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An application of quality function deployment techniques on developing existing product

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***Abstract**-The main objective of this study is to develop the existing product by the concept of quality function deployment techniques. The quality function deployment (QFD) is a method for developing a design quality aimed at satisfying the customers and redesigns the products into consumer's demand. It is also a structured or systematic approach to ensure that the voice of customer is heard during the design of the process, product or service. This study focuses on understanding the QFD concept and implementing the concept into redesign according to customers' requirements.*

Keywords — *Quality function deployments (QFD), House of Quality, centrifugal pump.*

I. INTRODUCTION

Nowadays, the ability to present new products to the market in a fast way while satisfying customer expectations is getting more importance for the entire customer focused firms. The success of every business is more and more customer driven. As an organization needs to develop a customer's delight in order to bring the profit and high productivity to the company [1]. QFD is the only solution to plan products and services to meet the customers current and future, stated and unstated needs. QFD collects customer demands through various methods and converts them into technical necessities, which allows the resources to be allocated considering customer priorities. The tool was developed in Japan in the late 1960s when they moved from reverse engineering to product development based on originality. The first application of QFD was at Mitsubishi, Heavy Industries Ltd., in the Kobe shipyard, Japan, in 1972[2]. Owing to a very strong competition on the market, the companies are forced to develop very high quality products in order to survive and to be profitable. Quality planning includes six stages: 1) identification of quality goals, 2) customer identification, 3) determination of customer requirement, 4) development of new product

engineering characteristics, 5) development of the process which capable to manufacture the product and 6) Establishing the process control.

QFD is an effective tool for eliciting customers Stated and implied requirements. Since QFD for a product will be developed through brainstorming, it brings together the talents of every employee. It is also an effective quality-planning tool [3]. The tool enables conversion of customer need into specific quality plans. In this paper a centrifugal pump was selected as a study for this research because of its high sales numbers and widely used in every household, farms etc. The ultimate goal of this research is to design and develop an existing centrifugal pump based on the customer's requirement.

II. LITERATURE REVIEW

Literature review in electronic media such as journal Publications, case studies, books, and reports give a brief Explanation such as Govers (1996) has mentioned that Quality function Deployment (QFD) is not just a tool it is a process for product as well as production process development based on concept of companywide quality control. Success for firm is the cross functional management approach. QFD means translating customer requirement into product concepts. The design requirements WHAT's and HOW's. QFD develop based on common sense and effective information.

Govers (2001) has mentioned that QFD is a method of continuous product improvement emphasizing the impact of organizational learning on innovation. A company that struggles with and process management these process together create the transparency, focus and cohesion required to motivate concerted effort. The general resistances to implement QFD approach are lack of time, short term thinking, and lack of support [1-2].

Chan and wu (2002) have mentioned that QFD is a technique employed to translate customer voice into technical requirement. They conducted analysis on QFD's functional fields, applied industries and methodological development. Fuzzy logic method is used to deal with subjectivity and ambiguity of evaluation on "WHAT's" and "HOW's". They suggested quantitative

methods to use in QFD to improve its reliability and objectiveness.

Vairaktarakis (1999) has mentioned that QFD has helped organization to realize the reduction in product design costs and development time. QFD charts provide marketing insights and identify winning marketing strategies of competitors. Carnevalli and Miguel (2008) have mentioned literature survey on quality function deployment produced between 2002 and 2006. They done conceptual and empirical research, they found difficulties in its application like interpreting the customer voice, correlation between quality demanded and quality characteristics. QFD method use technique like fuzzy logic, analytic hierarchy process, analytic network process and artificial neural nets.

III.METHODOLOGY

To accomplish the goal of this research, the house of quality of the QFD technique was chosen and employed. Fundamental data were collected through questionnaires where the study groups consisted of product users and sales agent stores. Due to the unknown number of customers, the sample pumps to explore the needs of customers and the rating of customer satisfaction through questionnaires' [4]. It is calculated with respect to

$$n = \frac{P(1-P)Z^2}{d^2} \quad (1)$$

Where n is the sample pump, P is the expected proportion at 30%, Z is a random variable, and d is the margin of error in estimating P

The first questionnaire was used for surveying customer needs as customer requirement. At 80% confidence interval, it was found that at least 62 customers are needed to be surveyed regarding to equation 1 in order to obtain the customer needs information. The second questionnaire was conducted to obtain the significance level of needs. The third questionnaire was used to achieve the satisfaction rating of the case study factory in comparison to other similar products. The final questionnaire was established to compare satisfaction of customers between the current centrifugal pump and newly developed performance modified pump.

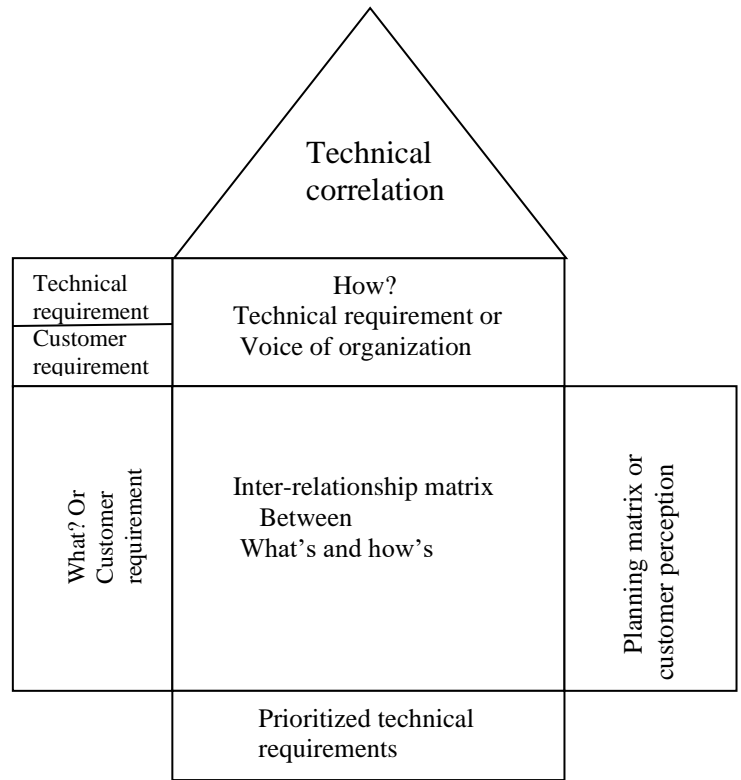


Fig 1: House of quality

Procedure

Three main steps is carried out the house of quality (HOQ) of QFD techniques is described as follows

Step 1: Voice of the customer

In order to obtain new modified product, the survey was conducted of the customer about the product. To obtain this information, two main groups from both product users and sales agent were investigated first questionnaire. Total of 60 questions were collected equally, 30 from product users and 30 from sales agent. This primary information from each side for questions which consists of personal ideas of each customer. From these ideas and analysis can be done using affinity diagram shown in Table 1

Step 2: Customer requirements

Based on the data collected from two or more questionnaire were produced to convey the significance level of needs and level of satisfaction on current pumps. There were many samples produced on each questionnaire focusing on category. The respondents were given an evaluation choice on a scale from 1 to 5, 5 being more important and 1 being less important [5]. In order to complete this task, the needs weights were multiplied by improvement ratio values, resulting in the important ranking.

Table1. Illustration of affinity diagram

Customers' needs
-performance pump
-energy saving pumps
-low cost
-Good functionality
-Safety pumps

Step 3: Product planning matrix

The first matrix of the QFD method is called House of Quality which is constructed to analyse and translate the customer requirements (what's) into technical requirements (How's). The basic structure of the HOQ is presented fig 1 (partovi and corredoira, 2002). The building of the first HOQ consists of 6 basic sections [6] (vairaktarakis, 1999), thus:

1. Customer requirement (WHATs) - a structured list of customer requirements
2. Technical requirement (HOWs)- a structured set of relevant and measurable product or service characteristics
3. Inter-relationship matrix- illustrates the QFD team's perceptions of inter-relationships between customer requirement and technical requirements.
4. Technical correlation (roof) matrix- used to identify where the technical requirements support or service design
5. Planning matrix- illustrates relative importance of customer requirements, customer perception of company and competitor performance in meeting customer requirements. It also contains prioritized customer requirements.
6. Prioritized customer requirement.

4. DEVELOPING A PRODUCT

4.1 Centrifugal pumps

The product which was chosen to develop is centrifugal pump. A pump is a device used to move fluids such as gases, liquid, or slurries. One common misconception about pumps is thought that they create pressure. Centrifugal pumps are widely used because of their design simplicity, high efficiency & low maintenance. Modern centrifugal pumps are not complex machines. Despite the simplicity of design and production, centrifugal pumps are still capable of posing complex puzzles during their operation. The performance of a pump must be modified sensibly, adapting the pump to ever changing needs of systems [7].

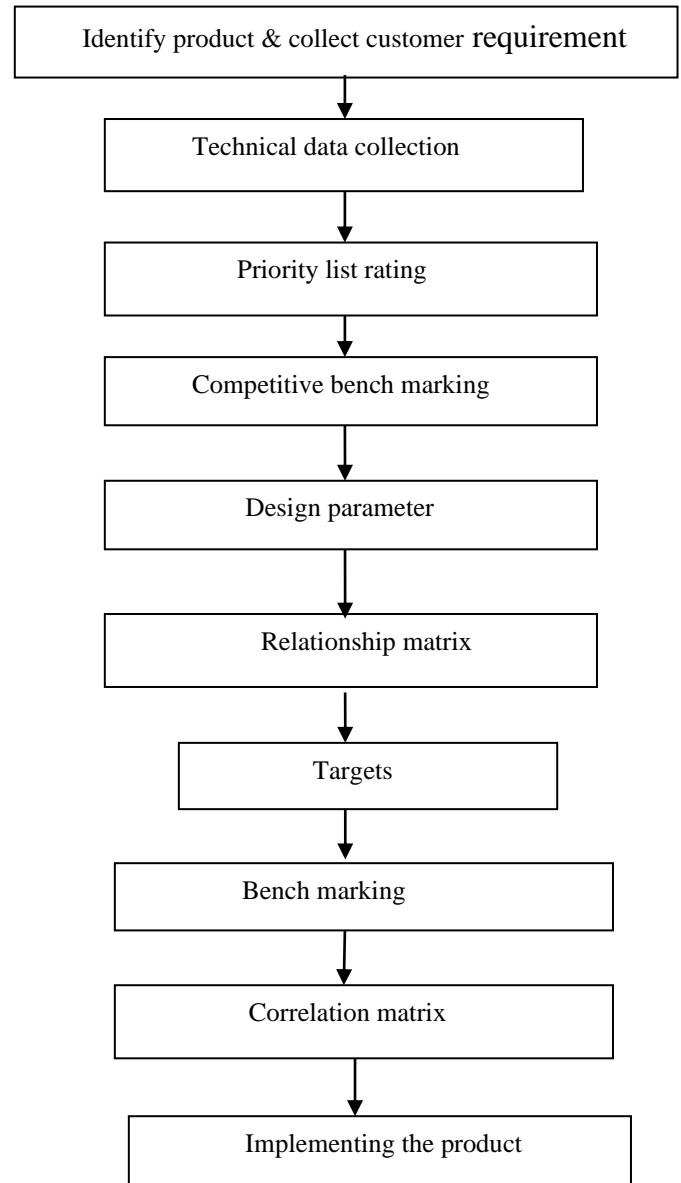


Table2. Methodology of QFD for product

In this work, one among the two most efficient methods, namely "Speed change" and "Impeller diameter trimming" method of speed change is used for analysis, and are experimentally investigated. Their effects on performance characteristics are comparatively evaluated. Effects of "Over filing" are also investigated. The pump used here is a low specific speed pump with overhung, enclosed, backward-swept, radial flow impeller and single volute casing. Experimentation is fully compliant with Hydraulic Institute (HI) standards [8]. The end results indicate that the methods give similar outcomes in terms of efficiency and financial saving as it is economical. The proposed work which satisfy the customer's need.

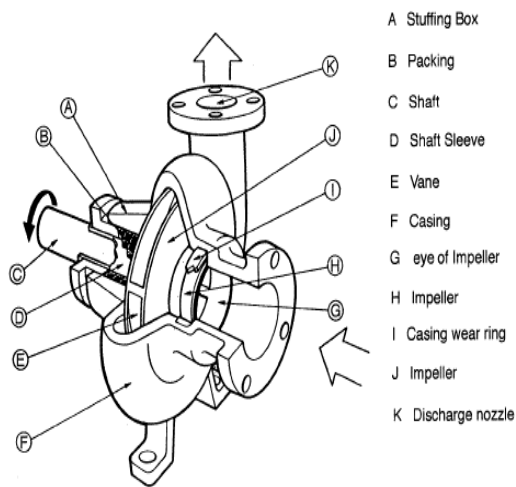


Fig2. Centrifugal pump

4.2 Test rig setup

Before establishing test-rig, nearly all popular pump standards were studied thoroughly, such as API 610, JIS B 8327, ANSI/ASME B73.1, ASME PTC 8.2, IS 5120 5659 6595 10981 9694, ANSI/HI. ANSI/HI standards are chosen as they are the most detailed and comprehensive standards for water applications. They are acceptable worldwide

4.3 Performance test prerequisites

It defines as two acceptance levels of tests; A & B. Level “A” is usually applied to those pumps that are manufactured for specific conditions according to customer’s requirement. Level “B” is usually applied to those pumps that are produced for stock. That’s why Level B test covers a wide range of operation points. As the present investigation work is comprehensive type rather than related to few points, Level B is chosen to test the pump.

Parameters measured were (1) suction gauge reading (2) discharge gauge reading (3) flow rate (4) rpm (5) motor output power or pump input power. For measurement of pressure, pressure taps should be located a minimum of 2DS (suction pipe ID) upstream from the pump suction flange, and a minimum of 2DD (discharge pipe ID) downstream from the discharge flange. Four static pressure taps shall provide around periphery of the pipe cross-section. The pressure tap opening shall be flush with the interior of the pipe and normal to the wall of liquid passage.

For measurement of capacity more than 10D long straight pipes were provided upstream to the rota meter for uniform velocity approach. A butterfly valve was used in the suction line. After suction valve, more than 10D long

straight pipe is provided upstream of pressure tap location to settle down turbulences. A globe valve was used to throttle the discharge line. A bypass discharge line with a gate valve, which bypasses the rota meter, is also provided for safety purposes. Variable frequency drive ACS350, manufactured by ABB Ltd., is used to vary motor speed. The drive has 3 control functions namely (1) Scalar frequency (2) Vector speed and (3) Vector torque. Pump installation was done according to HI 1.4[9]. Pump & motor shafts were aligned with wedges for parallel and angular misalignment. Details of instrumentation are given in Table 3

Table 3: Instrumentation details

Property	Instrument	Range	Resolution	Accuracy	Calibration
Discharge pressure	Digibar APCAL 6100, Altop Industries	-1 to 6 kg/cm2	0.0001 kg/cm2	±0.15% of FSD	Dead weight tester
Suction pressure	Bourdon Tube Vacuum Gauge, Fiebig	-0.1 to -0.95 kg/cm2	0.01 kg/cm2	±0.5% of FSD	Digibar APCAL 6100
Flow rate	Glass-Tube Rotameter, Flowtech Instruments	0 to 350 lpm	2 lpm	±1.5% of FSD	Venturimeter
speed	ACS350 variable frequency drive, ABB	0 to 30,000 rpm	1 rpm	± 5 rpm	Digital tachometer
Motor o/p power	ACS350 variable frequency drive, ABB	0 to 2000 watt	1 watt	±0.5% of FSD	Calibrated motor

4.4 Test procedure

The procedure of acceptance Level B test is recommended and followed throughout. Accumulation of test data shall begin only when steady-state test conditions have been settled down. Test shall include a sufficient number of points, but not fewer than 5 to accurately define the H curves. Test points shall include a minimum range of 25% to 120% BEP flow rate, plus the shut-off. Test arrangements shall be free from any hydraulic conditions which adversely affect pump performance. NPSHA shall be greater than NPSHR at all test flow rates during the test. See Table 4. Level B performance testing was done for speed change method [7].

Table 4: Test Summary Table

D2	147 mm		138 mm	128 mm	
P2	18°	18°	20°	24°	5° (overfilling)
RPM	2800	3188-3060 (55Hz)	3259-3150 (56Hz)	3352-3245 (57.4Hz)	2939-2872 (50Hz)
	2600	2919-2807 (50Hz)	2923-2834 (50Hz)	2938-2870 (50Hz)	
	2400	2336-2266 (40Hz)	Total pump running hours = 104 Total kWh consumed = 93		
	2200				

As the speed change method is advantages in terms of efficiency. It is observed that for all modified operations, the highest efficiency possible is less than the original (147mm-50Hz) operation. However, the power consumption may be more [9]. So, if system requirement change from 200 LPM – 22 m to 160 LPM – 15 m then the calculated bill is for 12 hours/day operation @ 5/- Rs. per unit. Thus, pump’s performance must be modified sensibly if system requirement changes.

5. RESULTS AND DISCUSSION

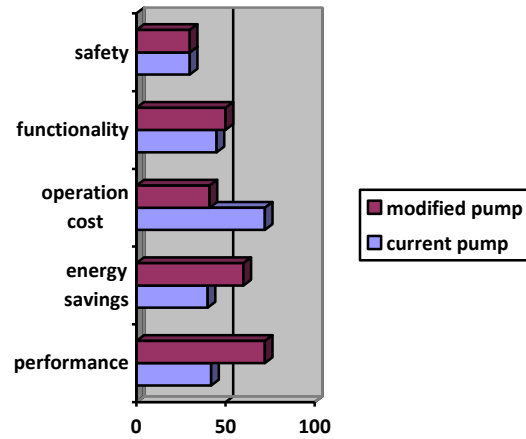
The HOQ of the QFD technique was applied to design and produce new modified type centrifugal pump. To determine customer satisfaction of the new modified type centrifugal pump over the current one, the forth questionnaire was used for evaluation. Since it is not possible for the total respondents to examine and trial uses the product, the evaluations were arranged through pictures and product descriptions.

To compare customer satisfaction before and after applying QFD technique, the percentage change valve out of 5 customer requirements (what’s) were considered as shown in table5.

Table5. Average percentage between current and modified centrifugal pump

Customer needs	Average customer satisfaction percentage	
	Current pump	Modified new pump
Pump performance	2919-2807 (55 Hz)	3188-3060 (55 Hz)
Energy savings per week	46 kWh	93 kWh
operation cost	12 hours/day @ Rs.10/- per unit	12 hours/day @ Rs.5/- per unit
Functionality in all aspects	No	Yes
Safety	Yes	Yes

Fig 3: Customer satisfaction of centrifugal pump before and after improvement



6. Conclusion

Quality function deployment technique can be used in the processing development of new modified centrifugal pump to improve customer satisfaction. The product satisfaction was evaluated by two parts groups of product users and selling agent stores. The results show that average customer satisfaction values for new modified type centrifugal pump increased over those of the current products.

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BIOGRAPHIES



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