An important technique in Quality approach in order to determine customers` needs and to convert these needs into technical information by satisfying, improving and developing is best done by the Quality Function Deployment (QFD) technique.

Quality Function Deployment Technique. QFD was found by Yoji Akao in 1966 in Japan [6]. However the usage of QFD in quality control started by the years of 1972 [7]. In 1972, Dr. Mizino and Furukawa improved a matrix which contains customer demands and quality features. Japanese firm Toyota was the first to apply this new technique successfully in their process improvement system.

Although mainly it has been linked to new product development, QFD can also be used for reviewing existing products, services and processes [8]. QFD has been used to improve the manufacturing process improvement [9]. QFD may be used as a means for developing new products and to modify existing products [10]. On the other hand Costa et al., points out that QFD is more suitable for the improvement of an existing product than for innovating new products [11]. In addition Benner et al., accept this fact and conducted QFD in their study and successfully improved the product [12].

QFD is based on the philosophy of meeting the customer satisfaction. So “sound of customer” is very important in the QFD methodology. It is used to determine what to improve. This technique helps to integrate the needs and wants of customers with R&D and production departments, in order to reach successful processes [13].

Analysis

QFD methodology was chosen for the product improvement process at IGDAS (Istanbul Natural Gas Distribution Company). Experts from engineers were selected to improve pipe choking equipment with the help of QFD. This product is used to stop the gas flow during maintenance without harming the gas pipe.

Application of QFD to pipe strangling equipment is described step by step in this article as follows:

Step 1: Firstly, customer expectations were determined by 70 technicians with survey. The customer expectations and weights were rated over 9 as shown in Table 1

Step 2: In this step, technical requirements related with customer expectation are determined and explained. Technical requirements are very important for QFD analysis because engineers and experts consider these requirements when they struggle to meet the customer expectations [14]. To determine the requirements, experts from different departments should work together. Technical requirements which were determined in this research are: Leaking rate, Jaw radius, Choking speed, Crushing rate of pipe, Size adjusting time, Grounding, Distance of control choking, Strength, Set-up time for secure, Product life, Weight, Preparation time of the equipment, Positioning time onto the pipe, Height, Cost.

Step 3: After determining the technical requirements (TR), experts construct relationships between customer expectations (CE) and technical requirements. Importance ratings and direction of improvement are other crucial points for QFD analysis. This information is evaluated and determined by experts. Furthermore, engineers and experts at IGDAS defined which customer expectations are related with technical requirement. All relationships are categorized such as either strong, medium, or weak. The score of 9 is used to indicate a strong relationship between customer expectations and technical requirements. The score of 3 signifies a moderate relationship and 1 refers a weak relationship between them. These relationships, direction of improvement and importance degrees are shown in Table 1.

Step 4: In this step, the importance value of each technical requirement was calculated. The formula is written as follows:

$$IVTR_i = \sum_{j=1}^{k}(IDCS_{ij} \times WCE_j) \tag{1}$$

where,

IVTR: The Importance value of i’th technical requirement

IDCS: Importance degree of customer satisfaction between TR i and CE j.

WCE: Weight of j’th customer expectation

Technical importance degree explains the most important requirements. According to the relations above the experts found that leaking rate, jaw radius, crushing rate of pipe, distance of control choking, weight, positioning time onto the pipe are the most important requirements for this product.

In this analysis, also normalization value of each technical requirement is calculated as technical importance degree is divided by summation of all technical importance degrees. All normalization value of technical degree was calculated and was written in the QFD matrix.

$$NTID_i = \left(TID_i \,/\, \sum_{i=1}^{n} TID_i\right) \tag{2}$$

where,
NTID: Normalization of i'th technical importance degree
TID: i'th technical importance degree

Difficultness degree indicates the feasibility level of each technical requirement. These degrees are calculated with five points scale. The points 1 means that feasibility is very easy and 5 means that feasibility is very hard. The normalized values of technical requirements and difficulties are shown in Table 1.

Relationships between customer expectations and technical requirements

Table 1

		TECHNICAL REQUIREMENTS														
CUSTOMER IMPORTANCE RATING	CUSTOMER EXPECTATIONS	Leaking rate	Jaw radius	Choking speed	Crushing rate of pipe	Size adjusting time	Grounding	Distance of control choking	Strength	Set-up time for secure	Product life	Weight	Preparation time of the equipment	Positioning time onto the pipe	Height	Cost
9	Complete stoppage of gas-flow	9			3											
9	Choking the pipe with.		9	3	9											
3	Easy to adjust for multiple pipes					9										
3	Electical grounding						9									
9	No need to get into trench							9								
3	Practical secure lock									9						
3	Durability								9		9					
9	Light weight											9				
9	Convenient and practicle												3	9		
3	Small in size as possible														9	
1	Cost-effective															9
	Technical Difficulties	4	2	2	2	3	1	3	2	2	3	3	4	1	2	4
	Technical Priorities	81	81	27	108	27	27	81	27	27	27	81	27	81	27	9
	Normalization Value	**0,1**	**0,11**	**0,04**	**0,1**	**0,04**	**0,04**	**0,1**	**0,04**	**0,04**	**0,04**	**0,1**	**0,04**	**0,1**	**0,04**	**0,01**

Step 5: In this step, correlations among technical relationships are described. Symbols which are explained above are put in the correlation matrix. "+" refers positive correlation, "++" refers strong positive correlation, " – " indicates negative correlation, and " ––" indicates strong negative correlation. These correlations are shown in the correlation matrix in Table 2.

Correlation Table

Table 2

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Leaking rate	Jaw radius	Choking speed	Crushing rate of pipe	Size adjusting time	Grounding	Distance of control choking	Strength	Set-up time for secure	Product life	Weight	Preparation time of the equipment	Positioning time onto the pipe	Height	Cost
1	Leaking rate				--											
2	Jaw radius								--		++	-				--
3	Choking speed															
4	Crushing rate of pipe								++		+	+				
5	Size adjusting time												+			
6	Grounding												-			-
7	Distance of con.											-				-
8	Strength										++	-				--
9	Set-up time for secure															
10	Product life															-
11	Weight															--
12	Preparation time.															
13	Positioning time onto.															
14	Height															
15	Cost															

Step 6: In last step, quality improvement plan has been carried out considering weights of the technical requirements. In this study, *crushing rate of pump* has the highest weight with the score of 108. Therefore it was determined the most important technical requirement to be improved first. In the quality improvement plan, after solving crushing rate of the pump problem, five technical requirements were found out next important technical requirement regarding weight of them. These are leaking rate, jaw radius, distance of control choking, weight, and positioning time onto the pipe. These four characteristics have a score of 81. Therefore one needs to consider technical difficulty of each technical requirement to determine the next one. Positioning time onto the pipe, jaw radius, distance of control choking, weight, and leaking rate were improved respectively. According to the QFD improvement plan, without considering correlation matrix among the quality requirements, the least important quality requirement is found as cost of the product. But if correlation matrix is

considered, the cost of the product becomes very important requirement in the quality improvement plan. After implementing quality plan according to results of study, an improved version of the product is produced and performance of the developed product is found better then the old one. Picture of the improved product is shown in Fig. 1.

Fig. 1. Improved Product

Conclusion

In this research, QFD methodology was applied at a major natural gas distribution company for product improvement. QFD was chosen as it is used to link customer expectations with the appropriate engineering design characteristics and requirements, so the voice of the customer is translated into product designs and specifications.

Customer expectations and product requirements were analyzed. Each customer expectation was rated and the most suitable one was chosen according to the customer expectations. Afterwards the requirements were listed. The relationship between requirements and customer expectations were listed and the technical importance degree of each requirement was calculated. All normalization value of technical degree was calculated and was written in the QFD matrix. Correlations among technical relationships are described. After all information and data had been evaluated quality improvement plan was determined.

Customer expectations are very important for firms to survive in the market. Considering customer expectations, changes in the products cause to earn much profit and advantages for companies. However, insufficient responses against to customer expectations cause many problems such as decreasing of sales, profit and image. When combining new product development and quality approach it is seen clearly that one should determine customers` needs as the most important factor. An important technique in Quality approach in order to determine customers` needs and to convert these needs into technical information by satisfying, improving and developing is best done by the Quality Function Deployment (QFD) technique.

It should also be acknowledged that the study is subject to some limitations. Various inputs, in the form of judgments and evaluations are needed in the QFD approach. These required inputs are gathered through questionnaires, deep interviews, and focus groups using 1, 3 and 9 measurement scale. This gives rise to uncertainties when trying to quantify the information. In order to reduce the uncertainty in the data collected, analytic network process, analytic hierarchy process technique, and fuzzy logic can be used.

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