A study on production design: considering quality function deployment, multi-item designing and operating efficiency in the design phase

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Abstract. Today manufacturing companies are facing a situation of intense competition when it comes to new product development. Innovations in information and communication technology connect people worldwide through the Internet without physical limitations, and in a faster and ubiquitous way. As global customer needs are continuously changed by these innovations, manufacturing companies need to create new products in short cycles. Furthermore, the quality of these new products and their demand is even higher than before. Therefore, manufacturing companies, in their production cycle have to overcome two main challenges. The first one relates to lead time or the time necessary to complete production of new commodities, which is constantly becoming shorter. The second one refers to the quality assurance of these new products, which is permanent and systematic. In this study, a framework that aims high quality and productivity in the design phase is proposed. This study applies the concept of quality function deployment, which is the process that organizes the information from the customer demand phase to the product manufacturing process. Finally, a new design approach of quality function deployment that considers multi-item designing and operating efficiency in order to facilitate production design is devised.

Keywords: production design, quality function deployment, operating efficiency, multi-item designing, product innovation

1. INTRODUCTION

Today, the problem of manufacturing companies under the global competition is to find solutions which consider shortening product development period and quality assurance. In the history of manufacturing, the keywords moved from “mass production” to “multi-item small-sized production”. As a result, “shortening product life cycle” is added to “multi-item small-sized production” in order to assure production viability through a higher demand and faster lead times. Accordingly, the role of the manufacturer is to supply not only developed products, which consider customer needs, but also shortening product lead time from the grasp of customer needs to complete its new products (see Figure 1). Of course, the manufacturer does not forget about quality assurance too.

This study focuses on production design, which considers product quality and operating efficiency. The role of production design is to devise commodities based on factory

design and schematics from the design department. This position is located in between design department and manufacturing department. Ideally, the flow of information should be smooth from design department to manufacturing department. However, the real flow of information is not really without its hiccups. That is because the highest priority of design department are the customers' needs, as they are the ones using the product, and the highest priority of the manufacturing department is factory's operation and efficiency respectively, to attend the customer's demands. In this study, quality function deployment is suggested as possible solution to these issues in the production information chain. Quality function deployment then devises a methodology, which possibly fixes design quality based on customer needs. This study proposes a new concept for production design combined with quality function deployment.

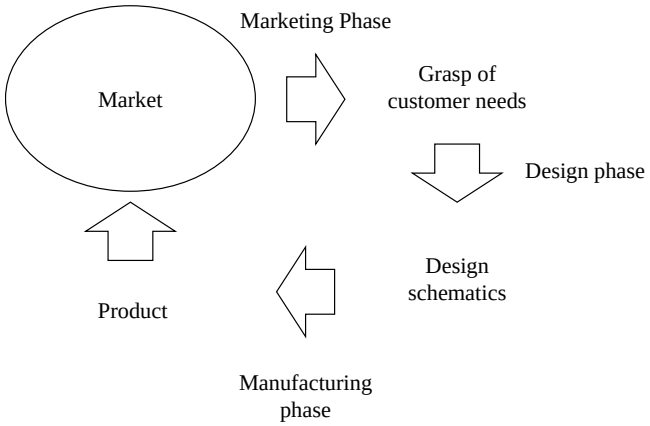

Figure 1: Flow of operations in manufacturing company

2. WHAT IS PRODUCTION DESIGN?

What is called production design, in the manufacturing industry, is the process of developing a product following a plan devised in the design phase and following the design plan (design schematics) throughout the whole manufacturing phase and beyond it, as it adds new ideas that would lead to new products (Morris, 2009).

Considering this definition by Morris, it is possible to understand that the production design process is a complex and multi-layered one, which is present in all the stages of product manufacturing and it involves an intricate communication chain between design and manufacturing phases, at times difficult to oversee. That said, the objective of the production designers is to make sure that the products are made in conformity with the design schematics and that the highest quality is always achieved in the production line. The location and role of production design can be observed in the Figure 2 bellow.

Firstly, the designer (s) would draw a product design schematics in the design phase. After this, E-BOM (Engineering Bill of Materials) is decided based on design schematics. Also, a BOM (Bill of Materials) is the necessary list of parts of a product, which has been created by the designers in order to manufacture this product as well.

The characteristic of E-BOM is focus on the functionality of the final product. After this, M-BOM (Manufacturing Bill of Materials) is rearranged by E-BOM considering production process. M-BOM express necessary details that helps in the stages of production with information such as standard time of operation, production area, and others.

Finally, the production starts in the manufacturing phase and in perfect conditions, the flow of information is smooth from the design phase to the manufacturing phase. The flow of information, however, has to be controlled in each step of the process.

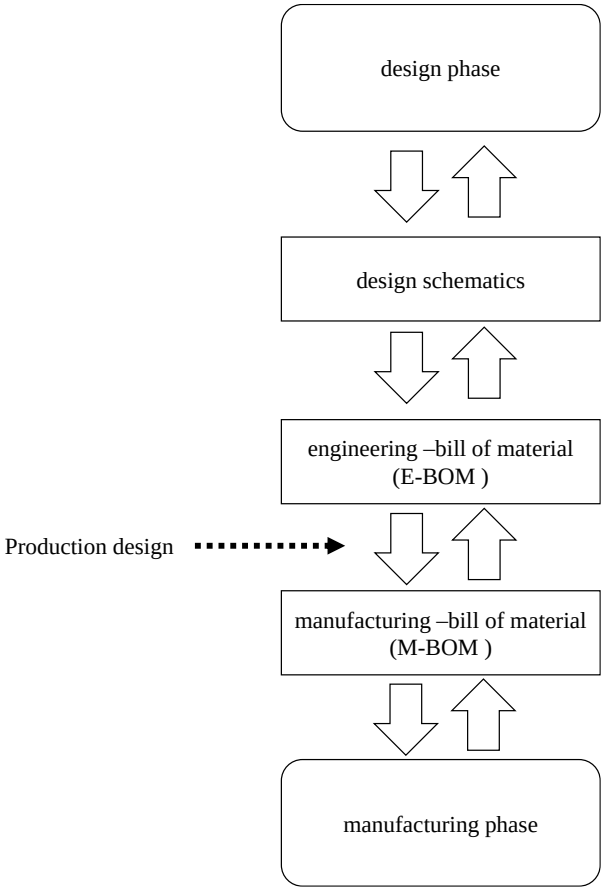

Figure 2: Flow of information from design phase to manufacturing phase

That is the moment when QFD (Quality Function Deployment) is necessary in order to maximize the efficiency of the production process.

3. THE BASIC CONCEPT OF QUALITY FUNCTION DEPLOYMENT

Figure 3 shows the flow of product from development stage to manufacturing phase. When considering quality in manufacturing, there are actually two types of quality in manufacturing to be observed. One is the quality of conformance, or simply putting it, the gap between the design of a product and its finished form.

Let us imagine, for example, a pen. Supposing that the length of this pen is 150.0mm in the schematics or its planning stage a modification in its planned characteristics will take place. That said, after the manufacturing stage or when the pen is actually made, its actual length is 150.2mm. This difference is what we call quality of conformance. The other type of manufacturing quality is quality of design. This type refers to the gap between the voice of the customer (VOC) and the design schematics. In the case of the pen, for example, the voice of the customer was "easy to hold". In order to satisfy this, the pen's length in the design schematics was to be 150.0mm. That is when quality function deployment, according to our approach is necessary. QFD (Quality Function Deployment) is used to determine and set this quality of design. In order to set the Quality of conformance, we use Statistical Quality Control (SQC) in tandem with QFD. Additionally, and according to our proposition, in order to set the Quality of design, QFD is then applied.

QFD organizes information efficiently and allows for proper flow of information in the production process. Figure 4 shows the "quality table". First, VOC (voice of the customer) is "collected," for example, through interviews, questionnaires and others. Then, the required quality is decided. After this, the quality characteristics, which evaluate the required quality, are set. Then, the design team considers the relationship between the required quality and the quality characteristics of the product. The result will provide quality of design for that product. Accordingly, the required quality transforms the quality of design for that product.

Moreover, QFD connects essential information about the product's parts and the production process as showed in Figure 5. The matrix in Figure 4 is expressed by matrix① in Figure 5. These are product's parts which affect the quality characteristic grasped in matrix② seen in Figure 5 as well. The production process of manufacturing these parts is detailed in matrix③ also seen in Figure 5. Accordingly, the totality of the production process, affected by customer requirements is grasped before, during real manufacturing phase and beyond it by applying QFD. Let us see now how QFD affects production efficiency.

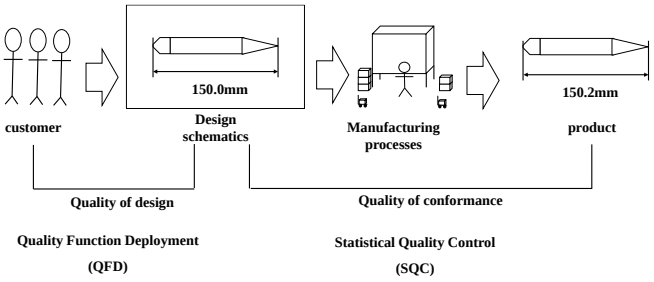

Figure 3: Considering of quality (Kiuchi et al, 2016)

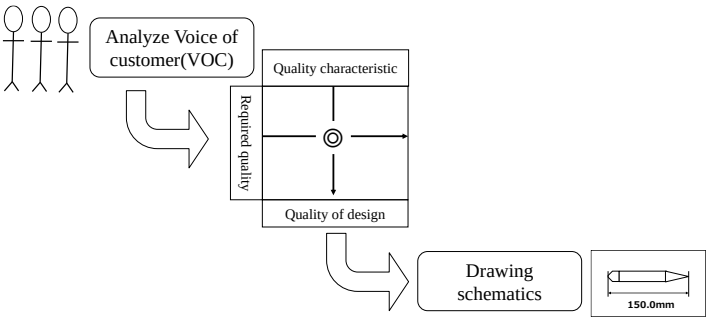

Figure 4 Flow of QFD (Kiuchi et al, 2016)

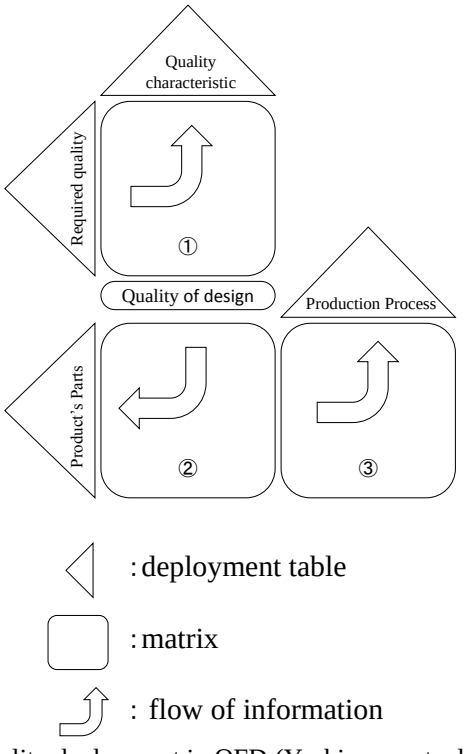

Figure 5 Quality deployment in QFD (Yoshizawa et al,2004)

4. CONCEPTUAL DESIGN OF QFD: CONSIDERING PRODUCTION EFFICIENCY

According to Mizuno and Akao (1978), QFD, taken as a concept, is focused on the production of one item only, which is then developed by the company. Therefore, the object of QFD would be the information flow from product design and the manufacturing of one single item. However, multi item design and production are situated in a production system that considers the viability of multi item production in a mixed production line system as well. In reality, though, this possibility is not really fully explored in the design and manufacturing lines.

As it is, if the designer decides to apply QFD as his/her production approach in the current manufacturing philosophy, it will be difficult to predict issues in the real production system. Accordingly, the information conflict between design phase and manufacturing phase becomes a major concern.

This study proposition for the use of QFD can be seen in details in Figure 6. The main characteristics of QFD presented in Figure 6 are two. The first one is when the designer recognizes the product's quality conformance. In typical QFD, the designer's focus are mostly on quality of design, thus, consequently, quality of conformance is often overlooked. Therefore, it is the main objective of this study to suggest an approach that considers not only quality of design, but also to consider quality of conformance as well. Hence, designers should understand all stages of real manufacturing process.

Another important step to consider is the production process table, which should be deploying information from the conception processes to operation stages. They should be connected when we are considering maximum operation efficiency. Consistently, the table bellow (see Figure 6) expresses real manufacturing stages in the production system. As a result, designers should be able to consider the whole production process in accordance with the proposition of the QFD conceptual design explained in this study.

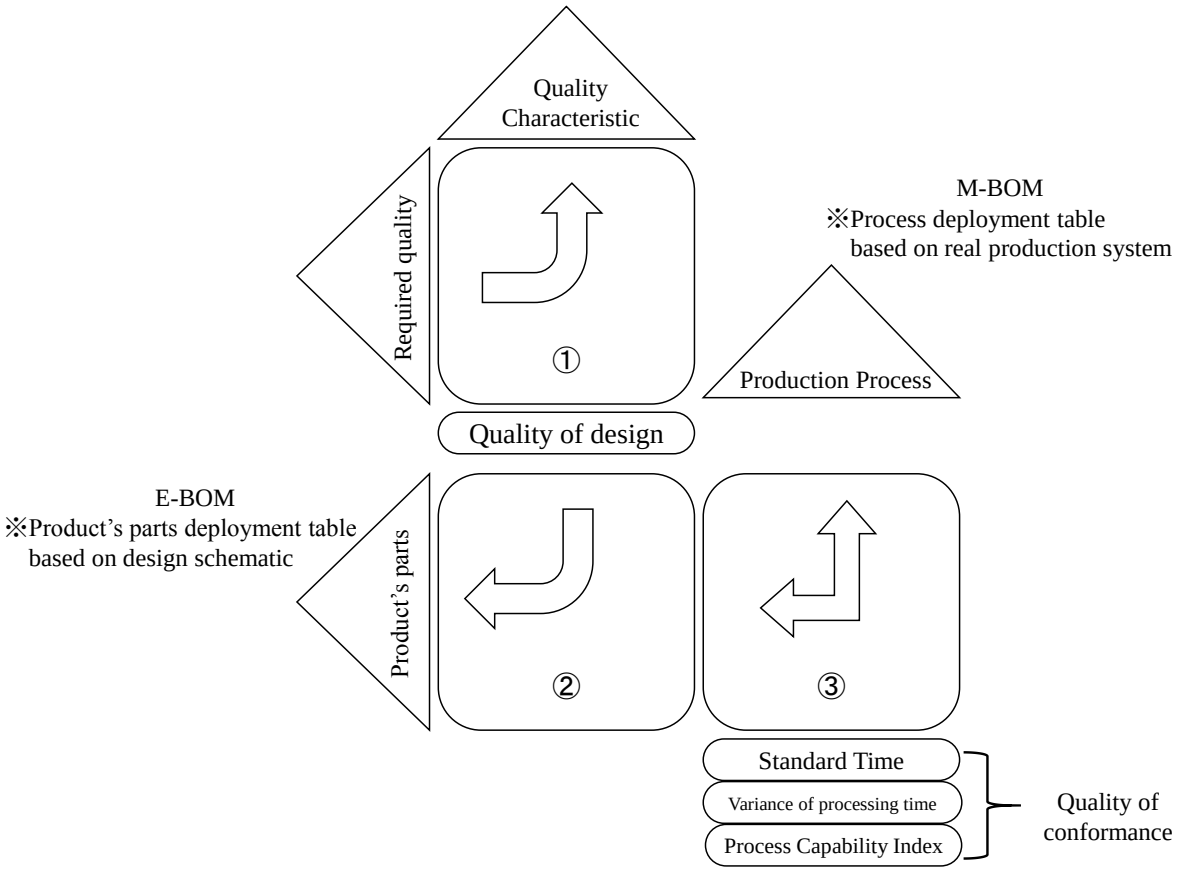

Figure 6: Conceptual design of QFD considering production efficiency

5. CONCLUSION

In this research, flow of information as seen in the process known as Quality Function Deployment (QFD) was approached from the design phase to the manufacturing stages. We focused our analysis especially on production design, applying QFD as an alternate methodology, which transforms the flow of information in the design phase to the production stages of a given product, interconnecting them.

The E-BOM (Engineering Bill of Materials) as seen through the application of QFD methodology on the manufacturing of a product, rearranges important production information that is then transferred to M-BOM (Manufacturing Bill of Materials) in order to holistically; connect the design and the manufacturing phases minimizing production issues.

This study proposed conceptual design of QFD considering production efficiency by using the flow of information from the design phase to the manufacturing stage. For future research, we would like to apply a new framework of this study in a real manufacturing company situation.

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