

Robust Design in Metal Furniture Design

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Abstract

This paper will manifest the concept of robust design and its roll in minimizing unnecessary costs that does not serve any function or purpose in order to satisfy the user needs with the required quality and performance with the lowest overall cost. This requires that all Furniture Designers and manufacturers have to meet the criteria of getting the best for less. In the other hand it is very important that robust design need to be implemented as a tool to get a competitive edge for all designers and manufacturers. Effective answers of (4Ws & H) lead to create a general concept of the meaning and important of robust design. Which reflects on the metal furniture design and its process. This paper presented proposed Strategy of embed R.D in F.D that depends on the adoption of good design and oriented job in the most successful way.

1. Introduction

The practice of modern industry and excellent design of any product intended to shift resources to the creative design process rather than relying on achieving quality assurance. A quality characteristic is identified, and quality is achieved by reducing the deviation from its target rather than mere conformance to specifications.

Effective answers of (4Ws & H) lead to create a general concept of the meaning and important of robust design. This set of questions will be used to find an approach to the benefits of robust design in developing the metal furniture design and manufacturing. The next figure shows the research theoretical framework as shown in figure 1.

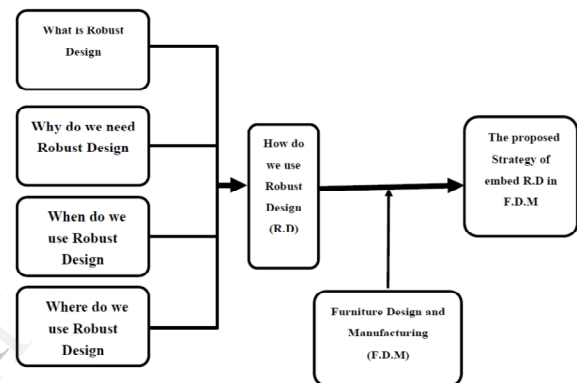


Figure 1 : research theoretical framework

2. Robust design through (4Ws & H)

Among the design methods currently studied in engineering, researchers often identify robust design (RD) as one of the most important fields for the purpose of quality improvement. The robust design concept is " the best design is one which performs as expected in the face of both expected and unexpected variations; and it does so by virtue of the fact that the design is inherently insensitive to changes in the design parameters and service environment" .So we study the robust design through the 4Ws (what, why, when, where and how) . This set of questions will be used to find an approach to a new thinking method, allows the designer to be acquainted with clear vision on the inputs and the challenges facing during the robust design process sequence.

2.1 What is Robust Design?

What? ... This question used to determining the process and actions, Such as setting goals, tools, roles, Etc. Questions started with What?.. It will be used in determining the general meaning of robust design (RD).

G. Taguchi, a Japanese engineer, had a big effect on quality control and experimental design in the 1980s and 1990s. Taguchi has proposed various performance measures known as Signal-to Noise (SN) ratios for

evaluating the performance of engineering systems. Taguchi states that a good design minimizes the quality loss over the life of the design, where quality loss is defined to be the deviation from the desired performance. So, Taguchi recommended robust design approach that reduces variation in a product.

Recently, "robust design" has become a popular design philosophy among major manufacturers.

A Design is robust when the product performance is minimum sensitive to:

- Material Variation
- Manufacturing Variation
- Operation Variation (Hong Zong Lin:2005)

A robust design is a design whose performance is not unacceptably compromised by expected variations in parameters which are known to effect its performance, and is more tolerant to unexpected variations.

Robust design can be achieved when the designer understands these potential sources of variation and takes steps to desensitize the rproduct to these potential sources of variation. Robust design can be achieved through "brute force" techniques of added design margin or tighter tolerances or through "intelligent design" by understanding which product and process design parameters are critical to the achievement of a performance characteristic and what are the optimum values to both achieve the performance characteristic and minimize variation.(Kenneth Crow:1997)

Robust design is an engineering methodology for improving productivity and optimizing the product and process conditions which are minimally sensitive to the various causes of variations, and which produce high-quality products can be produced quickly and at low development and manufacturing cost. (Sung H. Park, Jiju Antony: 2008, S. Phadke:1989).

Robust design method uses a mathematical tool called Orthogonal Arrays to study a large number of decision variables with a small number of experiments. It also uses a new measure of quality called signal-to-noise (S/N) ratio to predict the quality from the customer's perspective.(S. Phadke:1989, Sung H:1996, Tapan P:1993)

Robust design is a process to obtain product performance that is minimally affected by noise. (Sung H. Park, Jiju Antony: 2008)

A product or process is robust when it is insensitive to the effects of sources of variability, even though the sources themselves have not been eliminated.

Finally we can define robust product as the product that achieves a high level of performance and steady in

spite of exposure to the different conditions and effects during use and operation as well as during production.

2.2 Why do we need Robust Design?

'Why'? ... This question used to determine the cause, and used in the analysis and comparison. We ask about the reasons that we need for a Robust Design.

The fundamental principle of Robust Design is to improve the quality of a product by minimizing the effects of the causes of variations without eliminating the causes. This is achieved by optimizing the product & process designs to make the performance minimally sensitive to the various causes of variations.(Shyam Mohan,2002)

Robust design methodology serves as an "amplifier" that is it enables an engineer to generate information needed for decision making with less than half the experimental effort. (Shyam Mohan,2002) A robust design method is applied to enhance this quality by reducing the discrepancy between the actual consumer feeling and the target feeling, and by reducing the feeling ambiguity induced by the highly individualized characteristics of the consumers. (Hsin-Hsi Lai et al. :2005) Robust design approach can usefully be applied to improve the feeling quality of products.

2.3 When do we use Robust Design?

When? ...To incorporate the time dimension

Robust Design focuses on improving the basic functionality of the product and processes and thus facilitates flexibility in design and production technology associated with it, is an effective way to reduce costs and improve quality as well as reduce product development time.

Robustness is a quality system linked to cost and engineering focuses on the effective application of engineering strategies instead of using advanced statistical methods, and this includes the application in the early stages of the design of the product, as well as during different stages of production .Methods that are used in the early stages depend mainly on statistical testing on a small scale to reduce the possibility of change, taking into account a Robust product at a reasonable price can be produced in large quantities. As for the techniques that are used during the stages of production depends on production control during various stages to ensure the quality and the right price.

Differ from the rest of the other methods and techniques that focus on solving the problems of quality in that they focus on solving the problems of quality in the early stages of the design when developing production.

2.4 Where do we use Robust Design?

The word "Where" express about place, so we need robust design in the places that meet noise. Internal and external noise meets the interior places where the products performs its functions , while unit to unit noise meet the manufacturing places of the products .

Therefore, we need to robust design in productive places such as factories and workshops to avoid productivity factors affecting the quality of the production of these products represent unit to unit noise factors. We also need robust design in places where product perform function under different external factors such as humidity, temperature that affecting the performance of the product, as well as places in which the product perform function under pressure as misuse.

How do we use Robust Design?

How? ...use to determine the mechanisms and tools achieving the goals. that word answers the previous questions and ensure integration among them. Taguchi's view was that in traditional systems, robustness (or in general, quality) was measured by some performance criteria, such as:

- meeting the specifications
- % of products scrapped
- Cost of rework
- % defective
- failure rate

Hsin-Hsi Lai et al. (2005) found that the fundamental point in applying robust design is to develop the means to identify the controllable and uncontrollable factors which have a significant and powerful influence on quality. In other words, the appropriate selection of the controllable and uncontrollable factors, and their levels, has a crucial influence on the efficiency of the robust design.

Robust Design can be achieved by "Intelligent Design", by understanding which product/process design parameters are critical to the achievement of a performance characteristics and what are the optimum values to both achieve the performance characteristic & to minimize its variation. Robust Design is based on the principle of optimization in which the objective function is defined as the signal to noise ratio which will help in finding those values of the design parameters at which the response is least sensitive to the different effects of noise factors.(S. Phadke:1989, Sung H:1996, Tapan P:1993)

Table .1 Basic phases in robust design for feeling quality (Hsin-Hsi Lai et al. :2005)

Phase	Description
Setting target feeling	Identify crucial images and evaluation scales Construct multidimensional feeling space

	Select the position of target feeling
Taguchi experiment	Identify control factors and setting levels Identify uncontrollable factors and setting levels Select inner and outer orthogonal array Array the experiment and generate experimental samples Perform feeling evaluation experiment
Result analysis	Calculate feeling discrepancy Calculate S/N ratio Select the setting optimal parameters
Improveme nt and verification	Select powerful control factors by ANOVA (Analysis of variance) Redesign initial design Predict the S/N ratio of the improved design Perform verification experiment to confirm the prediction

3. Robust Design and Furniture Design

With advances in the furniture industry growing interest in employing the scientific and technological potential to achieve quality assurance and raise (the efficiency of the products)

A designer's main task is to apply scientific knowledge to the technical problem solutions and then optimizing that solution within the given constraints in order to determine the major attributes of the product, such as capability to meet product specifications, quality, and cost.(Jami Kovach et al.,2008)

"The robust design methodology provides the means to minimize the variability of products and processes in order to improve their quality and reliability. This particular design methodology has been successfully employed in a wide variety of fields" (Hsin-Hsi Lai et al. :2005)

In metal furniture Robust Design is an advanced level in the product design in examining relations governing the equilibrium and stability of structural configuration towards the influence of noise factors, and is considered the structural and functional behavior of the design elements is a key test for safety and security in the product to become Robust Design.

Robust Design works to improve quality standards in the manufacture of metal furniture even kept pace with scientific and technological development, and activate their role in improving the competitive position, create the means to achieve compliance with the specifications of international quality.

In metal furniture robust product must achieves a high level of performance and steady while exposure to

the different noise conditions and effects during use and operation .

4. The proposed Strategy of embed R.D in F.D

Design Research confirmed the excellence ability of Robust Design and its role in maximizing the added value and competitive advantage, as the design source and a catalyst for fundamental ideas in product development strategies. While Design strategy is a plan of action to have competitive advantage through product design process. .(James A. Fitzsimmons et al., 1991). Also manufacturing strategy is interested in key decisions about the role to be played by the manufacturing function and emphasizes increased interaction between manufacturing and marketing in achieving competitive advantage.(G.S. Dangayach and S.G. Deshmukh,2000)

Achieving Robust Design goals in metal furniture industry depends on the adoption of good design and oriented job in the most successful way, through innovation in coming up with ideas, flexibility, the ability to change, and organize ideas in patterns broader and more comprehensive (such as the ability of synthetic and analytical capacity)

The proposed model consists of the following steps:

1. Identify the vision, the vision is how the organization sees itself or wishes to be seen at some time in the future. (Glenn H. Mazur: 1998)

2. Identify the strategy mission, the mission identifies the activities that the organization believes will allow it to achieve the vision. Missions are activities over which the organization can exert enough control so that it can predict if its performance will be adequate to achieve the vision. (Glenn H. Mazur: 1998)

3. Identify planning stage through the furniture design variables , quality characteristics and identify noise factors. This is often based on prior knowledge concerning the furniture design system under investigation.

4. Select appropriate test which deals with the noise factors (External, Internal, and Unit to unit) noise.

5. Analysis stage through analyze noise tests results to determinate the required data.

6. Analyze the data. Estimate the fitted functions for the robust design considerations.

7. Determine the optimal process in design or redesign stage .

The next figure shows the proposed model of Robust Design Strategy in Metal Furniture:

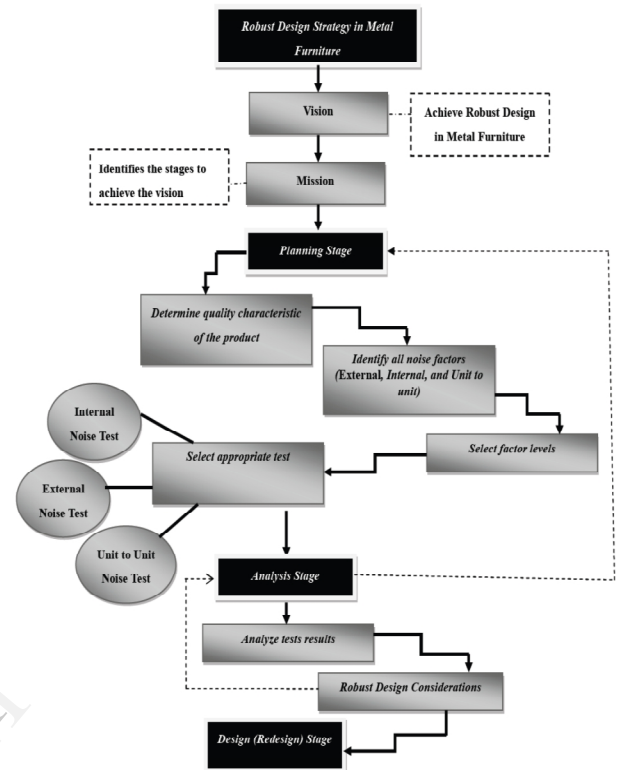


Fig. Robust Design Strategy in Metal Furniture

5. Case study in Egyptian market " Mohm high back chair (CHWJ 1)"

Mohm company started in 1991 in the Egyptian market, Mohm took an oath to be the innovative contemporary Egyptian furniture company that matches universal standards, such a progression was not an easy task; with the hard work of 1200 workers and high-tech machines along with 6 factories, Mohm was able to engrave its name in the furniture business worldwide and keep its important role in flourishing Egyptian furniture industry.

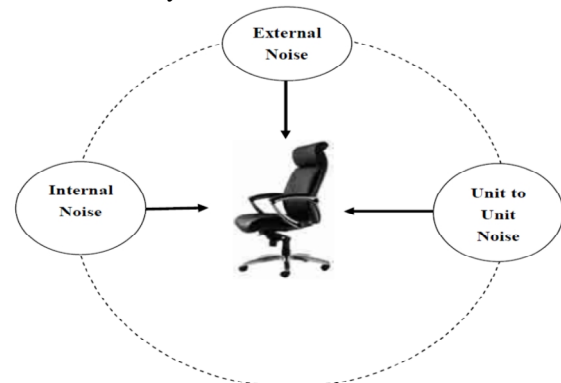


Fig. Mohm high back chair (CHWJ 1)

Mohm presents metal in a good quality, so we choose one of its products to be the case study" Mohm high back chair (CHWJ 1) ".

table 2 identify noise factors

Noise	Description
External Noise	Temperature/humidity in which product is used
	Any unintended input of energy (heat, vibration, radiation)
	Dust in the internal environment where chair is used
	Human error, including misuse of chair
Internal Noise	Distortion during use or storage of chair
	Compression set or creep of a chair
	Distortion of compositing Materials (Chair upholstery, Wheels, Hand supportive)
Unit to Unit Noise	Variation that take places in the manufacturing process

table 3 appropriate tests

Noise	test
External Noise	Tests related to the extent of adapting the materials compositing the chair for climatic and behavioral changes.
Internal Noise	Tests related to the extent of adapting the materials compositing the chair for distortion during misuse or storage.
Unit to Unit Noise	Questionnaire to indicate the extent of the precautions that are available when manufacturing processes and to avoid variations

Conclusion

In this paper, manifest the concept of robust design through the 4Ws&H (what, why, when, where and how). This set of questions used to find an approach to concept of robust design. We proposed a strategy of embed robust design in furniture design that depends on the adoption of good design and oriented job in the most successful way .Our proposed model considers the identifying of vision, mission and planning stage through the furniture design variables , quality characteristics and identify noise factors. The selection of appropriate test which deals with the noise factors ,followed by analysis stage through analyze noise tests results to determinate the required data to estimate the fitted functions for the robust design considerations.

These considerations determine the optimal process in design or redesign stage.

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