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LEAN SIX SIGMA IN PLASTIC FORMING PROCESSES

Prof.dr Vojislav Stoiljković,
Predrag Stoiljković,
CIM College d.o.o.
Skopljanska 8, Niš,
Serbia

ABSTRACT

Plastic Forming Processes are integral part of the chain that contains a set of other processes as well. The chain is supposed to deliver products that satisfy customer requirements. In order to be able to achieve so, process inputs have to be defined by customers themselves. It is clear that customers perceive final products only, but not sub-products delivered by Plastic Forming Processes (these are actually contained within the final products). In order to have the «Voice of Customer», as input for Plastic Forming Processes, one has to make use of Quality Tools and Methods.

This paper looks at an extended system that includes customers who define their requirements for the final product, Plastic Forming Processes that deliver on these requirements, and at the end, customers once again. Now, customers are supposed to evaluate deliverables. Quality Function Deployment (QFD) method helps us take «Voice of Customer» into account, by relying on the first «House of Quality». The remaining three «Houses of Quality» are aimed at establishing critical Plastic Forming Processes, as well as Critical-to-Quality characteristics that are reflecting customer requirements. Critical processes can be simplified using lean tools and analyzed using DMIAC methodology (Define Measure Analyze Improve Control) in order to be able to reach Six Sigma quality level.

Key words: Plastic Forming Processes, Six Sigma

1. INTRODUCTION

Plastic Forming Processes are often perceived as isolated processes from the other processes that deliver parts which are to be integrated in the final product. Such an approach allows products delivered in the Plastic Forming Processes to have a high level of quality. Unfortunately, it might happen that the organization chooses a wrong plastic forming technology, so that the price of the delivered product becomes too high. This further leads to the increased cost of the final product. The impact that arises thereof is decline in competitiveness, which further leads to the decrease of market share.

A company was producing a cylindrical part by drawing, in five operations. This part serves a as cover of oil verger and was generated by backward aluminium extrusion, in one operation. By wrong selection of a plastic forming process, the company was forced to establish five tools, use five presses, and five workers to produce the part. On the other hand, by generating the product using backward aluminium extrusion, one only needs to generate a matrix and patrix within the existing tool. One press one worker approach is used. The cost of a product generated in such a way is 20 times lower. Elementary customer requirement regarding products are low price with high quality.

The first question that arises is whether it is possible to simultaneously fulfil these two seemingly divergent requirements. The answer is yes. It is possible if we embark upon a new concept that starts of with the customer demands and defines processes that are most suitable for producing a part from the low cost perspective, with simultaneously fulfilling all the customer requirements.

Once the part generation process that will fulfil customer requirements is selected, one can define WHAT the part actually needs to fulfil. WHAT requirements further define Critical-to-Quality and finally lead to the definition of a machine, lubricants, and needed parameter values.
This paper presents a new concept for defining Plastic Forming Processes that are capable of fulfilling all customer requirements related to the final product. The concept is supported by quality tools. One of the critical quality tools serving this purpose is Quality Function Deployment (QFD).

2. PRODUCT DEIGN ACCORDING TO CUSTOMER REQUIREMENTS

Design for Six Sigma (DfSS) methodology is used for product design according to the customer requirements. This is specific product design methodology where customer requirements dictate critical parameters and the variability of the critical parameters are optimized for predictive product performance, manufacturability and reliability. DfSS is an enhancement to product development process, not a replacement for it.
DfSS is a set of tools and techniques that will allow your designs to be right the first time, work better than existing and competing products, with manufacturing and supply chain support, and have greater market share. These tools include state-of-the-art Voice of Customer (VOC) techniques as well as advanced statistical and experimental tools.
The first step of DfSS asks for realization of the following:

- Identification of what is important to the Customer;
- Translation of Customer Requirements to CTQ's;
- Determination of how to measure CTQ's;
- Flow down product CTQ's to sub-systems.

In the first step, the organization uses QFD method for the assessment of Voice of Customer. QFD idea came from Yoji Akao in 1966, whereas its practical application was realized for the first time at the shipyard Kobe Werft when designing super tankers. In order to fulfil customer requirements, they embarked upon implementation of the QFD method, for two main reasons:

- Establishment of better quality in the development phase;
- Improvement of production operations.

QFD assumes «Quality planning directed towards customer needs». As an example, Toyota widely uses QFD method as from 1973. The method allowed the company to realize noticeable results. A turn point in implementation of QFD method was achieved in 1991 and 1992.
Generally speaking, QFD method determines Critical-to-Quality characteristics of a product or service with regard to fulfilment of customer requirements. Depending on the demanded analysis, the first House of Quality serves the purpose of identifying core processes fulfilling customer requirements or critical product parameters.
The remaining Houses allow definition of optimal values for these characteristics. This leads to identification of machine and process parameters that are capable of fulfilling customer requirements that came as input into the first House of Quality. Furthermore, this serves realization of the ultimate goal which is quality of a product that completely fulfils customer requirements. The results that can be achieved can be presented with the following:

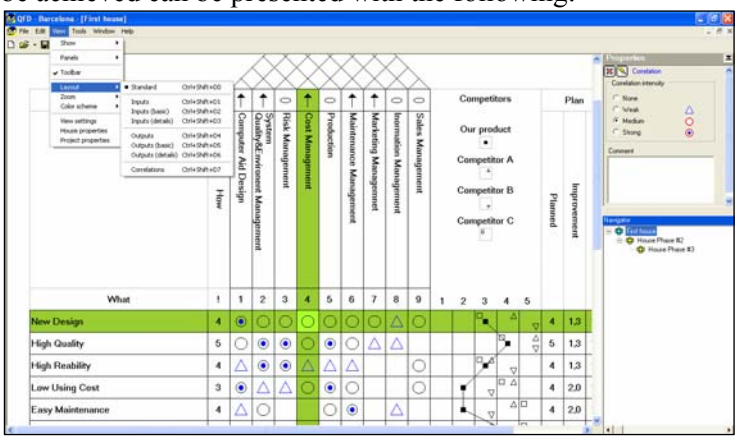


Figure 1 Software Supported QFD Method

- Cost reduction by 50%;
- Development cycle time reduction by 33%;
- Increase in productivity by 200%.

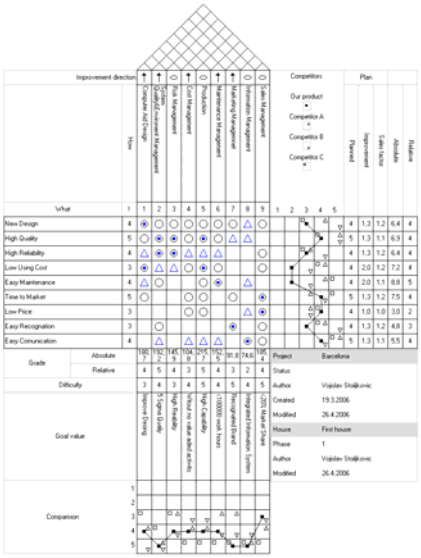
CIM College d.o.o. developed a software support for QFD method. A 3.0 version was developed on the .NET technology providing users with a wide set of functionalities. Figure 1 depicts a part of the first House of Quality, indicating some of the available functionalities.

The purpose of this paper is not to provide a description of the QFD method itself, but rather of its application.

3. APPLICATION OF THE QFD METHOD IN PLASTIC FORMING PROCESS

Experts working in the Plastic Forming Process usually have no direct contact with the customer. They receive technical documentation form the Sales or R&D departments. Documentation usually contains specifications, but without «intangible» customer requirements which can be critical to the selection of the right Plastic Forming Process and definition of its characteristics.

Author's experience in the field of Plastic Forming, as well as a newer experience in the field of process management and application of quality tools, allow establishment of new opportunities for elimination of defects in the development phase. This asks for extension of knowledge of Plastic Forming experts with the skills and know-how outside their specific domain. Primarily, they need knowledge about process improvement and quality tools and methods.



With extended skills and knowledge, Plastic Forming experts can take into account Voice of Customer from the Marketing and R&D departments. These departments can determine, for example, that the customer wants: a new product design, better quality, lower usage costs, simple maintenance, just-in-time market appearance of the product, simpler communication, etc. (Figure 2). Each of the customer requirements has to have assigned priority by a customer, within 1 to 5 range. Customer requirements say noting about which Plastic Forming Process to select for generating any of the parts needed for the final product. In order to be able to define Plastic Forming Process that will fulfil top level customer requirements in the best way, one first needs to identify processes capable of allowing it. In our example, these could be: Computer Aided Design, Quality and Environmental Management Systems, Risk Management, Cost Management, Production, Maintenance Management, Information Management, Sales Management, etc.

Figure 2. First House of Quality

Once customer requirements are defined and processes capable of responding to these requirements identified, one can establish their interconnection as assumed by QFD method. These interconnections can have values: strong (9), medium (3), weak (1), or there is no connection (0). Number in brackets represents interconnection intensity. Intensity is depicted with the appropriate symbol as well.

HOW from the First House of Quality becomes WHAT in the second house. For WHAT from the second house we define its own HOW. Within the scope of our example, we can conclude that the "answer" to the production can be either Forging or Extruding Plastic Forming Processes. By assigning importance to the requirements as well as by establishing interconnection intensity between WHATs and HOWs, we get absolute values for all the HOW categories. The values we entered provide us with the result saying that: Extruding Plastic Forming Process fulfils customer requirements by 180 absolute points, whereas Forging Plastic Forming Process does so with 120. This leads us to a conclusion that the former is more suitable to use with regard to fulfilment of customer requirements for the specific part we want to produce.

The third House of Quality can be developed for each of the HOWs from the Second House. As this paper is dedicated to Plastic Forming Process, we develop the third House for the Extruding technology that fulfils customer requirements in the best way. At this level, experts can establish requirements that the part should fulfil once generated using Extruding technology. Such requirements can be: less variation of thickness, straight profile, surface without chink, quality chemical protection, high durability, less wear, etc. All the requirements have to fulfil certain target values defined in the third House. For these requirements we than define actions about HOW to realize them. The answer can be: speed of extruding, lubrication, quality of tool surface, tool design, chemical protection

technology, material part quality, temperature in plastic zone, temperature of part, etc. By assignation of priorities to the requirements and by establishment of intensities between WHATs and HOWs, we get absolute values for all the categories in the HOW group. From the results one can conclude that we need to pay special attention to the Tool Design, Temperature of part, and than to the other aspects subsequently.
Finally, in the forth House of Quality one can define the press to be used for Extruding, oil to be used for lubricating, the type of tool to be used for forming, material to be used for forming of a part, and other aspects important for the fulfilment of customer requirements from the first House of Quality. Established selection guarantees that all the customer requirements posed regarding the final product will be fulfilled (including the part produced using Plastic Forming Process).

4. CONCLUSION

Plastic Forming Processes ask for expensive tools and a large number of workers. Therefore, a wrong selection of the Plastic Forming Process leads to unnecessarily big costs for the organization. It further leads to the increased cost of the final product. Increased cost leads to reduced comparative advantage of the final product and can provoke decrease in market share. Ultimately, lose of market share risks survival on the market.
Proposed methodology for the selection of the Plastic Forming Process, based on customer requirements using QFD method, eliminated possibility of defect occurrence and improved the process of defining all needed parameters. All in all, the methodology adds to the success of an organization and helps its market performance.

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