ANALYSIS OF ERRORS IN THE MANUFACTURING USING DESIGN FOR SIX SIGMA. (DFSS)

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This paper uses the results of research in the field of automotive, manufacturing line process optimization. Achieving quality components with documentation, in line with the conditions of a large series and mass production, generates the need for an optimization process at a global level (logistics, manufacturing, assembly, sales), depending on the components 'magic triangle' quality costs and time. Simultaneously, an improvement (downwards) the error rate towards achieving manufacturing - assembly lines of robust products generates an improvement in the net value of production, an increase in the competitiveness of the company by increasing production capacity, labor productivity and delivery terms. DFSS is considered a way to improve the training process of product components, by diminishing the number of defects. It aims to improve the management of specific aspects of manufacture, reducing manufacturing risk by avoiding the use of bad or defective components, from the design stage of the process. DFSS was used to analyze the structure of functions of electronic parking brake fitted to the car (Electronic Parking Brake - EPB); model was used for analysis V or "cascade" each come with the design, to avoid errors, and especially to the structuring tasks, functions of each component in the system structure. DFSS implementation stages followed DICOV circle (Definition, Identification, Characterization, Optimization, Validation).

Keywords: functions of product, continuous improvement components, magic triangle, the car's electronic parking brake (EPB)

INTRODUCTION

Due to the significant economic potential for the prevention and reduction of production scrap in recent years, an increasing number of preventive quality management techniques have been used; the actual report addresses the Six Sigma method as part of the scientific research program.

Only those who can react in a short time to the customer changes in the life cycle of the product and who can can also show a higher quality of the product supplied, in parallel with the reduction of errors in production (achieving zero-defects), may invest on long term in crucial resources for product development.

The increasingly larger competition from the automotive market has caused many companies to seek a sustainable concept, through which company processes may be optimized in accordance with quality criteria.

Quality, cost and time are known in many areas as the "magic triangle" of product development, considering that these are key elements that ensure sustainable development in the industry.

In the automotive industry and particularly in the relationship with suppliers these factors are in the spotlight.

A superficial analysis highlights the fact that manufacturing of products at the quality level required to meet the requirements of beneficiaries with lower costs, generates a discordance between the required quality or requested quality, the time consumed for repair and the additional costs of bringing the product to parameters.

However, it can be shown that an improvement of the error rate leads to an improvement in the net value of the output. A strategy of "zero defects", increases the competitivity of a company by the increasing production capacity, increasing employment and the decrement of manufacturing duration, ensuring compliance with/reducing of the delivery times.

ERROR ANALYSIS ON THE MANUFACTURING LINES

The goal of every product developer ist o detect in time production errors and also to establish the necessary measures to avoid such errors, so as to ensure the success of the finished product for the customer. About 70-80% of all faults in the structure of a product can be caused by deficiencies in planning, in which the greatest contribution lies in the research, development, and production-preparation sectors.

Discovering and fixing errors usually occurs in the late phase of production or even when the product arrives to the client. This means that the very late discovery of errors in the development product process generates higher costs to eliminate these errors. This phenomenon can be viewed by using the so-called magic triangle (Figure 1).

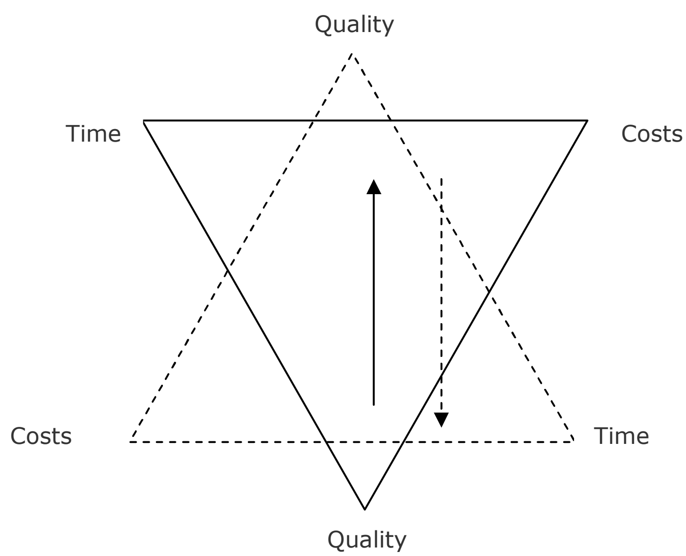

Figure 1 Triangle cost - quality - time (magic triangle)

From the figure it is observed that, if for a product there are high levels of quality required even in the early stages of manufacturing, any deviation from the required quality will be removed with low cost and in irrelevant time spans. However, if for a product low quality levels are required, deviations from quality will be corrected with additional consuming time and increased costs.

In practice, for preventing production faults along the lines of production, various methods can be applied. A comparison between the two methods highlights specific differences. Thereby:

The **Six-Sigma Method** used for the analysis of the basic method DMAIC (Define - Measure - Analyze - Improve - Control) to make the quality of existing processes measurable as well as of those resulting from their continuous improvement over time.

The DFSS Method uses the **DICOV** model (Define - Identify - Characterize - Optimize - Validate) to develop the product, to make it safer, more robust, beginning with the design and manufacturing phases. The differences between the objectives of the two methods is given by the following characteristics (Table 1).

Table 1. Objectives of Six Sigma and DFSS

No.	SIX SIGMA	DESIGN FOR SIX SIGMA
1.	It focuses on existing processes	It focuses on product development
2.	Optimizing production in order to create new value	Optimization of design, with strong emphasis on continuous innovation
3.	Company-specific requirements and customer requirements.	Future requirements at the company, taking into account the diversity of customer requirements
4.	Avoid the additional costs of deviations from the planned processes.	Avoid the additional costs of possible deviations on the entire manufacturing cycle of the product

The DFSS Method aims:

- A complete understanding of the products requirements, imposed requirements determined by the system in which it is integrated.
- Identification of areas with early stage design problems, and addressing solutions to ensure robust structure for the designed product.
- The products interface must to be clearly defined from the design stage.

For correlating product requirements with the requirements of production line capacity is frequently used in the V model known as model in cascade.

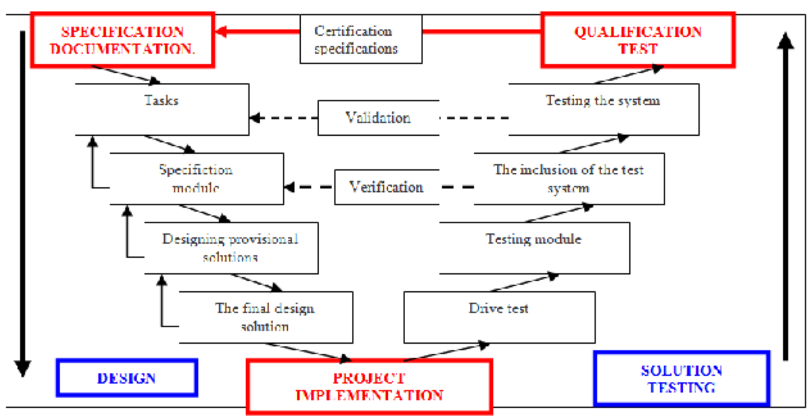

Figure 2. The Model in cascade

The Cascade Model

From Figure 2 it is seen that the Cascade Model has the advantage of a direct correlation between design activities, both at the system level and at the level of modules or specifications, related to such documentations specification purposes. At the same time each solution, before being made permanent, is tested in terms of the parameters that must be provided. In designing the final solution, one starts from the product specifications required by documentation, and continues with the selection of modules according to the tasks resulted for each module; then continues with the choice of interim final solutions which, by combining functions, generates a final solution. So the design process follows a TOP – DOWN approach, namely from the product to the components, using optimization solutions that ensure objectives and ensure implementation possibilities in the manufacturing components line, modules and systems. After the implementing of the final solution, verification tests of the new elements introduced in the project are performed, validating the newly created module with respect to the design requirements, and after the qualification test pecifications required by the product documentation are certified. The staged testing process follos a BOTTOM-UP approach, in parallel with the top-down approach. Only after this test, one may pass to large serial production or to mass production under the condititions required by the documentation specifications.

This method has at least two advantages:

- it reduces implementation time of new solutions in the manufacturing,
- it eliminates possible errors that may occur after implementing the process solution through verification testing, validation taking place alongside with the design process.

Each of the activities of the cascade model are analyzed using the DICOV method (Definition, Identification, Characterization, Optimization, Validation); by using the method of analysis it is intended to ensure the optimal solution for the development of that activity so that further work can be carried out in the most favorable conditions, taking account of the requirements of the specifications in the documentation.

CASE STUDY - DFSS APPLICATION FOR THE ELECTRONIC PARKING BRAKE (EPB)

Electrically operated brakes of the type “duo servo” are used in combination with electronic parking brakes (EPB) braking systems. Parts of the brakes structure are safety pieces. Because of this, registration, listing and filing each operation of the production process and highlight errors / rejects is necessary. The error can be avoided by resuming the activity as specified in the budget documentation; the spoilage requires replacement of the defective part and its traceability analysis until the test. Documentation must exist to prove that during the production period the audit has been conducted and that the nominal parameters, provided in the documentation have been met.

EPB assembly line comprises assembly of the new posts, placed in a continuous stream; from each running one specific operation, as shown in Figure 3.

Operation # 1 is a manual operation combined with a robotic operation, which ensures logistic processes at the job 1.

Operation # 2 ensures printing of the code and batch of the finished manufacturing product.

Operation # 3 mechanical component assembly 2.

Operation # 4 mechanical component assembly 3 and lubrication.

Operation # 5 installing protection systems.

Operation # 6 installing electrical and electronic assemblies.

Operation # 7 # 8 End of Line(EOL) control and measurement of system parameters.

Operation # 9 visual check, packaging and storage.

The production quantity consists of 12,000 pieces/month, in a system consisting of two shifts of eight hours each; tact follows the line T=3.3 min/piece. This follows the implementation of the project, which at its time structured optimal solutions in terms of the modules selected and from the point of view of the specifications.

Under these conditions at the test operation EOL, during a work week a number 8 ... 10 exchanged defective products were noted. Applying DFSS operations # 7 # 8 and analyzing the causes which have generally found defects classified as "critical failures" that do not belong to management solutions, but are due to the poor structure of the components that enter into the structure of braking.

Given the annual production of about 150,000 units EPB/year, preliminary statistics have a value of 500 pcs. rejected items/year. Considering the correlation that exists between DPMO (Defects Per Million Opportunities) and Six Sigma function, it follows that for a production of one million units, the company is on a position close to the lower limit of 4σ, with about 3333 units produced which are considered critical flaws in terms of product quality.

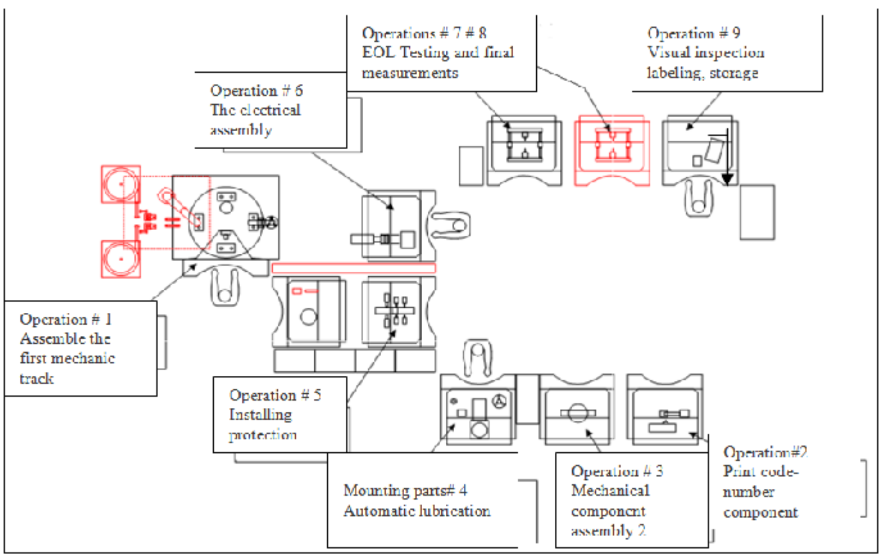

Figure 3 Assembly line components parking brake (EPB)

Given the connections between function Six-Sigma, DPMO and costs for improving product quality, costs of quality can be statistically determined (Table 2):

Tabel 2 Costs related to quality production

Level σ	DPMO	Costs related to quality
2	308 537 (Companies can not compete on Marketplace)	No sense issue of quality costs
3	66 807	25 – 40 % of turnover
4	62 10 (medium)	15 – 25 % of turnover
5	233	5 – 15 % of turnover
6	3,4 (very good)	> 5% of turnover

CONCLUSION

1. Using DfSS in the design process allows removing errors from the design phase, and at the same time optimizing single or multi-criteria solutions adopted by the design team of a product. The project team can focus on the product development and at the same time costs incurred by improving quality, both in design and manufacturing-cycle of products can be reduced.

2. The lower DPMO is, the lower costs to improve the quality get, and as a result economic efficiency of the company's work is better.

3. Knowing where the company stands in relation to the Six Sigma, allows setting out strategies on medium or even long term. So in the case of hardware EPB companies, after applying DfSS for mounting activities, the strategy applied took into account some specific issues such as:

- Fundamental change in business thinking of the company's management team. While in a classical situation one tries to eliminate the problems, by implementing DfSS in the organization, one tries to avoid them. The classical management perspective focuses on the product, while the DfSS perspective is oriented towards quality of the manufacturing process.
- Since EPB is a product that contributes to human security, applying DfSS is a process that provides a vision regarding the anchored quality in the company's business model, as in all important processes regarding the relationship with the customer. The road to implementing DFSS becomes thereby a process of continuous improvement.
- The use of DFSS has completely changed the "genetic code" of the company, since by reducing the variation limits of its manufacturing process, an error is evaluated differently and the improvement programs are different, more transparent, and more flexible.

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