ISSN: 2277-9655
Impact Factor: 4.116

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

QUALITY FUNCTION DEPLOYMENT IN THE DESIGN OF CUSTOM MADE FURNACES

SivadasAniyan T.S.*,Pramod V.R.
Mechanical Engineering, Karpagam University, Coimbatore, India
Mechanical Engineering, NSS College of Engineering, Palakkad, India.

DOI: 10.5281/zenodo.56940

ABSTRACT

QFD has been used effectively by various companies as a planning methodology. The main advantage of the QFD is that it shortens products development time, increase products quality, reduce cost and meet the requirements of the customers that have become the crucial issues in today's enterprises competition.Heat treatment is an important manufacturing process andfurnace is the key element in heat treatment process. The heat treat process variations can be often be attributed to temperature variation in the process. A tight control of temperature during the process is the key to achieve minimum path variation during heat treatment.

KEYWORDS: Quality function deployment,Furnace,Customer,Temperature uniformity,Control system

INTRODUCTION

Companies are finding that the effort to develop new products is crucial for their survival. QFD is a method for developing a design quality aimed at satisfying the consumer and then translating the consumer demands into design target and majority assurance points to be used throughout the production stage. While designing a new product, the approach must be looking downwards towards the quality that consumer demands in the finished product. Those demands must be incorporated into the quality plan and design quality and then systematically deployed from the upstream towards the downstream end of the production process regarding greater manufacturing specifics. This method is called design approach and quality function deployment is one such design approach. QFD as converting the customers demand into quality characteristics and developing a design quality for the finished product by systematically is deploying the relationship between the demand characteristics, starting with the quality of each functional component and extending the deployment to the quality of each part and process. The overall quality of the product will be formed through this network of relationships.

Electric based process heating systems are manufacturing technologies that use electricity to make to transform a product through heat related process. With indirect resistance heating, a heating element transfer heat to the material by radiation, convection or conduction. The heating element is made of high resistance material. To improve the efficiency of the resistance heating system (1) control system (2) clean heating elements (3) improve the insulation of the heat containment system (4) Match the heating element closely to the Geometry of the part being heated.

In this paper, QFD is a well-known new product development tool, is used to develop the quality and functionality of the indirectly heated resistance furnace to meet the customer requirements.

LITERATURE SURVEY

Adaptation of QFD effectively used in contract manufacturing in a suitable form in modern supply chain [1]. Enhanced QFD system with NPD cycle by using design of excellence, 6σ, process characteristic design, prevention by prediction against potential design problems. [2] Both QFD and FMEA can be linked through team work process. [3] A comprehensive level of understanding for all customer requirements that need to be deployed in to product development process has only been achieved by one quality to QFD. [4] Computerised heat treatment

ISSN: 2277-9655
Impact Factor: 4.116

planning system for batch type furnace is a software tool used to determine optimal part load design and furnace temperature control in heat treating process. [5] The development of numerical calculation method for estimating the temperature distribution in the furnace and work piece by FEA analysis. [6]

METHADOLOGY

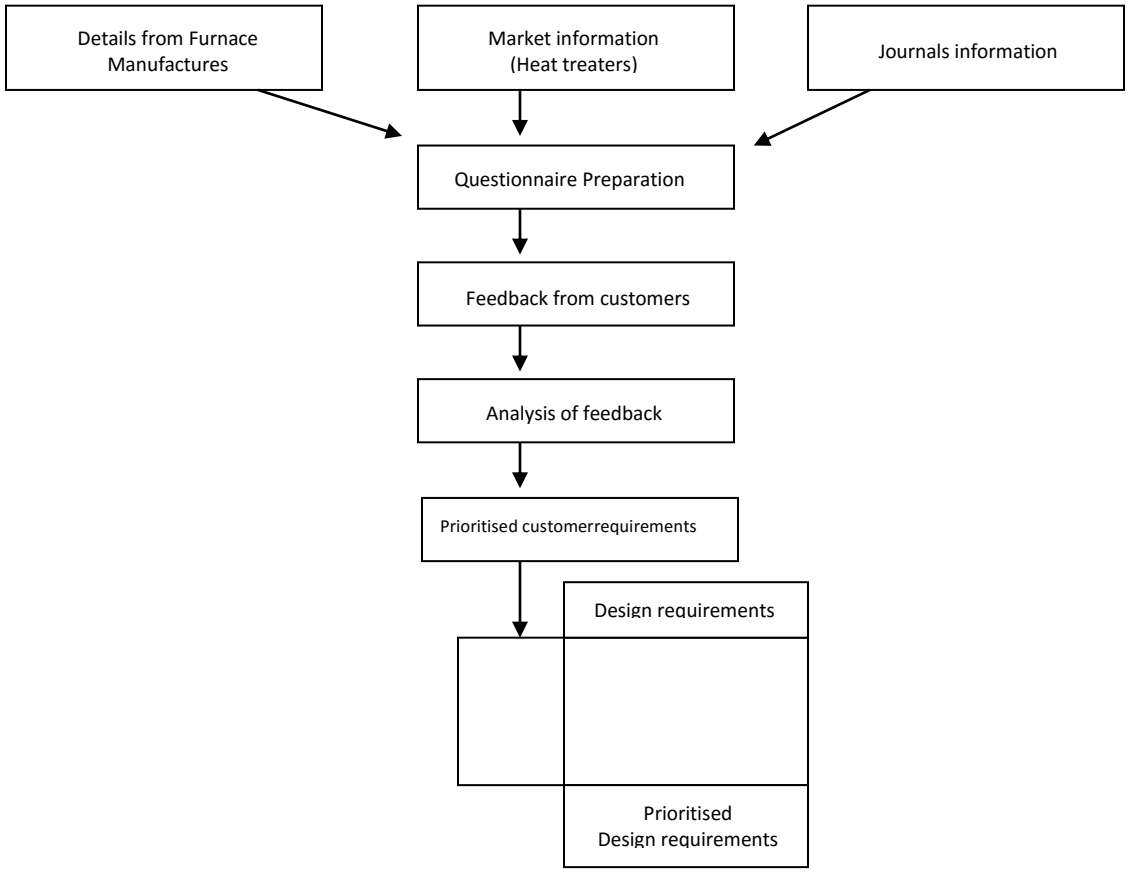

Figure 1: Methodology

QFD methodology provides a structural frame work for concurrent engineering that propagate the voice of the customer through all faces of product development. QFD is a set of metrics that relate inputs to outputs. In the product planning matric of QFD, house of quality, qualitative customer requirements are translated in to design independent, measureable, quality characteristics of the product. For the input to QFD, the use of voice of the customer table as a means for the collection and analysis of the customer information. Analysis of these data provides for greater opportunities for identifying exciting customer needs. There is a considerable evidence that brings market information into product design is critical for success. The objective of the QFD is (1) How to design a new product that meets customer needs. (2) To desire to provide QC processes chart (control) to manufacturing before initial production.

Akao's comprehensive model of QFD that broadly define to addresses both quality of the product as well as the quality of process. The QFD process will be very effective if there is strong cross functional involvement among the project team.

CASE STUDY

History of the company

The company was established in the year 1965, and started manufacturing furnaces, ovens and driers. Generally the furnaces are custom made. The company has the capability to design and manufacture the thermal processing

ISSN: 2277-9655
Impact Factor: 4.116

systems in house. The company has independent units of refractory and insulation brick unit, fabrication shop, Electric/Electronic assembling unit and testing facilities. The company has very experienced design, fabrication engineers and 50 numbers of highly skilled technicians. The main customers are defence establishments, Indian Railways, HAL, VSSE, Pharmaceutical companies and testing labs.

Design begins with the acceptance of the customer's full specification of the thermal processing equipment. Since the company is designing and fabricating the thermal processing system in the last 50 years, similar products that had been developed in the past is taken as the base line. Usually the new design will be the combination of old and new.

Discover the voice of the customer

One of the weakest links in the new product development process is the detailed market survey. The exact or exciting needs of the customers have to be identified. Questionnaire is prepared, distributed to the customers personally and Interviews were conducted to identify the exact requirements. The Questionnaire is a self compilation type and is a 10 point numerical scale rating. The numerical scale rating is very friendly, leads itself very readily to statistical analysis and visual communication of results.

Questionnaire preparation starts with the collection of information from furnace manufacturers, commercial heat treaters, metallurgists, aerospace customers and also from the journals. The detailed questionnaires were prepared and are distributed to 13 customers. All these customers are still using furnaces from the company. The result of the customer feedback is (prioritised customer requirements) is the input to the QFD matrix.

Linking customer part with QFD

QFD is a method, that starts with customer needs. The prioritised customer needs are taken in to QFD matrix and corresponding measurable design requirements are also identified after consultation with furnace designers, journals and R & D Engineers. The correlation and relationship matrix were established. The QFD thus formed is shown in figure.

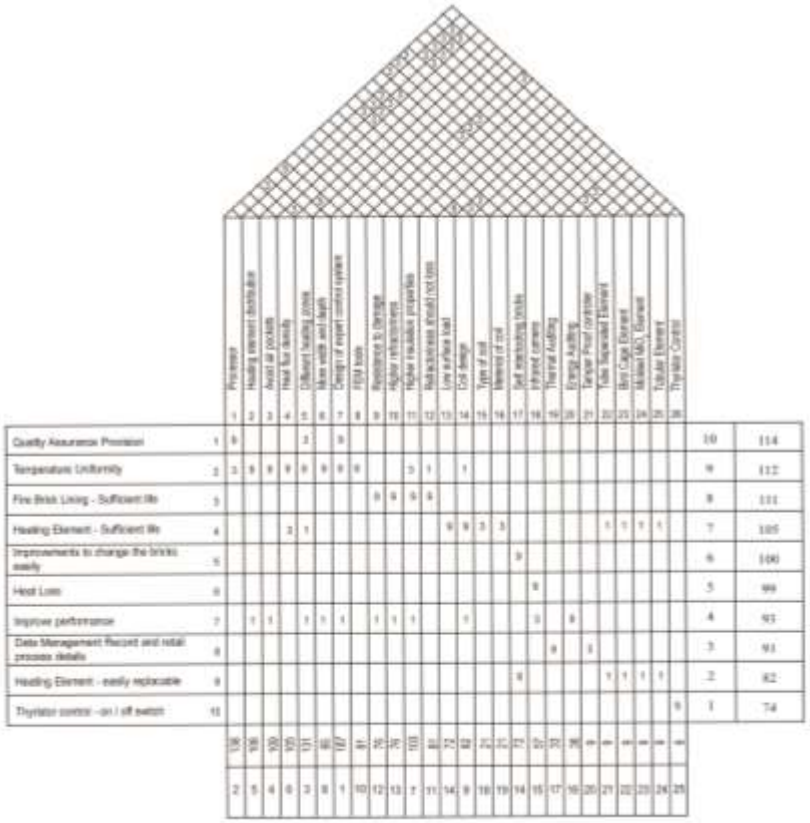

Figure 2: QFD matrix

ISSN: 2277-9655
Impact Factor: 4.116

PRIORITISED CUSTOMER REQUIREMENTS	ENGINEERING CHARACTERISTICS
1. Quality assurance provision	1. Processor
2. Temperature Uniformity	2. Heating element distribution 3. Avoid air pockets 4. Uniform heat flux density 5. More width and depth 6. Different heating zones 7. Design of expert control system 8. FEM tools.
3. The fire brick lining has sufficient life	9. Furnace lining has higher resistance to mechanical damage 10. Higher refractoriness 11. Insulation properties should not loose for long period of time 12. Refractoriness should not loose for long period of time
4. Furnace element has sufficient life	13. Law surface load (watts / cm^2) 14. Coil design 15. Type of coil (Strip / Wire) 16. Material of coil
5. Improvements has to be made to change the damaged refractory bricks instead of changing the whole set of bricks	17. Self interlocking bricks
6. To identify the heat loss, thermal imaging must be conducted	18. Infrared camera
7. To improve the performance of furnace	19. Thermal auditing 20. Energy auditing
8. Data management – record and retain process details	21. Tamper proof controller which can record the process information (Alarm, process variation)
9. Heating elements must be easily replaceable	22. Tube separated element 23. Bird cage element 24. Moulded MISIO2 element 25. Tubular element
10. Furnace power control	26. Thyristor control with parallel on / switch

RESULTS AND DISCUSSION

(1) Design of Expert Control System

Accurate and repeatable temperature control is at the heart of most heat treatment processes. This require accurate control for both the programming set points and the study state temperature control over a wide range of temperature set points and furnace loading

(2) Processor

Temperature in a defined work load region must be within a given tolerance and temperature uniformity surveys (TUS) are often carried out to determine the degree of compliance. Heat treatment furnaces are also controlled by a range of system accuracy test (SAT's), which define the type and accuracy requirements for the control instrumentation and sensors.

(3) Different Heating Zones with Control System

- Using optimal size of the heating zones with independent control system
- Proper distribution of Electrical Heating Elements.
- Fans can be provided for air circulation

(4) Avoid Air Pockets
- Chamber shape can be made as capsule shape.
- Proper design of Heating Element distribution.

(5) Heating Element Distribution
- Strip Element with transformer and distribute the Element in maximum area.
- Freely Hanging Wire Heating Element.
- Low surface load (W/m^2) for maximum life of the heating coil.

(6) Heat flux density
- Chamber size and shape.
- Wall loading (KW/m^2)

(7) Higher Insulation properties
- Insulation Bricks: For continues furnaces, bricks are preferred but the initial heating time is 4 times higher than Ceramic Insulation. For heavier load, bricks are preferred.
- Ceramic Insulation.

eg:- Ceramic bond, Ceramic wool, Ceramic Blanket, Fibre bond.
For batch type furnace, where the power saving is required (Rapid heating and cooling) Ceramic Insulation is preferred.

(8) More width and depth
The furnace chamber has more width means it can carry more load. By increasing the depth of the chamber, more heating zones can be accommodated with independent control system, ultimately improve the uniformity of temperature.

(9) Coil design
- For increased life of the coil and lesser construction cost, less width and high depth are preferred for furnace chamber.
- If the heating coils were placed on the bottom of the furnace, it may sacrifice the life of the coil.
- Freely radiating corrugated wire element will radiate more heat
- Vertically hanging corrugated strip element is also radiate more heat.

(10) FEM Tools
The CFD modelling and study can be conducted to predict the thermal gradient inside the chamber, to position the heating coils in the chamber, positioning the fan etc.

CONCLUSION
The most important customer requirement is to maintain temperature uniformity inside the furnace. By using higher insulation properties for the bricks, the heat loss can be reducing which safes the electric energy to the furnace. By using FEM tools, in the design stage itself we can predict the characteristics of the furnace which ultimately reduce the final fine tuning cost of the furnace.

REFERENCES
[1] Jui-chin Jiang and Ming – Li Shiu, Mao – Hsiung Tu. “Quality function deployment technology designed for contract manufacturing” The TQM magazine, Vol 19, No 4, 2007, PP 291-307
[2] Ming – Li Shiu ,Jui – chin Jiang, Mao – HsiungTu Reconstruct QFD for integrated product and process development management. The TQM magazine, Vol 19 No.5 2007 PP 403-418
[3] D.M. Ginn, D.V. Jones, Hrahnejat, M. “ZairiThe QFD/FMEA interface” European Journal of Innovative Management
Vol 1, Number 1, 1998, PP 7-20
[4] Brown P.G. (1991) “QFD echoing the voice of the custome”r, AT&T journal March / April PP 18-32
[5] Dr. Quansheng (Charls) Lu, Jinwu Kang, RohitVaidya, Cheng Bai, Wei Wei Wang, Yiming (Kovin) Rong. Research programms
CHT – bf – Computer aided heat treatment planning system for batch furnaces
Jan 2000 – Dec 2002.
[6] Jinwu Kang, RanjeetYadev, RohitVaidya, Weiwei Wang, YimingRong Research programms.

ISSN: 2277-9655
Impact Factor: 4.116

Development of analytical tool for part load design and temperature control within loaded furnace and parts.