International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-6, May 2013

Integration of Quality Function Deployment and Value Engineering in Furniture Manufacturing Industry for Improvement of Computer Work Station

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Abstract: ***Manufacturing operations in the Indian furniture industry are currently very competitive. It is necessary for entrepreneurs to improve the quality of their products and to develop processes including quality management to obtain new product design and development. Quality function deployment technique can be used in the processing development of new Computer work station to improve customer satisfaction. The use of QFD would enlarge the chance of success, produce higher quality products, and decrease the cost. The Computer Work Station was selected for this research because of its high sales number and it is most complicated compared to other furniture products. The ultimate goal of this research is to design and produce a new type of Computer Work Station. Important ratings of customer requirements are increased to some extent by effective implementation of Value Engineering with QFD. The result revealed that the average satisfaction values for all new types of computer work station are increased over those of the current computer work station from 1131 to 1956 (54.45%). Also design target values are increased from 1138 to 1988 (79.14%). Therefore with QFD approach, there is significant increase in average customer satisfaction between the current and the new designs.***

Keywords: ***Quality Function Deployment, Value Analysis, Productivity Improvement, Cost Improvement, Furniture Industry, Computer Work Station***

I. INTRODUCTION

Quality Function Deployment was developed by Yoji Akao in Japan in 1966. By 1972 the power of the approach had been well demonstrated at the Mitsubishi Heavy Industries Kobe Shipyard ullivan, 1986 and in 1978 the first book on the subject was published in Japanese and then later translated into English in 1994.

The 3 main goals in implementing QFD are:

1. Prioritize spoken and unspoken customer wants and needs.
2. Translate these needs into technical characteristics and specifications.
3. Build and deliver a quality product or service by focusing everybody toward customer satisfaction.

Manuscript published on 30 May 2013.
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Manufacturing operations in the Indian furniture industry are currently very competitive. The problems caused by economic stagnation have resulted in the current situation that industries of all types have to develop a better organization, produce higher quality products, and better respond to the needs of the customers. In recent years, the competition in furniture manufacturing has grown dramatically. It is necessary for entrepreneurs to improve the quality of their products and to develop processes including quality management to obtain new product design and development. The importance of developing products that meet the customer's needs is a priority in the product development process. It also is important to match the customer's needs with the product characteristics, which can be achieved by using the quality function deployment (QFD) method. The use of QFD would enlarge the chance of success, produce higher quality products, and decrease the cost and the time consuming in the product development. A Computer Work Station was selected as a study for this research because of its high sales numbers and its most complicated shape compared to other products, such as showcase, office desk, and counter. The ultimate goal of this research is to design and produce a new type of prototype Computer Work Station for the furniture industry.
This paper proposes a quality function deployment (QFD) framework and demonstrates its successful application to process analysis.
We begin with an overview of quality function deployment and some of its limitations. An improved QFD framework is then proposed that involves process mapping using Integrated Definition (IDEF) to formulate a process for arriving at the design specification of a system before the "House of Quality" is applied. A case study is then conducted to illustrate the use of the proposed framework in the analysis.

II. PHASES IN QFD:

QFD uses some principles from Concurrent Engineering in that cross-functional teams are involved in all phases of product development. Each of the four phases in a QFD process uses a matrix to translate customer requirements from initial planning stages through production control.
Each phase, or matrix, represents a more specific aspect of the product's requirements.

Relationships between elements are evaluated for each phase. Only the most important aspects from each phase are deployed into the next matrix.

Phase 1, Product Planning: Building the House of Quality. Led by the marketing department, Phase 1, or product planning, is also called The House of Quality. Many organizations only get through this phase of a QFD process. Phase 1 documents customer requirements, warranty data, competitive opportunities, product measurements, competing product measures, and the technical ability of the organization to meet each customer requirement. Getting good data from the customer in Phase 1 is critical to the success of the entire QFD process.

Phase 2, Product Design: This phase 2 is led by the engineering department. Product design requires creativity and innovative team ideas. Product concepts are created during this phase and part specifications are documented. Parts that are determined to be most important to meeting customer needs are then deployed into process planning, or

Phase 3, Process Planning: Process planning comes next and is led by manufacturing engineering. During process planning, manufacturing processes are flowcharted and process parameters (or target values) are documented.

Phase 4, Process Control: And finally, in production planning, performance indicators are created to monitor the production process, maintenance schedules, and skills training for operators. Also, in this phase decisions are made as to which process poses the most risk and controls are put in place to prevent failures. The quality assurance department in concert with manufacturing leads Phase 4.

III. OVERVIEW OF QUALITY FUNCTION DEPLOYMENT (QFD)

QFD is a tool for improving the development cycle and manufacturing products that better match customer needs. QFD accomplishes these goals through the use of a design tool that is known as the "House of Quality" (HOQ) as shown in Figure 1. The "Whats" room represents the voice of the customer and on the right is a customer competitive assessment that is expressed in form of a rating. The "Hows" room records the functional characteristics of a product including how customer needs can be met. The roof is the correlation matrix room which indicates the positive and negative relationships between the technical characteristics of the product. These relationships can help to generate new alternatives by highlighting areas for improvement in current products. After completing the "Whats" and the "Hows" rooms, these relationships can be worked out and expressed in a relationship matrix as indicated in the center of the house. Once the relationship matrix has been completed, the extent to which the product performance will satisfy customers is calculated and is expressed as an absolute score and a score that is relative to the target value.

Traditional QFD methodology has many limitations. For example, the identification of customer requirements is ambiguous and unsystematic and the functional characteristics of a complicated product cannot be easily determined. In this paper, an improved QFD framework is reported in which customer requirements are identified systemically using the "value engineering" concept.

IV. QFD PROCEDURE

Three main steps to carry out the house of quality (HOQ) of QFD technique are described as following:

Step 1: Customers' voices collection In order to design and produce the new type of computer work station and its abilities to satisfy customer needs, the customer requirements are gathered. To obtain this information, two main groups from both product users and sales agent stores were investigated. This kind of primary information, which consists of personal ideas of each customer, is not an official language and hence needs to be revised for grouping and resolving confusion. Analysis can be done by using different costumer requirements i.e.

Strong and Durable, Suitable Size, Attractiveness, Easy to Use, Functionality, Cupboard Storage, Low Maintenance, strong Joints, Easy to Handle, Quality Material etc.

Step 2: Customer requirements ranking Based on the basic data obtained from the first step, two more questionnaires were produced to convey the significance level of needs and the level of satisfaction on the current computer work station of the case-study factory comparing to other similar industries. A sample is used on each questionnaire focusing on two main categories; format and material of the product as listed above in costumer requirements. The respondents were given an evaluation choice on a scale from 1 to 5, with 5 being most important and 1 being less important. The geometric mean equation was used to calculate the primary data from these two questionnaires. In order to complete this task, the needs' importance weights were multiplied by improvement ratio values, resulting in the important ranking.

Step 3: Product planning matrix, or *House of Quality* development

The first matrix of the QFD method is called the *House of Quality* which is constructed to analyze and translate the customer requirements (What's) into technical requirements (How's). The basic structure of the HOQ is presented in Figure 1. The building of the first HOQ consists of 6 basic sections, thus:

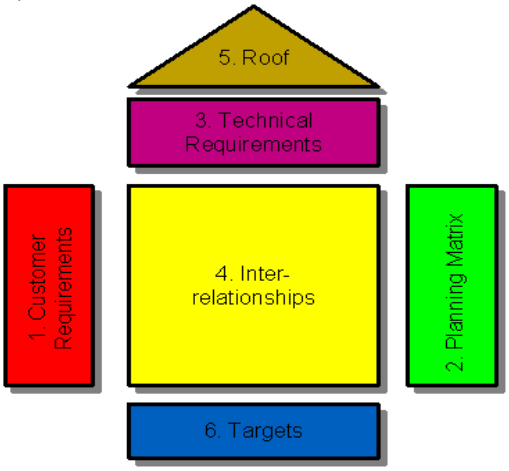

Figure no. 1

Section 1: The customer requirement and the significance level of needs are gathered from the existing needs of customer. This information was identified through a survey with the first and the second questionnaire.

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The most mentioned items were listed as the "customer requirement" (What's)

Section 2: The levels of satisfaction of the case-study factory comparing to other similar industries, depicted on the right hand side of Figure 1 and exhibited in Figure 1, were assigned by the respondents of the third questionnaire. The goal of satisfaction level in each customer requirement was selected from the maximum value between the value of the case-study factory and the other similar industries. The improvement ratio for each customer requirement can be evaluated by dividing the goal value with the rating of satisfaction value of the case-study factory. Lastly, the important ranking value for each customer requirement was determined by multiplying the improvement ratio with the significance level of needs.

Section 3: Technical requirement (How's) is the result of group brainstorming from various sections in the factory including ownership and the management team, marketing, production, design, and delivery departments. Two classifications were categorized; format and material. A cause-effect diagram was applied to analyze the relationship of the technical requirements to meet the customer requirements As a result, the target value of the technical requirements was set to measure and determine the direction of the goal of improvement.

Section 4: Rating of the relationship between the customer requirements and the technical requirements was evaluated by a group of product development team. The relationship matrix was then constructed to provide a listing of how the technical requirements represent each customer's needs on a scale of 1, 4, and 9. The rating scale 1 represents a slight or possible relationship, 4 represents a moderate relationship, and 9 stands for a strong relationship.

Section 5: Priority relationships are composed of two sections, the significance levels of the absolute and the relative technical requirements. These are the measurement for the How's. The use of the significance value is to determine priorities and direction for improvements of the How's. The value of the significance level of absolute technical requirement (SL_ABS) represents the technical requirements necessary to meet the customer needs, and can be calculated by:

SL _ ABS = ∑ (Value of relationship between customer requirements and Technical requirements x Important ranking value) …….. (1)

The value of the significance level of relative technical requirements (SL_REL) can be calculated by:

SL _ REL = (Significance level of absolute Technical requirement) x 100 / ∑ (Total of significance level of absolute Technical requirement) …..……..(2)

Section 6: The technical correlations, assigned in the roof of the HOQ, are the result of group brainstorming to determine the relationship between the "How's" and to show what "How's" influence each technique. These indications show that technical elements affect the performance of each other's, which is represented by the sign "√" for a strong relationship and by "x" for a weak relationship. The application of HOQ matrix "What's versus How's" is presented in Figure 3.

The application of HOQ matrix "What's versus How's" study is on the product, in this case we use furniture product, modular computer work stations. As already mentioned above there are many differences to measure the effectiveness of the modularity, modularity is measured in the research the most appropriate to the needs of consumers with the voice of the customer notice to find exactly what is needed and desired by consumers to indicate the level of interest "interesting", "should be have "or" one dimensional ". From the measurement of a modular approach of the seventh over, the most relevant needs and desires is a sound approach to consumer approach that is based on the first function (function based modular design). Attribute of a successful vote was unearthed from the consumer and this is developed a system module design based on sound consumer, where the needs of the product needs to search critically use Quality Function Deployment (QFD) to get any technical needs that must be present in the product. Next to find the product functions in the split components and modules used method to get the FAST modules are prepared in accordance with the product functions.

V. COMPUTER WORK STATION

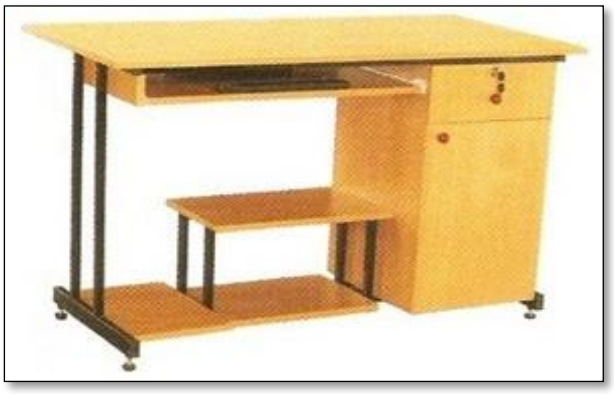

Figure no. 2

The company Gayatri Industries Pvt. Ltd. is selected for case study, located in Sangli, Maharashtra in India. This company came into existence in March 2007. The major product of the company is Different types of Computer work stations, Office tables, Bed, Benches, Wardrobe, Study table, TV Stand, Stools etc. currently supply to local dealers in Sangli and near by area. This company is mainly focused on manufacturing as per customer's design. Computer work stations are manufactured in different models by using different types of material. In the present case it is manufactured in steel and board. While manufacturing this computer work station we have observed that no. of cut pieces are wasted. Every component of computer work station is manufactured from new board material. After analyzing the production process, it is observed that keyboard guide strip, keyboard stopper, complete drawer assembly can be manufactured from waste pieces by cutting in required size. There by which the product will be attracted to customers by cutting down the cost with maintaining good quality. Here saving in material is achieved with reduction in waste. Also existing computer work station (4'x 2') can be modified in two types only by changing the table top to size (4.5' x 2.5' and 5' x 3') where maintaining the bottom structure as it is. By this variety of computer work station can be increased up to 3 and customer has choice according to their spare available and multi-functionality. This can be used as Office Table cum Computer Work Station.

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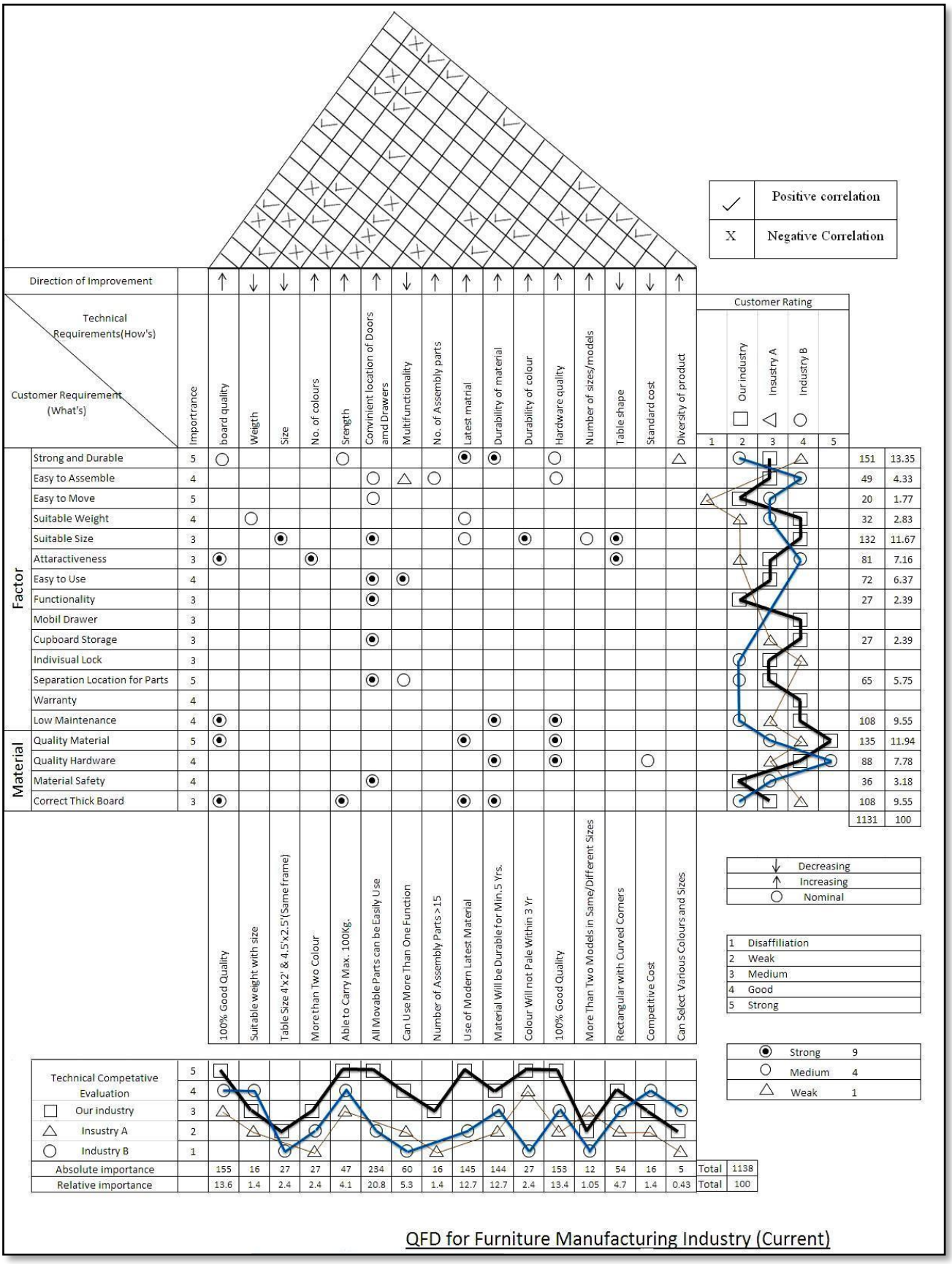

Figure no. 3

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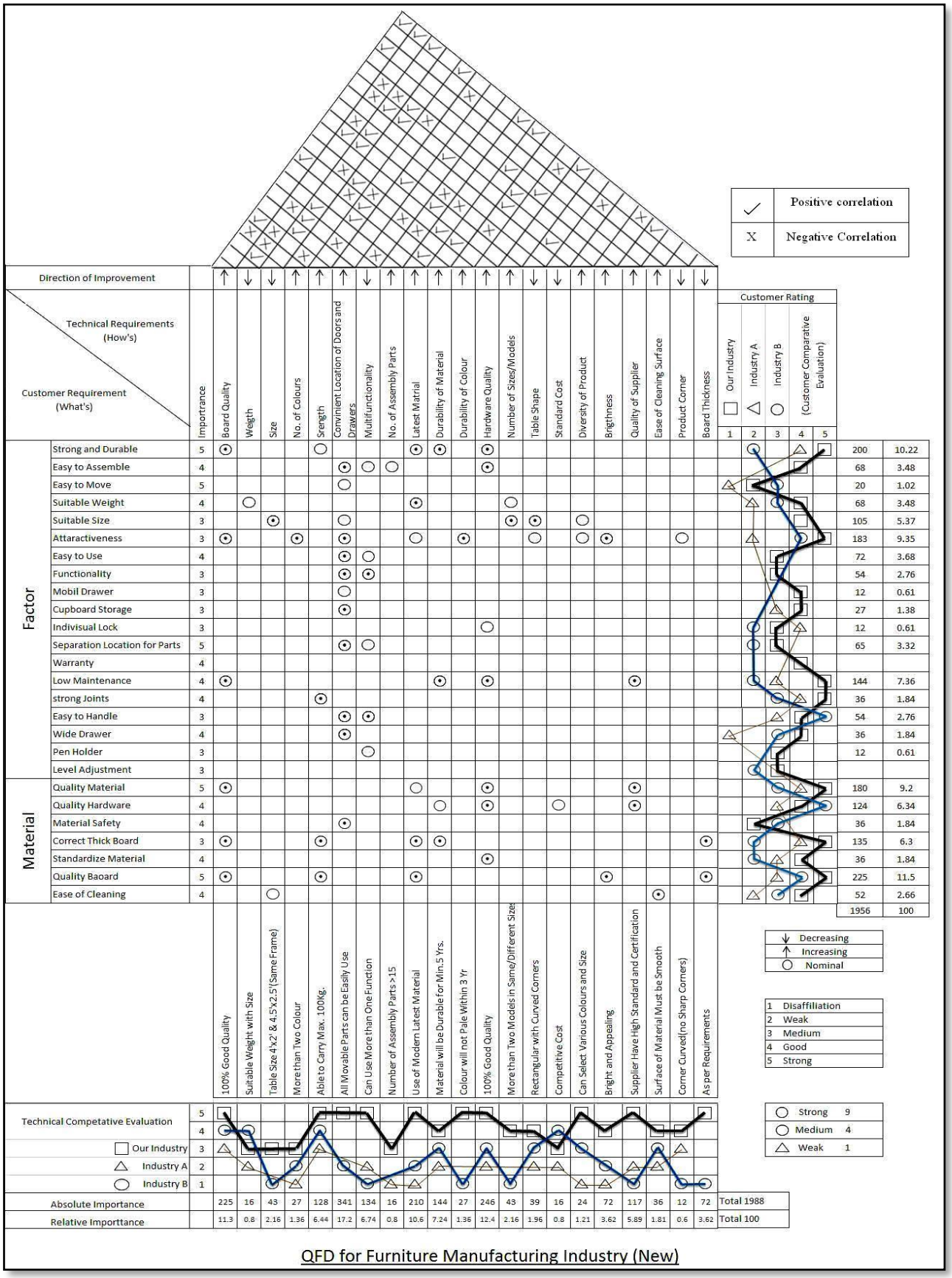

Figure no. 4

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VI. RESULTS AND DISCUSSION

The QFD technique was applied to design and produce the new type of Steel Computer work station. The result of the QFD technique takes note of the furniture characteristics that the customer's desire. For example, the most important requirements were indicated depending on the highest value of the significant of relative technical requirement. These parameters include the weight, size, number of color, number of assembly part, board quality, strength, hardware quality, multi functionality, durability of material and color etc.

It can be seen that these technical requirements (How's) were highly related to the various customer requirements and would have a high impact to increase the satisfaction value of the Computer work station. The product was therefore designed and manufactured based on the important requirements, particularly on the above discussed parameters. To determine customer satisfaction of the new prototype of computer work station over the current one, the evaluations were therefore arranged through pictures and product descriptions

However, the pictures before and after the improvement were very carefully taken in order to cover the information needed, and the associated features were thoroughly described in order to ease the rating determination. Graph no. 1 shows comparisons of the average values of customer satisfaction for 18 of the 26 customers' needs; the other 8 criteria above being neglected. The average total satisfaction value for the new product increased over the current product by about 54.45%, as calculated and shown in Table 1. Also average value of absolute importance design target of computer work station for 14 of the 21design requirements; the other seven criteria being neglected. The average total absolute importance design target value for the new product increased over the current product by 79.14 % as calculated and shown in Table no. 2. It is clearly found that customer appreciated the improvements in every item/part of the new product. This highlights the effect of new product features that better meet customer demands, leading to an increase in customer satisfaction. The result is one other supportive evidence that QFD analysis can yield some useful information what product properties are important when it comes to meet the customer demands.

After analyzing the QFD for furniture manufacturing industry for current type, it is observed that Important ratings of customer requirements is less as compare with new type as far as the design (Tech.) requirements are concerned. These are increased to some extent by effective implementation of Value Engineering with QFD.

Also no. of factors e.g. strong joints, easy to handle, wide drawer, pen holder, level adjustment are considered in new type QFD which are not in current QFD and also customer requirements related to material i.e. standardize material, Quality board, Ease of cleaning are considered in new QFD which are also not in current QFD. The result revealed that the average satisfaction values for all new types of computer work station increased over those of the current computer work station from 1131 to 1956 (54.45%). Also design target values are also increase from 1138 to 1988 (79.14%).

Hypothesis testing of satisfaction

To compare customer satisfaction before and after applying QFD technique, the percentage change values out of 26 customer requirements (what's) were considered for study (see Table no. 1). The average customer satisfaction values showed that the attractiveness of part gave the highest (111.11%) and the lowest for Suitable weight (12.5%) values. The average customer satisfaction of the new design (1956) is higher than that of the current design (1131) for 26 types of customers need.

The result reveals that the average customer satisfaction regarding the new design of each feature increased significantly, based on the QFD approach. Therefore, it can be claimed that other features, which have a higher percentage change value of customer satisfaction would also be significantly acceptable. Therefore with QFD approach, we found that there is significant increase in average customers satisfaction between the current and the new designs

Table No. 1 Customers Satisfaction Performance

Customers Needs		Current Design	New Design	% Change
Strong & Durable	X1	151	200	32.45
Easy to Assemble	X2	49	68	38.77
Easy to Move	X3	20	20	0
Suitable weight	X4	32	68	12.5
Suitable size	X5	132	105	-20.46
Attractiveness	X6	81	183	111.11
Easy to use	X7	72	72	0
Functionality	X8	27	54	100
Mobil Drawer	X9	0	12	100
Cupboard Storage	X10	27	27	0
Individual Lock	X11	0	12	100

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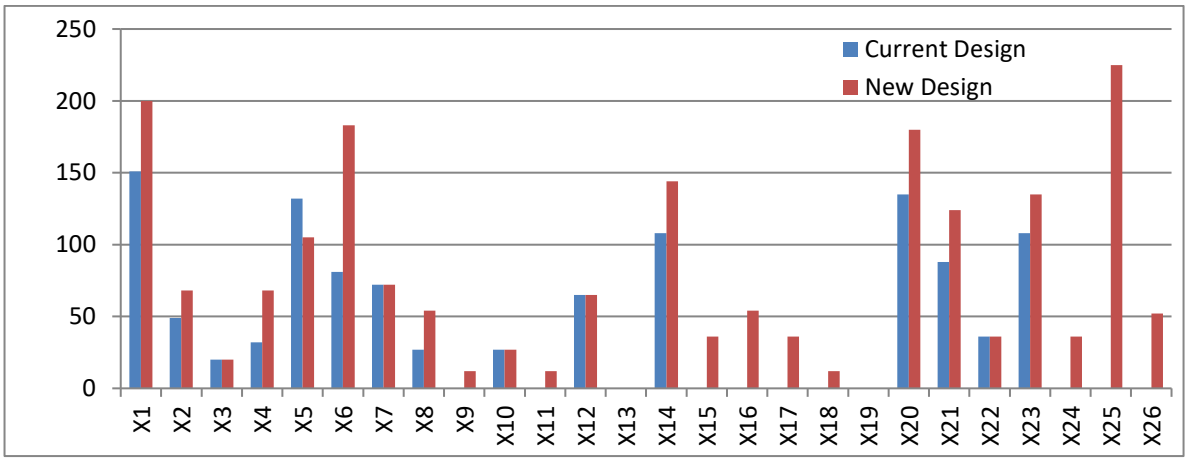
Separate location for parts	X12	65	65	0
Warranty	X13	0	0	0
Low Maintenance	X14	108	144	33.33
Strong Joint	X15	0	36	100
Easy to Handle	X16	0	54	100
Wide Drawer	X17	0	36	100
Pen Holder	X18	0	12	100
Level Adjustment	X19	0	0	0
Quality Material	X20	135	180	33.33
Quality Hardware	X21	88	124	40.9
Material Safety	X22	36	36	0
Correct Thick Board	X23	108	135	25
Standardize Material	X24	0	36	100
Quality Material	X25	0	225	100
Ease of Cleaning	X26	0	52	100
Total		1131	1956	--
Average		43.5	75.23	54.45



Graph no. 1 Average Customers Satisfaction of Computer work station before & after Improvement

Table No. 2 Absolute Importance Design Target

Customers Needs		Current Design	New Design	% Change
100 % Good Quality	X1	155	225	45.16
Suitable weight with size	X2	16	16	0
Table Size 4' x 2' & 4.5' x 2.5' same frame	X3	27	43	59.25
More than two color	X4	27	27	0
Able to carry max 100 Kg	X5	47	128	172.34
All movable parts can easily use	X6	234	341	45.72
can use more than one function	X7	60	134	123.33
No. of assemble parts > 15	X8	16	16	0
Use of modern latest material	X9	145	210	44.82
Material will be durable for min 5 Yrs.	X10	144	144	0
Color will not pale within 3 Yrs.	X11	27	27	0
100% good quality	X12	153	246	60.78
More than 2 model in same / different size	X13	12	43	258.33
Rectangular with curved corner	X14	54	39	-27.77

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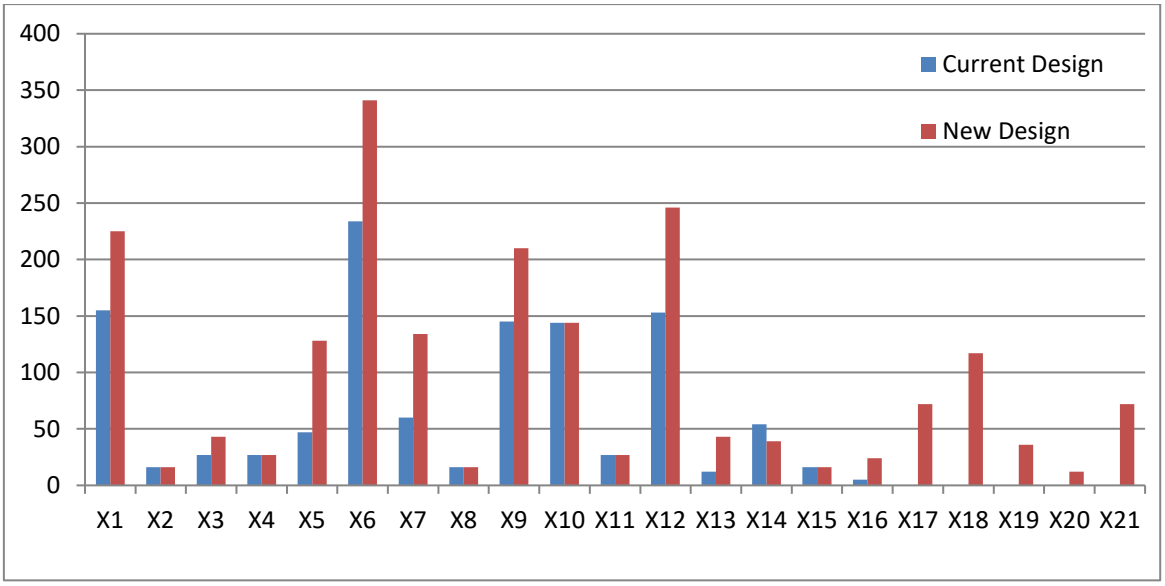
Competitive cost	X15	16	16	0
Can select various color & size	X16	5	24	380
Bright and Appealing	X17	0	72	100
Supplier have high standard & certification	X18	0	117	100
Surface of material must be smooth	X19	0	36	100
Corner curved (No sharp corners)	X20	0	12	100
As per Requirements	X21	0	72	100
Total		1138	1988	--
Average		54.19	82.83	79.14



Graph no. 2 Average Absolute Importance Design Target of Computer work station before & after Improvement

VII. CONCLUSION

Quality function deployment technique can be used in the processing development of new Computer work station to improve customer satisfaction. Customer requirements were transformed into the *House of Quality*. The newly designed and developed products varied in durability, assembly, attractiveness, Additional Features, shape, Size, Ease of cleaning, functionality and quality of the materials. The product satisfaction was evaluated by customers comprising of groups of product users, retailers and wholesalers. The results revealed that the average satisfaction values for all new types of products increased over those of the current products, from a level of 1131 to 1956 (54.45%) as shown in graph no. 1. Similarly absolute importance of design target for new design is increased over those of current design from a level of 1138 to 1988 (79.14%) as shown in graph no. 2. Hypothesis testing of the average customer satisfaction between the current and the new designs was found to significantly increase with regard to the QFD approach.

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