Customer driven quality improvement of jute yarn using AHP based QFD: A case study

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Abstract: *The ready-made garment (RMG) industries in Bangladesh have become very competitive to cope with the competitors. The performance of this sector has attracted many countries to invest their money safely here and also earns foreign currency by exporting different materials like jute yarn. Jute yarn is a spun material which is prepared to use for weaving, knitting, sewing threads, carpets, carrying bags etc. In fiscal year 2015-16, according to data from Bangladesh's Export Promotion Bureau (EPB), Bangladesh has earned $559 million by exporting jute yarn and twine. To meet the growing demand of jute yarn worldwide, Bangladesh still has lots of possibilities to earn huge amount of foreign currency by improving the quality. It's a persistent need for Bangladeshi local jute yarn manufacturers to come forward, seek possibilities for improving quality, and fulfill the worldwide demand. The paper focuses on the application of AHP based QFD approach on a manufacturing company to improve its quality of product & improving the level of customer satisfaction. The paper shows how customer requirements can be identified and used them to prioritize the design requirements for improving quality of jute yarn. Here, AHP is integrated into house of quality (HOQ) that can be guide for overcoming the pitfalls of traditional QFD.*

Keywords: *AHP based QFD, Product Quality, Customer Satisfaction, Jute Yarn*

1. Introduction

A product won't go for long run until customer satisfaction is fulfilled. In competitive markets, product should be in high quality for long sustainability. For meeting the customers on going demands, every manufacturer needs to pay attention on customer satisfaction and customer requirements. Because customer satisfaction is the key thing that plays the lead role on getting the product successful. To capture the global competitive market, manufacturers should quick response to the customer requirements. But the current situation is very few manufactures are responding on customer requirements. For establishing a long term collaboration with the customers, customer survey is mandatory for the specific product. When manufactures will do the customer survey about the product, they will get the product problems,

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customer expectations and exactly what improvements are asking from the company by the customer. If the manufacturer consider the expectations and improve the product can increase the sales significantly. In the current situation of Bangladesh manufacturing industry, Bangladeshi manufactures are stepping on survey steps to make the product customer perceived for long run. For jute yarn perspectives, by nature Bangladesh produce huge amount of jute every year. The principal material of producing jute bags, weaving, knitting, sewing threads, carpets, carrying bags etc. is made from jute yarn which is made from jute. The demand of jute yarns are increasing day by day both in the Bangladesh and worldwide. It is a pressing need for Bangladeshi local manufacturers to come forward, produce high quality jute yarn and fulfill the demand of the local market and international market. Only effective delivery of service quality can enhance the corporate profit and competitiveness in the fierce competition market (Fonseca et al., 2010). Thus how to improve the jute yarns quality which will give the customer value is an important issue in the Bangladesh jute yarn manufactures. Many marketing researcher recognized service quality as well as customer satisfaction. However few studies have explored the both internal and external side of the service process: Operations the internal side and the customer the external side perspectives of quality and satisfaction (Zhu et al. 2010).

Now, Bangladeshi manufacturing industries changing their business operations policy from product oriented base to marketing oriented base in order to fulfill the expectations of customers. Because long term success hidden in the customer satisfaction. As quality is defined as the characteristics of fulfilling of customer needs, the customer needs of the product play an important role in customer satisfaction. Customer base product design is the key thing to increase product purchasing. For an example, carpets are using in office floor, home, balcony and many places. If the proper ratio of jute yarn is not maintained in the carpets properly by the manufactures, when customer use the carpets from the using friction carpets hairiness problem can arise and it's filaments will be broken from many places. If customer understand the problem of the source, they will not buy the existing manufacturers carpet again. In this situation, customer will prefer different company's carpet.

This paper focuses on the use of AHP Quality Function Deployment approach to improve the quality of the final product and give the best experience according to the expectations. This paper also shows how customer requirements can be identified and used them to prioritize the design requirements for improving quality of jute yarn.

2. Literature review

Since the application of fuzzy AHP and quality function deployment model has been gaining attention progressively from the past 30 years, it has produced large numbers of product development, quality management, such as weigh calculation, priority calculation, identifying customer needs, importance of customer needs, relation between customer needs and engineering characteristics. In short fuzzy AHP and quality function deployment model has huge impact on the customer driven quality improvement of a product. This literature review will close look at those research works, exploring the scopes and impact of those studies on customer satisfaction level. Neff (1991) stated that "Under total quality control, it was difficult by the product designers to improve their work that spawned QFD in Japan". D. Lock, Hill (1994) edited in chapter 21, Quality function deployment, of the second edition of Gower handbook of Quality management wrote similarly, QFD has two drivers which influence it's creation in Japan were those:

1) To improve the “Quality of Design”.
2) To provide manufacturing and field staff with the planned quality control chart before the initial production run.

QFD is a step by step planning process which converts voice of the customer (VOC) into customer perceived product design and development. For creating globally competitive and sustainable products, QFD is a very effective product development tool that already proved (Carnevalli et al., 2011; Kalargeros & Gao, 1998; Pai et al., 2016; Singh et al., 2015). Cohen (1995) showed how to make Quality Function Deployment (QFD) works for you. He stated, it is a collection of techniques and processes which will give the ability to customize in real life situations. Kalergeros and Gao (1998) proposed a fuzzy analytic hierarchy process (FAHP) to determine the importance weighting of customer requirements. Fung et al., (1998) combined Fuzzy logic and AHP concepts to evaluate the target values for the product characteristics. Sower et al. (1999) on their redesign of pizza improvement studies told that current redesign of the product needs to be superior to both competitors on the basis of all three counts. He made the redesign process of pizza project with strong connection between the design requirements of meat and cheese and customer needs of value. Also, “Trade-off” to be considered to overcome the negative correlation between meat, cheese and price. A way must be founded to provide meaty, cheesy pizza at a low price.

Wang (1999) told that “Quality Function Deployment (QFD) model is a Multi criteria decision making (MCDM) problem and that’s why he developed a new fuzzy outranking method to get the importance ranking of engineering characteristics”. Shen et al. (2001) represented the necessity of the translation of the customer requirements for future trend analysis. He also added that, importance ranking of engineering characteristics affected by several factors. Sohn and Choi (2001) used Fuzzy QFD in the supply chain for the reliability in the assessment. Büyüközkan et al. (2004) used network hierarchy based QFD and assigned fuzzy extent analysis for calculating weight of each pair wise comparison matrix.

Lin et al. (2008) established a Fuzzy quality function deployment model to calculate the target values of the design requirements. According to Ho (2008), AHP helps the decision makers to make more realistic and promising decision making by integrating with it. The above literature review proved that AHP based quality function deployment model helps the decision makers to exact and accurate improvement process. For this reason, in the study of “Customer Driven Quality Improvement of Jute Yarn” AHP based quality function deployment model is used.

Vinod et al. (2009) told that modern organizations are looking for techniques which would be a combination of quality, innovation, and agility to face high global competition. They proposed a method named “ITQFD” which means innovative total quality function deployment. They implemented this research study in a switch manufacturing company. Study implemented on two switches. Feedback was gathered from the team members who participated in the implementation study. Sugumaran et al. (2011) integrated QFD, TPM, MQFD and AHP. This paper concerned with the exploitation of quality function deployment technique with total productive maintenance. They exploited it from TPM to analytic maintenance quality function deployment. Finally, they evolved a method called analytic maintenance quality function deployment (AMQFD). Jose and Paulo (2011) said that QFD is complex, time consuming and still there is room for it’s improvement. They specified that, three QFD application conducted in the Brazil. They also identified four relevant factor’s of QFD such as prerequisites for its use, difficulties experienced, methodological constraints and benefits of using QFD.

According to Boppana (2014), Quality function deployment is a very effective and useful tool to product design and development. Determination of customer demands and fulfilment of engineering characteristics is an important issue for the development of new product. By using fuzzy quality function deployment, he developed computer aided design and engineering and design for environment. Just prioritized the engineering characteristics. Here, fuzzy helped him to translate linguistic judgements. Seyed et al. (2015) used a new QFD approach for prioritizing engineering characteristics on the car sun shade. The main and important function of QFD is converting customer demands into product design/service quality. And it is not so easy to convert and prioritizing design requirements precisely. In this reason, they developed a robust model for analyzing QFD. They used a system divided into two phases: consideration of customer attitudes and engineering prefers concurrently.

Arash Apornak (2017) described QFD is an instrument with descriptive information and expert peoples advice for identifying customer requirements and translating them to interpreted need. In his research paper "Customer satisfaction measurement using SERVQUAL model, integration Kano and QFD approach in an educational institution" he divided customer needs into three categories by using Kano model. Finally, he found that teaching method has the important relative weight. Mandeep et al. (2015) used analytical hierarchy process and quality function deployment model for justification of advanced manufacturing technology. Basically, they used this methodology for providing a framework for implementing AMT to a company. They applied this QFD-AHP methodology on an aerospace supplier company between three groups of advanced manufacturing technology to select one. They first identified the demand and then prioritized the design requirements.

Rui-Yang Chen (2016) used QFD in green design quality management in industrial chain. He also used Fuzzy decision tree for this approach. Green design principle is to identify the ability of each finished product standard to meet customer demand. Moreover, green design principle also helps the green environmental reduce, reuse and recycle criterion for green design. It is commonly known as 3R. He combined the construction of QFD with fuzzy membership function and fuzzy multilayer quality function deployment model. These method helped him a lot to find out the largest influence on 3R green design criteria. According to Ramezan and Elahe (2017), Quality function deployment is a planning, problem solving and customer driven product design tool for translating customer needs into engineering characteristics.

Mahmoud et al. (2017) integrated Quality function deployment and ANP model for improving quality of financial services in consulting engineering firms in Iran. Here, they used Delphi method for identifying financial sector's customer demand. Design requirements prioritized by ANP methods. They found that "Transparent system of payment" is the most wanted customer demand and "Cash management of the company" were proposed to meet this customer demand. Chen (2016) used QFD technique for measuring service quality in Macau luxury hotels. Macau is a very famous tourist destination. And many people wants and entered this business. But it is highly competitive. For improving service quality and identifying critical customer needs, they collected data from 280 Macau hotel customers and from others. They presented the QFD method with some minor modification which helped them to achieve 100% customer satisfaction for hotel management. Ashish and Sunanda (2017) prioritized technical requirements for effective design of online shopping websites with QFD. Online shopping is growing rapidly. Customer satisfaction for online shopping is dropping day by day largely because of poor design. So, it is a pressing need to well-designed a website. Here, QFD tool acts as a decision making tool which employed for designing online shopping websites. They just aimed on prioritization of technical requirements which ultimate goal was making fuzzy integrated technical requirements prioritization tool. Gagan and Suman (2017) used AHP methods to prioritize needs of the customer for their study about "Miniature Circuit Breaker". Then they used fuzzy logic system to remove vagueness between what and how room precisely. They also use ANN technique to make comparison between case study firm and it's competitive firm. The result were parallel computational models comprised of densely interconnected adaptive processing units.

3. Why AHP based Quality Function Deployment (QFD) model?

The Analytic Hierarchy Process (AHP) is a MCDM (Multi Criteria Decision Making) approach which was proposed by Satty. (1977 and 1994). The AHP method is very famous among many researchers because of very nice logical structured framework and for the required input data is very easy to obtain. With AHP method, complex decision problem can be solved very easily. AHP method uses multilevel hierarchical structure of criteria, sub-criteria and alternatives. The relevant or applicable data are derived by using set of pairwise comparisons. And these comparisons are used to calculate the importance of the decision criteria and relative performance measures of the alternatives. As a result, if the comparison result is not accurately consistent, then the consistency in the judgment can be checked.

QFD as defined Quality function deployment. Quality function deployment method state customer needs or requirements and then translation made for the specific product to meet the customer needs which increase the desire customer satisfaction. Many manufacturer use QFD method to implement customer requirements, product design, production information. As a result by implementing Quality deployment Method manufacturing time reduced and enhance quality of the product. Using QFD method manufacturer can produce better quality product. QFD method is widely used by the industry and academic research field (Hauser & Clausing, 1988).

In short, AHP-QFD method is taken together to calculate the weights of criteria, for prioritizing the design requirements (How) and for the further improvement. In together, AHP-QFD method provide excellent priorities for the improvement of customer satisfaction. Also, AHP-QFD method improve service quality by enhancing customer satisfaction.

4. Research methodology

This study involves the application of Quality function deployment model to provide a systematic and structured method to support the integrated decision-making process. The purpose of this research is to develop an AHP based House of Quality (HOQ) model for determining customer requirements and also demonstrate how these requirements can be used to prioritize the design requirements for improving the quality of jute yarn and level of customer satisfaction. Analytic hierarchy process (AHP) approach is integrated into house of quality to calculate the importance level of customer requirements. A simple flowchart portrayed in Figure 1 shows the outline of the proposed methodology.

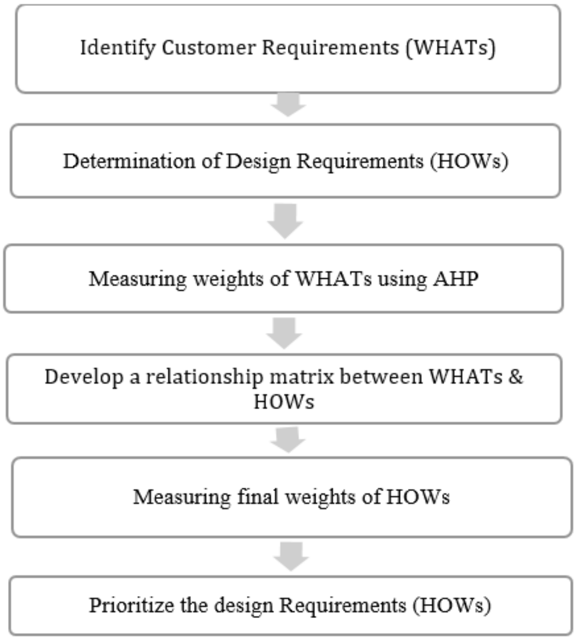

Figure 1. Flowchart of systematic approach

The following section shows the detailed descriptions of the proposed tools.

4.1. Quality function deployment

Quality Function Deployment (QFD) is a structured Total Quality Management tool which can translate customer requirements (CRs) into specific technical or engineering characteristics (ECs). This technique was originated in 1972 in Japan and now, it is widely used in all sectors such as banking sector, educational institutions, garments industry etc. It helps the quality improvement team systematically through identifying customer needs (performance needs) and converting them into design requirements. Proper use of QFD can help a company to sort out its design requirements and as a result will make the product more responsive to customers. The conventional QFD methodology involves four basic phases, namely product planning, part planning, process planning and Operations/ Production planning. The customer requirement planning matrix, also known as "house of quality" (HOQ), is the communication platform in investigating what customers want and their relative position in the market. The matrix starts with the identification of "voice of customer'' (VOC) which is obtained from customer interview, market study, past data etc. As customer needs vary so, the relative importance of the WHATs is articulated by allowing the customers to divulge their perceptions on the relative importance of the WHATs. Then, a list of measurable engineering characteristics are specified and used to convert customer requirements. Now, the product development team performs some measures such as relationship matrix between CRs and ECs, the competitive analysis, and the correlations between ECs etc. Finally, the importance of ECs is calculated using the obtained information from house of quality (Cohen 1995). A 7-step HOQ model can be described as follows:

Step 1. Identify customer requirements (CRs)

To keep business successful, the producing company must have to know who their ultimate customers are and what their needs are. The only way to satisfy your customers is done through the realization of customer needs for a product. The voice of the customer (VOC), the first step of HOQ, is captured in a variety of ways:

- Direct discussion or interviews
- Surveys using questionnaire
- Direct observation
- Field reports
- Focus groups, etc.

According to American Supplier Institute, focus group and individual interviews are the most suitable and economical methods to capture customer needs.

Step 2. Compute the relative importance ratings of WHATs

The needs of the customer are varying depending on different degrees of importance and the companies focus on that particular requirement which is relatively more important than others. The relative importance of the CRs is articulated by allowing the customers to divulge their perceptions on the relative importance of the CRs. In this research, AHP, one of the well-known MCDM methods, has been anticipated to obtain customers' perceptions as well as rating importance weight of CRs using 1-9 preference scale as shown in Table 1.

Table 1. 1-9 point scale for preference weight

Linguistic Meanings	Short Form	Scale
Equal important	E.I.	1
Moderately more important	M.I.	3
Strongly more important	S.I.	5
Very strongly important	V.I.	7
Extremely more important	EX.I.	9
Intermediate values of importance	I.I.	2,4,6,8

Step 3. Identify competitors and conduct customer competitive analysis

The company needs to identify its competitors of the similar products. To keep pace with competitors in the competitive business, the company has to know the strengths and constraints in all aspects of a product with respect to its main competitors. Actually it is done by involving customers to express their opinions and rate the relative performance of the company and its competitors on each CR (Chan & Wu, 2005). There is an unending need for aggregation of expert opinions that prevents the bias and diminishes the unfairness in the decision process. Therefore, a group decision should be adopted to improve the customer competitive priority ratings on the CRs in the evaluation process.

Step 4. Determine the final importance ratings of WHATs

The final importance ratings of customer needs are calculated through the multiplication of relative importance perceived by customers, competitive priority and improvement ratio obtained from step 3. Companies must have to give more attention on CRs with higher final ratings indicating both higher importance and potential business benefit to the company.

$$\textit{Final importance ratings of CRs} = \textit{Relative}\ \text{importance} \times \text{Competitive priority rating} \times \text{Improvement ratio} \quad (1)$$

Step 5. Develop technical or engineering characteristics (ECs)

After the customer needs are identified, next task is to generate a set of design requirements (HOWs) by company's technicians or product development team for translating CRs into meaningful ECs.

Step 6. Develop the inter-relationship matrix between CRs and ECs

Interrelationship matrix, essential part of house of quality (HOQ), is conducted by analyzing to what extent the CR is technically related as well as influenced by the EC. The accuracy of the matrix depends on how carefully and collectively the relationship is developed.

Step 7. Determine technical ratings of ECs

The technical ratings of design requirements are calculated through the multiplication of two factors, final importance ratings of CRs and the relationships between the ECs and the CRs.

$$\textit{Technical ratings of ECs} = \text{Final importance ratings of CRs} \times \text{Interrelationsip matrix} \qquad (2)$$

4.2. Determining the importance of CRs by AHP

The analytic hierarchy process (AHP) is a multiple criteria decision making tool for organizing and analyzing complex decisions and firstly developed by Thomas L. Saaty (1980). This method is used to solve complex decision making problem having several attributes by modeling unstructured problem under study into hierarchical forms of elements .The essential components of hierarchical system are the main goal, criteria that affect the overall goal, sub-criteria that influence the main-criteria and finally the alternatives available to the problem. To obtain the degree of relative importance of elements at each level, a pair-wise comparison matrix is developed using Saaty 1-9 preference scale. Then, the eigenvector and the maximum eigenvalue (λ_{max}) are derived from pair-wise comparison matrix. The significance of the eigenvalue is to assess the strength of the consistency ratio CR (Saaty, 2000) of the comparative matrix in order to validate whether the pair-wise comparison matrix provides a completely consistent evaluation. The final step is to derive the consistency index and consistency ratio.

The stepwise procedure of AHP is presented as follows:

Step 1: Construct the structural hierarchy.

Step 2: Construct the pair-wise comparison matrix.

Assuming n attributes, the pairwise comparison of attribute i with attribute j yields a square matrix $A_{n\times n}$ where a_{ij} denotes the comparative importance of attribute i with respect to attribute j. In the matrix, a_{ij} = 1 when i = j and $a_{ji} = 1/a_{ij}$.

$$\begin{array}{c|c|ccccccc}
 & & & & & \mathbf{J} & & & \\
 & & \mathbf{1} & \mathbf{2} & \ldots & \mathbf{k} & \ldots & \mathbf{n} \\
\hline
 & 1 & 1 & a_{12} & \ldots & a_{1k} & \ldots & a_{1n} \\
 & 2 & a_{21} & 1 & \ldots & a_{2k} & \ldots & a_{2n} \\
 & \vdots & \vdots & & & & & \\
\mathrm{i} & k & a_{k1} & a_{k2} & \ldots & 1 & \ldots & a_{kn} \\
 & \vdots & \vdots & & & & & \\
 & n & a_{n1} & a_{n2} & \ldots & a_{nk} & \ldots & 1 \\
\hline
 & \text{Sum=} & y_1 & y_2 & \ldots & y_k & \ldots & y_n
\end{array}$$

Step 3: Calculate geometric mean from elements of row

$$b_k=[(a_{k1}).(a_{k2})......(a_{kn})]^{1/n} \quad (3)$$

Step 4: Calculate the normalized weights

$$x_k = \frac{b_k}{\sum_{k=1}^{n} b_k} \quad (4)$$

Step 5: Calculate Eigenvector & Row matrix

$$E = N^{th} rootvalue \Big/ \sum N^{th} rootvalue \quad (5)$$

$$Rowmatrix = \sum_{j=1}^{n} a_{ij} * e_{j1} \quad (6)$$

Step 6: Calculate the maximum Eigen value $\lambda_{\max}$.

$$\lambda_{\max} = Rowmatrix \Big/ E \quad (7)$$

Step 7: Calculate the consistency index & consistency ratio.

$$CI = (\lambda_{\max} - n) \Big/ (n-1) \quad (8)$$

$$CR = CI \Big/ RI \quad (9)$$

Where n & RI denote order of matrix & Randomly Generated Consistency Index respectively. The values of RI are listed in Table 2. If CR ≤10%; then, the criteria or alternative is accepted. Otherwise the criteria or alternative is rejected.

Table 2. Average random Index (RI)

Size of matrix(n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.499

4.3. An illustrative example

In this section, customer perceived quality improvement of jute yarn of Akij Jute Mills Ltd. is presented as an example to illustrate the concepts and computations of the proposed AHP based HOQ model in details. Akij Jute Mills Ltd. wants to make an improvement on jute yarn for raising their market share. The basic idea is to (i) identify what are customer needs (WHATs) and determine the important ones using analytic hierarchy process (AHP), and (ii) satisfy the customer needs with appropriate technical measures (HOWs) and to prioritize the important ones. HOQ model is developed for this example according to the qualitative and quantitative descriptions in section3.

At first, the company must know what the customers are and what they want. This information can be obtained through market survey or direct observation. In this research, customers of Akij Jute Mills Ltd. were divided into 10 focus groups. In order to identify customer requirements, they were interviewed personally and their expectations were captured directly from a market survey, e.g. personal interview, focus group discussion and questionnaire survey. From the survey, 10 voice of customer (VOCs) were gathered. After summarizing the voice of customer, the data were translated into customer needs. The basic guidelines were followed for the conversion process such as use of positive phrases, avoiding use of must and should, expressing the needs in terms of yarn's attributes, conducting personal interviews with experts, senior managers of several textile industries etc. Necessary customer requirements with respect to voice of customer are shown in Table 3. For example, "proper elasticity of jute yarn" can be satisfied providing "tight winding" properties. Similarly, for "No random filament in the yarn" customer requirement is "Cross winding''.

Table 3. Voice of Customer Translated in Terms of Customer Needs

Voice of Customer	**Customer Needs**
There should be acceptable number of filaments in the yarn	Hairiness (CR_1)
It shouldn't have poor abrasive resistance	High abrasive resistance (CR_2)
Yarn should have acceptable bending ability	Bending (CR_3)
Yarn should have good strength ability to prevent mutilate	Strength (CR_4)
Available in the market	Continuous market supply (CR_5)
Physical attractiveness of the yarn	Shinning yarn (CR_6)
Weak yarn should be avoided	No broken yarn (CR_7)
No random filament in the yarn	Cross winding (CR_8)
Proper elasticity of the yarn	Tight winding (CR_9)
Acceptable weight of the package	Package weight (CR_{10})

Once the customer needs were identified, next task was to determine the degree of importance of the customer expectations. For this purpose, a total of 100 customers were asked to reveal their opinions on the relative importance of the ten WHATs using six linguistic terms. Then, linguistic terms were converted into numerical values using scale shown in Table 1. Here, a total of 100 customers were divided into 10 groups and their comparison matrix was formed. Using the comparison matrix, geometric means along with normalized weights of ten WHATs were calculated using necessary formulas described in previous section. The decision maker's judgment was valid as the value of consistency ratio (7.22%) was below than prescribed value (10%) by Saaty. Table 4 shows all calculations.

Table 4. Fundamental importance of CRs by AHP method

Attributes	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6	CR_7	CR_8	CR_9	CR_{10}	Geometric mean	Normalized weight
CR_1	1	3	1/5	3	1	1/2	5	1/3	3	2	1.245	.1101
CR_2	1/3	1	1/2	1	1	1/5	1	1	1	1	.7109	.0628
CR_3	5	2	1	3	1	2	3	1	1	2	1.801	.1593
CR_4	1/3	1	1/3	1	1	1	3	1	1	1	1.067	.0943
CR_5	1	1	1	1	1	1	4	1/2	1	1	1.071	.0947
CR_6	2	5	1/2	1	1	1	9	1/2	3	1	1.523	.1347
CR_7	1/5	1	1/3	1/3	1/4	1/9	1	1/4	1/5	1	.4216	.0372
CR_8	3	1	1	1	2	2	4	1	1	1	1.472	.1302
CR_9	1/3	1	1	1	1	1/3	5	1	1	1	1.123	.0993
CR_{10}	1/2	1	1/2	1	1	1	1	1	1	1	.8705	.0770
Consistency ratio = 7.22 % < 10%												

A graphical representation of weights of customer requirements is shown in Figure 2.

From diagram, it is quite obvious that 'Bending' feature should be of more concern of the company to meet customer demands.

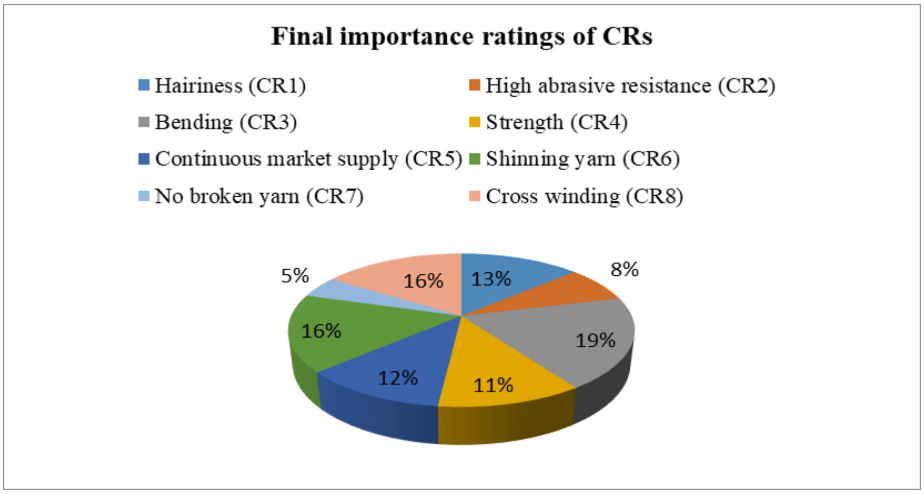

Figure 2. Schematic diagram of final importance ratings of CRs

The second highest requirement is 'Shinning yarn' which is followed by 'Cross winding'.

Now, the most time consuming and difficult part of HOQ model is the determination of design requirements (HOWs) and to convert customer requirements into design specifications. This process involves expert's knowledge and experience in the relevant field. After careful considerations, design team of yarn manufacturing companies proposed fourteen technical measures to realize the ten WHATs. Design requirements based on the customer needs were listed in Table 5.

Table 5. Design requirements based on customer needs.

Customer Needs (WHATs)	Design Requirements (HOWs)
Hairiness	Proper ratio of filaments
High Abrasive Resistance	Chemical improvement in the values of the dry and wet crease resistance
Bending	Avoid yarn irregularities
Strength	Reduction in moisture in the bleached jute
Continuous Market Supply	Proper utility support
	Digitally data collection
	Time to time communication with customer
Shinning Yarn	Improvement of the physic-chemical properties
No Broken Yarn	Cooling oil
Cross Winding	Travers guide
Tight Winding	Belt and pulley
	Trained production officers
Package Weight	Closed supervision by production officers
	Travers guide

At this stage, an inter-relationship matrix between each CR and each EC was established by means of linguistic terms shown in Table 1. The relationship matrix has been shown in Table 6.

Table 6. Relationship matrix between WHATs & HOWs

How's / What's	Weight	Proper ratio of filaments	Chemical improvement in the values of the dry and wet crease resistance	Avoid yarn irregularities	Reduction in moisture in the bleached jute	Proper Utility Support	Digitally data collection	Time to time communication with customer	Improvement of the physic-chemical properties	Cooling oil	Travers guide	Belt and pulley	Trained production officers	Closed supervision by production officers
Hairiness	.1101	EX.I.	S.I.						E.I.					
High Abrasive Resistance	.0628		EX.I.						M.I.					
Bending	.1593			EX.I.	E.I.									
Strength	.0943		M.I.		EX.I.									
Continuous Market Supply	.0947					M.I.	M.I.	E.I.						
Shinning Yarn	.1347		M.I.						EX.I.				E.I.	
No Broken Yarn	.0372									M.I.			E.I.	
Cross Winding	.1302										EX.I.			
Tight Winding	.0993											EX.I.	M.I.	E.I.
Package Weight	.077										EX.I.			M.I.

The above steps complete the HOQ matrix for improving quality of the product. The corresponding tables of results, after appropriate arrangement, formed an HOQ that could link customer needs to technical considerations. Figure 3 shows the complete HOQ matrix for improving the quality of jute yarn. From the HOQ matrix, the final importance weights of technical measures were determined. The last row of figure 4 shows the importance weights of HOWs (percentage score).

	Proper ratio of filaments	Chemical improvement in the values of the dry and wet crease resistance	Avoid yarn irregularities	Reduction in moisture in the bleached jute	Proper Utility Support	Digitally data collection	Time to time communication with customer	Improvement of the physic-chemical properties	Cooling oil	Travers guide	Belt and pulley	Trained production officers	Closed supervision	Importance Weight
Hairiness (CR_1)	9	5						1						0.1101
High abrasive resistance (CR_2)		9						3						0.0628
Bending (CR_3)			9	1										0.1593
Strength (CR_4)		3		9										0.0943
Continuous market supply (CR_5)					3	3	1							0.0947
Shinning yarn (CR_6)		3						9				1		0.1347
No broken yarn (CR_7)									3			1		0.0372
Cross winding (CR_8)										9				0.1302
Tight winding (CR_9)											9	3	1	0.0993
Package weight (CR_{10})										9			3	0.077
Score	0.9909	1.8027	1.4337	1.008	0.284	0.284	0.095	1.5108	0.112	1.8648	0.894	0.4698	0.33	
Percent score(100)	8.95%	16.28%	12.94%	9.09%	2.57%	2.57%	0.86%	13.64%	1.00%	16.83%	8.06%	4.24%	2.97%	

Figure 3. Flowchart of systematic approach

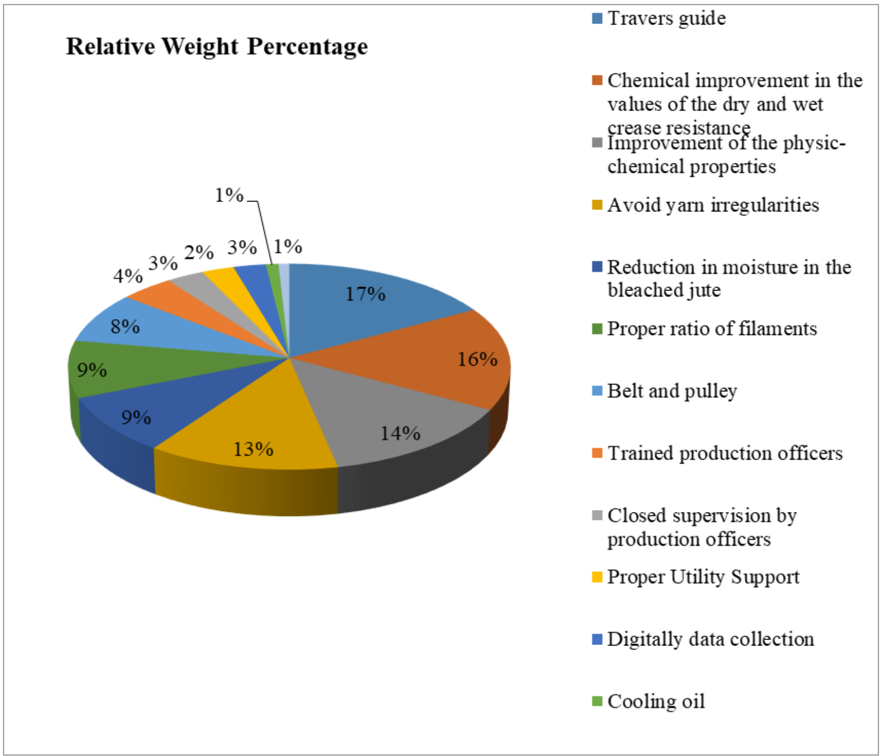

Figure 4. Relative weight percentage of HOWs

5. Results

The objective of applying AHP based quality function deployment is to find prioritize design requirements to satisfy customer expectations. A graphical representation of relative weight of design requirements has been created in Figure 4 from where largest measure is easily identified. The figure reveals that percentage scores of HOWs range from 0.86 to 16.83. The highest priority was for 'Travers guide' attributes and the second top priority was 'Chemical improvement in the values of the dry and wet crease resistance'. The design requirement 'Time to time communication with customer' had the lowest weight. From figure, it is evident that, all design requirements' relative weight percentage priorities are different from one another significantly. So, it is very important to observe the table for customer requirements and decide the requirements that should be chosen for quality improvements.

6. Discussion & Limitations

The sole purpose of this paper was to identify the best customer demand about jute yarn, establishment of best usable and effective design requirements and prioritizing those design requirements. For identifying customer demands or requirements, we made a survey which have useful questions. We have also taken statement of the jute yarn buyers, jute yarn processor personnel, from yarn to craft makers, chemical department personnel, Jute farmers, Jute yarn specialists for establishing a strong design requirements for the customer demands. We also got importance ratings from the customers. To eliminate vagueness of the importance ratings, we used Analytical Hierarchy method to convert importance ratings to strong weight. Here, AHP method helped a lot to determine appropriate weight for the each criteria. For converting linguistic importance to statistical importance, Satty's importance table is used for getting the importance number. For constructing housing of quality to make relation between what room and how room, we gathered the customer demands or requirements and best effective design requirements in one place named on HOQ diagram. Also put the importance rating value on the HOQ diagram. Then made the relation between Customer Requirements (CR) and design requirements (DR). Here, expert peoples in this field helped a lot to make the precise relationship between CR and DR. One thing, we also noticed that for making best customer driven jute yarn, availability of good quality jute is also noticeable. For this reason, jute farmers need to use good quality jute seed. And also farmers need to pay attention on proper growth of jute. They can also take suggestion from Agriculture scientist available in their area. On the other hand, jute yarn manufacturing company needs to select best jute supplier for their purpose. They will first investigate the jute quality and then buy and store for further purpose. They can also do acceptance sampling for selecting the best jute lot. After all, proper expertise is required to produce A+ graded jute yarn for a company. There are some limitations of this study. We only considered one jute yarn manufacturing company. If we would have considered more jute yarn manufacturing company had the possibility to find out more jute yarn quality problems. Also, price of manufacturing jute yarn can increase.

7. Conclusions

This case study observed ten customer quality requirements are related to product quality, product durability, product sustainability and better customer using experience. Customer's always expect what they use that will keep good for long time. As a customer sense, they always want their product will not damage within short time period, product would not be costly, provide comfortable using experience in the environment and treated with a friendly attitude at the time of purchasing. In this paper, AHP based Quality function deployment model is implemented for the improvement of customer driven quality of the jute yarn. Here, QFD method is primarily focused on translating customer requirements into design requirements. Therefore a gap can be created between customer conception and designer's conception due to translate the actual customer needs into design requirements. To eliminate the shortcomings of the QFD model AHP based Quality Function Deployment model is proposed in this research.

Prior research has shown that perceived progress toward quality goals are achieved. This research advances theory on combined AHP based QFD leads the jute yarn customers to fulfill their goals. Proper ratio of filaments, close supervision of production officer, chemical improvements of jute yarn can lead customers to fulfill their goal. AHP based quality function deployment model allowed Akij Jute Mills Ltd. to find the design requirements that they mostly need to keep their loyal customers happy. Finally, customer objection are reduced remarkably and as a result new possibility open up

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