POSSIBILITIES OF PRODUCT QUALITY PLANNING IMPROVEMENT USING SELECTED TOOLS OF DESIGN FOR SIX SIGMA

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Abstract

Although the requirements on quality of products are increasing, most companies still pays little attention to product quality planning. Furthest in this direction they are automotive suppliers, which include most of metallurgical companies, which use quality planning methodologies developed for this industry area and which must within the framework of production part approval process submit evidence about successful products and processes quality planning. However, even for these companies, there are ways that open the door to further improvement in this area. One of those possibilities is methodology Design for Six Sigma. The paper focuses on selected tools and methods of approach Design for Six Sigma, which can significantly streamline the course of individual phases of product quality planning. With timely deployment of these tools, an organization can significantly contribute to the development of a robust and competitive product while maintaining the idea of Six Sigma approach (maintaining a low proportion of defects in manufacturing the product).
Keywords: Design for Six Sigma, Voice of Customers, Pugh Matrix, Design for X.

1. INTRODUCTION

As times bring customers into the spotlights of organizations, the pressure rises to achieve inherently perfect results. In fact, the results not only mean that the fundamental requirements of the customer are satisfied within the competitive pricing but also the accent is put on associated quality and services. Six Sigma strategy offers the way to produce goods of higher quality level with lower costs and faster. Although the implemented Six Sigma methods made the production processes lucidly improved, the expected elevation of market values did not appear. Then the Six Sigma conceptual elements were implemented to the pre-production stages, particularly to the development one. This gave rise to an autonomous Six Sigma concept branch, the Design for Six Sigma (DFSS). At the outset, the fact should be clarified that the DFSS is intended for both, the new product developments and the re-designs.

A continuous improvement of the existing processes (DMAIC) and new developments (DMADV) represent linchpins of the Six Sigma methodology. DMAIC (Define, Measure, Analyse, Improve, Control) – the improving process consists of five diffused and interacted stages resulting in stepped improvements of existing processes. Similarly the process designing new processes and products consists of five stages (Define, Measure, Analyse, Design, Verify). The DMADV process is principally used in situations where improving of the existing processes is no longer adequate owing to feasibility and cost-effectiveness. The DMAIC and DMADV correlation model (see Fig. 1 [1]) may be useful when deciding whether the improvement procedures or a new design concept should be applied.

One of the most important step toward the successful integration of the DFSS philosophy into the organization processes is a thorough understanding of all available tools and the appropriate selection of those with potential to ensure savings to the organization. Refer the survey of DFSS methodology tools offering to produce a "great job with a minor effort". No time consuming and expensive training of new

professionals is required, no mandatory software revolution is necessary. These tools well grasped may be of an excellent use for their master. This paper comes with the assumption that the minimally complicated way is the sequential application of one tool after another.

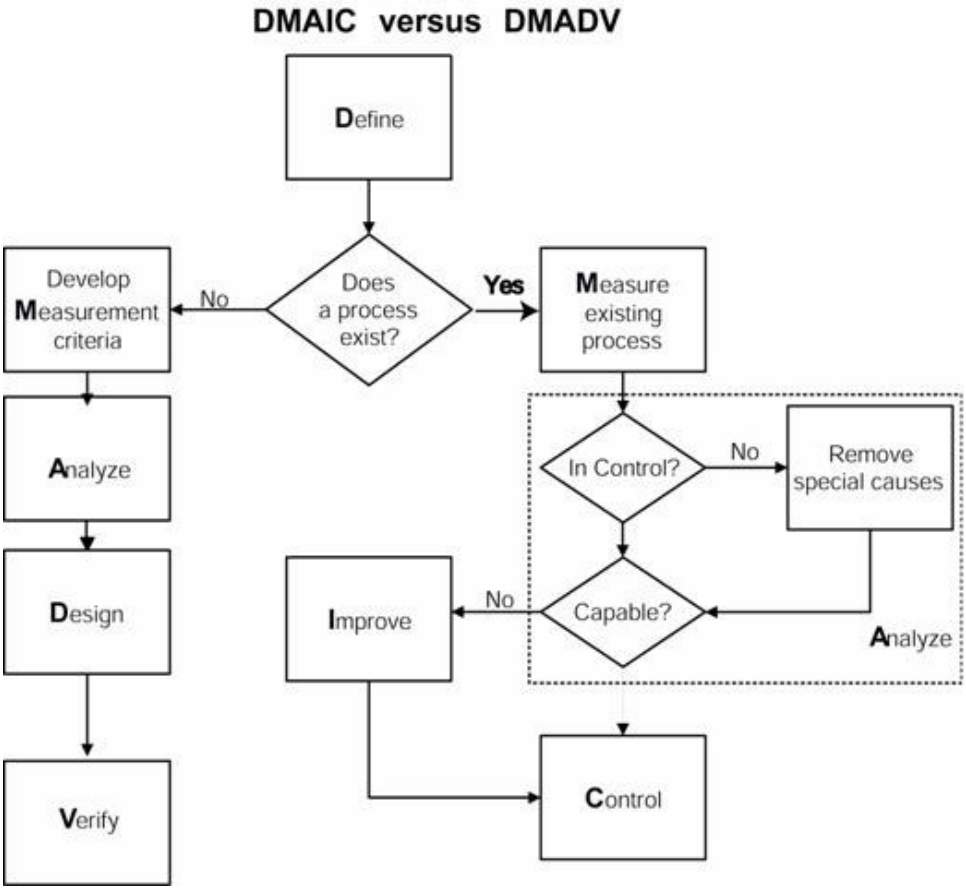

Fig. 1 DMAIC versus DMADV correlation model [1]

For projects of Design for Six Sigma it is proposed this algorithm [2]:

1. Form a Synergistic Design Team
2. Determine Customer Expectations
3. Understand Functional Requirements Evolution
4. Generate Concepts
5. Select the Best Concept
6. Finalize the Physical Structure of the Selected Concept
7. Initiate Design Scorecards and Transfer Function Development
8. Assess Risk Using DFMEA/PFMEA
9. Transfer Function Optimization
10. Design for X
11. Tolerance Design and Tolerancing
12. Pilot and Prototyping Design
13. Validate Design
14. Launch Mass Production.

In the next part of paper attention is paid to suitable tools for steps „Determine Customer Expectations“, „Select the Best Concept“ and „Design for X“.

2. VOICE OF THE CUSTOMER (VOC)

Within a new product design, the measure stage pivotal aim is to identify customer requirements and to translate them to the product quality characteristics (Critical to Quality, CTQ) with well set priorities. Understanding the voice of customers is assisted by the VOC tool, offering procedures for the best identification of the customer requirements. VOC is a tool integrated in the Quality Function Deployment (QFD). VOC serves as a team tool for groups of users, such as marketing or sales department, R&D, design or planning staff as well as for the quality management professionals. Data acquired using the VOC and other tools should be recorded into the matrix known as the House of Quality [3,4]. The matrix makes available not only the product requirements but also the customer priorities set by the weight and comparison with competitors.

The suitable steps in creating the set of customer requirements as input of House of Quality are [5]:

1. Gather the Voice of the Customer
2. Sort the Voice of the Customer into major categories
3. Structure the needs in Affinity Diagram
4. Arrange the needs in the Customer Requirement section.

Before gathering the Voice of the Customer it is necessary to define who customer is. Often they are various categories of customers. Suitable methods of gathering VOC data are focus groups, conference-room interviews and contextual inquiries [5].

Specification of the customer requirements utilizes questions of four basic spheres: customer expectations, customer satisfaction, customer benefits and the future customer benefits from the new product use. Also, the conditions are amended about the legislation charges bearing upon the product despite the customer cognizance, yet vital e.g. in competition view. Information gathered by the team while completing the requirements come from customers on the one hand and from the legislation, marketing analyses and the experience of the team on the other. Knowledge about the customer priorities related to the product presents an integral part of the feature set. [6]

Better understanding of customer requirements can be supported using Kano model (see Fig. 2), which is also considered as DFSS tool. The Kano model is an (x, y) graph, where the x-axis represents how good producer is at achieving the customer outcomes or Critical to Quality Characteristics. The y-axis of the Kano model records the customer’s level of satisfaction.

Kano model distinguishes three categories of Critical to Quality Characteristics [7]:

1. Must Be (the quality characteristics must be present or the customer will go elsewhere)
2. Performance (the better is meeting these needs, the happier the customer is)
3. Delighter (those qualities that the customer was not expecting but received as a bonus).

Results acquired using the QFD method and the VOC main tool are finalized into the form of all inputs available to the organization about the product outputting profile. While the early inputs are often very general, the outputs stay in the technical speech with the required ranges of final values set. The advantageous nature of this tool is seen in complete customer orientation including competitive examination aspects "in situ". Combined with the FMEA design method this tool potentially brings substantial decreasing of quality costs.

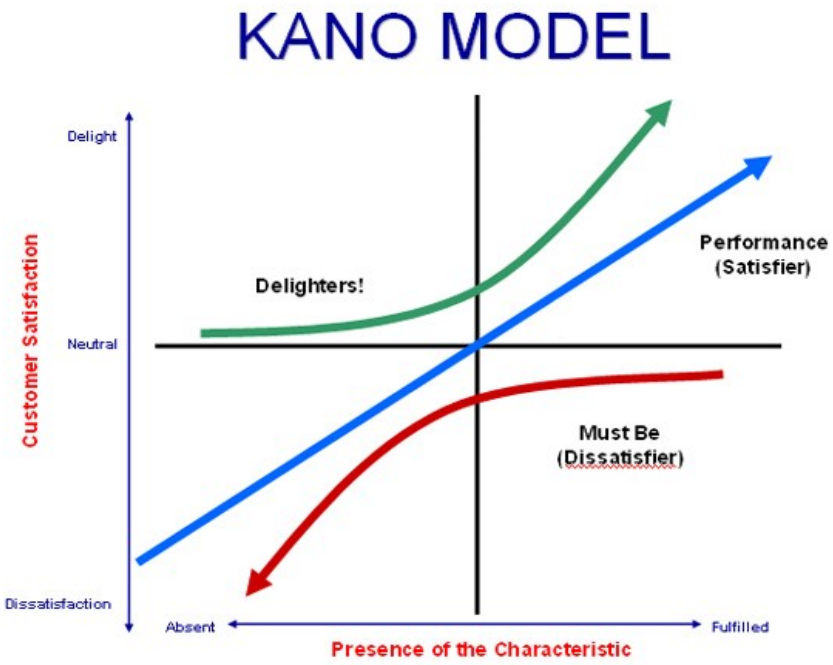

Fig. 2 Kano model [7]

3. PUGH MATRIX

The Pugh matrix which is also known as Criteria Based Matrix is a kind of Decision Making Matrix, enabling to find the optimal product design. Similarly to the VOC tool, this is a team method with members recruited from project managing staff, technology and planning professionals and R&D Department specialists. [8]

At the beginning of application appropriate criteria for evaluation should be established. They may be, for example, the experience with the material supplier, ease of manufacture, or the amount of any repair costs. At the same time it is necessary to decide about weights of these criteria according to their importance for the final product. Before the start of comparing concepts team must choose appropriate scale of assessment. It is possible to use a numerical assessment (e.g. from 1 to 3), as well as easy identification of the impact of applying the concept of the assessed criteria (e.g. "+" for better, "-" for worse and "0" for neutral).

Team will present a list of proposals to compare concepts and ongoing evaluation of each specific concept. After evaluating all variants weighted sums of criteria assessment or only simple sums of positive and negative impacts are calculated and the best concept is chosen. It may happen that during Pugh Matrix solution team on the bases of current ideas and benchmarking proposes a new concept. It then joins to the list of proposals to compare. An example of a suitable template for recording evaluation of individual concepts is shown in Fig. 3.

Pugh matrix is a modification of some matrix diagrams presented within the framework of Matrix of Matrices by B. King [9]. These matrix diagrams assess the impacts of new product concepts to the meeting of individual customer requirements, to the desired product functions or to the product quality characteristics.

Pugh Matrix

Product: Home Security System			Date:				Put **+, -, or S** in each cell to represent if concept is **SIGNIFICANTLY** better, worse, or same as the datum concept.						
Project Leader:													
Concept / CTS (Critical To Satisfaction or Requirement)	**Importance Rating**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Auto dial-up city connection	10		-	+	+	+	+	S	+	+	S	+	+
Auto dial-up call center connection	7		S	S	S	S	S	S	S	S	S	S	S
Free 24 hr technical support & service	7	D	-	S	S	S	S	S	S	S	S	S	S
Liquid Crystal Display (LCD)	5	A	S	S	S	S	S	S	S	S	S	S	-
Large print keyboard	5	T	S	S	S	+	S	S	S	S	S	S	S
One-touch overide	10	U	S	S	+	S	S	S	S	S	S	S	-
Remote control modules	6	M	S	S	S	S	S	S	S	+	S	S	S
False alarm protection feature	7		S	S	S	S	S	S	S	S	S	S	S
Easy keyboard access	7		S	S	+	+	S	S	S	+	S	S	S
Decorator color housings	5		S	-	-	-	-	-	-	-	S	-	S
Σ+			**0**	**1**	**3**	**3**	**1**	**0**	**1**	**3**	**0**	**1**	**1**
Σ–			**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**2**
ΣS			**8**	**8**	**6**	**6**	**8**	**9**	**8**	**6**	**10**	**8**	**7**

Fig. 3 Pugh matrix template example [10]

4. DESIGN FOR X (DFX)

DFX is a DFSS tool that allows assessment of the proposed product with regard to series of important aspects, which should be taken into account during product design (individual aspects are this X in the name of the tool). The most common applications include [2,11]:

- Design for Manufacture
- Design for Assembly
- Design for Reliability
- Design for Safety
- Design for Environment
- Design for Inspection
- Design for Service
- Design for Maintainability
- Design for Recycling
- Design for User-friendliness etc.

In practice, companies most often apply Design for Manufacture or Design for Assembly. In these cases product design is optimised from the point of view of its manufacture or assembly. However, sufficient attention should be paid also to other aspects.

Set of DFX applications is usually named as Design of eXcellence. At present it includes number of other aspects of product design optimization e.g. Design for Cost, Design for Marketability, Design for Logistics, Design for Procurement etc.

DFX is a team tool, the design assessment from different perspectives give different departments according to their specialization. Concrete practices based on the Best Practice are usually used for design assessment. The result should be a holistic assessment process, at the end of which is an optimized product design. DFX application can be supported with using suitable templates. Suitable template for DFX methods is described in the work [12]. It standardizes DFX tasks and information flows and facilitates the implementation of DFX methods.

CONCLUSION

Criteria for the evaluation of product quality are constantly tightening, so the organizations are constantly on the lookout to increase their product quality with no increase of their costs. In this field, the increasing importance is placed on the quality planning. As it has been demonstrated many times, the properly solved

quality planning helps reveal imperfections and possible defects prior to the series production. The costs linked to the poor-quality products and refunds decrease. There are a lot of ways to be followed by the companies in the field of quality planning. A lot of them are very initial costs- and time-consuming – to look for specialists in the given branch, to train employees, to pay for suitable software. But there are quality planning tools that companies can start applying to its pre-production processes almost immediately at minimal cost. These include presented DFSS tools. Their successful application can be followed by successive use of other tools and application of whole DFSS methodology.

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