The Use of DFSS Tool / Design for Six Sigma in the Innovative Process of New Product Development: a Case Study

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Abstract

The SS methodology is being widely used as a quality management model. Focusing on "Zero Defects" production, the tool that support DNP used in the planning phases, that precede manufacturing is DFSS methodology, suitable for production processes with SS requirement. There is a contradictory question regarding the differences and complementarities between DFSS tool and the SS methodology: to conclude about what is the best strategic decision by two companies, in which one uses the SS and the other uses the DFSS; else more, if it would be a competitor at a higher level with regard to the experience and knowledge, by using both. The case study indicates that given the intrinsic characteristics of the company, common to other Portuguese Small, Medium Enterprises (SMEs), it is clear that the use of DFSS tool turns out to be the most effective, especially when the client is a big company.

Keywords: Design for Six Sigma (DFSS), New products development, Six Sigma (SS).

1. Introduction

Motorola enterprise faced a problem in the past. The company was losing market and needed to find the cause of such problem. Even after testing several tools already used by other companies, still couldn't be competitive enough. However, after several studies, it became possible to confirm that the stock of waste, material, time and manufacturing defects, were generating high costs. Then Bill Smith, a Motorola engineer, in 1986, created the Six Sigma methodology (Suski and Maukiewicz, 2010), which replaced the program TQM (Total Quality Management). This methodology has brought very positive results and after its release, it has been implemented worldwide in many organizations such as: General Electric, Ford, Caterpillar, Microsoft, Raytheon, Siemens, Citybank, and others. The SS methodology has this name because, according to Cone (2001, p.31) the letter sigma is the Greek letter that represents the statistical unit of measurement that defines the standard deviation of a population. It measures the variability or data distribution. The higher the sigma, better are the products produced or services, and from another point of view, the less are the defects presented by these products and services. So with the application of this methodology, it is possible the realization of products and services with only 3.4 defects per million of the units produced.

The SS methodology (Six Sigma) is used for strategic changes. It is an organizational approach to the excellence of performance, the persistent search of perfection to answer the customer needs, decision making driven by data and facts, process improvement, strict alignment of actions with the strategies and the measurement the ultimate impact. (Pande, 2001). In this conditions, the design and develop of new products with this goal of perfection offered by SS philosophy, is essential to its success in the market and for the achievement of its effectiveness (Dias, 2015; p 128.). The DFSS tool is an alternative to this, it is an approach to product development that integrates effective analytical methods, to ensure that the design is: orient-

ed to the customer (voice of customer); innovative; robust against the causes of variation and have a minimum total cost. (Mader, 2003) The approach based on DFSS becomes more suitable to the creation and development new products, services and processes, not so much in the improvement of existing ones, getting this aspect and the curative nature of interventions for the SS (Dias, 2015). The DNP is the launch of new products that is increasingly common in the Portuguese industrial sector instead of non-innovative and less value-added industries. In this research directed to the DNP, the right tool for the design phase, is the DFSS and instrumental tools that are DMADV cycle (Define, Measure, Analyze, Design, Verify), and all that have developed from this one. These cycles represent the various methodological ways through which DFSS theory can be used, and allow each company to follow its methodological approach because each company is unique and has intrinsic characteristics.

2. Six Sigma Production

Since the movement that quality began a few decades ago, many improvement models were created, adapted and applied to processes over the years. Most of them are based on the steps introduced by W. Edwards Deming, the PDCA cycle (Plan, Run, Check, Act) which describes the basic logic process improvement based on data (Fioravanti, 2005).

Motorola developed the MAIC cycle (Measure, Analyze, Improve, Control) as an evolution of the PDCA cycle. Later, this cycle was adopted by the company G.E. which included an initial phase called the letter D in order to recognize the importance of defining a project, calling it the DMAIC (Define, Measure, Analyze, Improve, Control) (Fioravanti, 2005). The DMAIC method became the base of Six Sigma philosophy for business, it is fundamental to its success. It is a revolutionary methodology for the improvement of business processes, which gives improvements in quality and productivity gains due to the reduction of costs. It uses the application of statistical methods to business processes, to eliminate defects. There are several benefits such as operational efficiency increased, costs reduced, quality improved, and customer satisfaction and profitability both increased.

2.1 DFSS (Design for Six Sigma) Methodology

According to Treichler et al. (2002), DFSS is a culture change that occurred in the organization design and product development, from deterministic to probabilistic. People are trained to incorporate statistical analysis of failure modes in products and processes. The goal is to incorporate changes which eliminate design features with a statistical probability of failure within a predefined range of conditions and operating systems. According to Dias, (2015), the methodology or methodological tool, DFSS (which integrates DMADV cycle) is directed to:

• Create new products that motivate the purchase by customers in order to obtain higher profits;

• Detect and prevent the occurrence of failures before they occur in the product (prevent them from occurring during or after the production phase).

There are several tools that can be useful when related to the DFSS and DNP. Between the beginnings of the development creative design and creative solution, is expected that it should use some instrumental tools such as: Pugh analysis; DOE (Design of Experiment) and/or DFX (Design for Excellence). DOE is used to support the planning optimization, implementation and analysis of an experiment in order to obtain solutions to DNP problems. DFX is suitable to quality improvement during the production phase. It is expected the achievement of creative solutions by the creative design, for the respective problems of DNP projects (Dias, 2015). It is possible in the same problem of DNP, associate several tools such as tolerance design that sometimes is use in combination with DFSS and robust design; and the axiomatic design with robust design and both with DFSS.

2.2 SS vs. DFSS

The Design for Six Sigma, at first analyze, appears to be an extension of the Six Sigma methodology. It should be noted that this is not a reality. The DFSS and Six Sigma methodologies are independent, however, DFSS has many characteristics that make the Six Sigma methodology known worldwide. Having in account the differences between these two methods, it can be concluded that the DMAIC cycle is used in production processes and services that are in need of significant improvements in its sigma level performance. I can say that the DFSS is the planning of the SS, to which (SS) corresponds the DMAIC (production). First of all, it is important to understand which are the parts of the process that are underperforming and must need an improvement, for after applying Six Sigma in these specific parts, the performance in general, improve an satisfactorily way. The application of the DFSS is different. It is applied when is wanted to do a new process. So it is studied and designed (Design

for Six Sigma) to start its activities having a Six Sigma level performance. (Dias, 2015).

All the tools that are applied in Six Sigma methodology can also be applied in DFSS methodology, but the opposite is not true, some tools are specific to the DFSS because they are applied specifically to the development of new products (Fioravanti, 2005). Figure 1 shows a diagram that explains the integration of Six Sigma methodology (improvement of product performance and process) and DFSS (design of new products and processes) based on the procedure for design selecting.

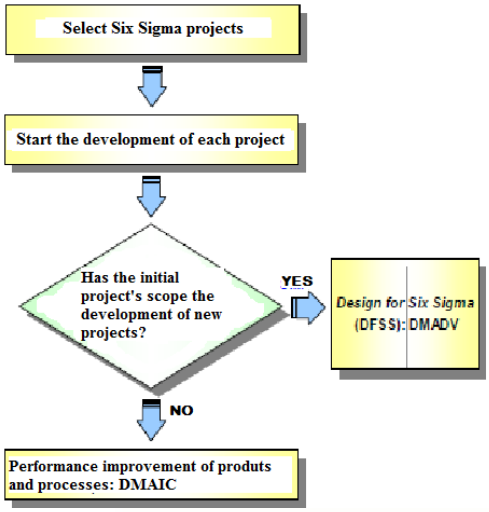

Fig. 1 This is an example of a figure caption Decision of the best methodology to use, Six Sigma (DMAIC) or DFSS (DMADV). Adapted from FioravantiI (2005).

The approach based on DFSS is suitable to the creation and development of new products, services and processes, not so much to the improvement of ones that already exist, taking this aspect and the curative nature of interventions linked to the SS methodology (Dias, 2015).

Sometimes the best solution isn't start over. Often improve the current situation can be necessary and the best option in financial terms. The development of a new product depends on a several factors like the stage of the current product life cycle, its competitive position in the market, its projection to the following years, etc. So, DFSS and Six Sigma are presented like complementary and independent methodologies (Werkema, 2002). On the other and, Treichler et al. (2002) are stringent in their affirmation that diverges from the above idea exposed by Werkema (2002), which Treichler quoted: "The DFSS is a much more effective way in financial terms of obtaining Six Sigma quality levels rather than trying to fix problems after the product finds it's place in the market".

As shown in Figure 2, it's in the DFSS operating area that the costs associated to the correction of non-conformities are lower. However, these non-conformities are harder to detect, which is why it's necessary to use several analytical tools, in order to anticipate potential anomalies (Dias, 2015).

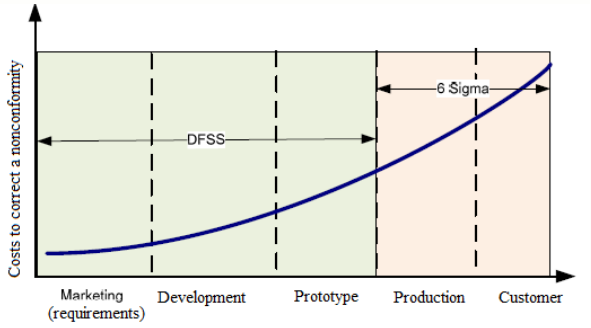

Fig. 2 Operating area of the DFSS and SS, concerning the product life cycle. Adapted from Dias (2015).

Concerning the present investigation focused on DNP innovative process, the most adequate tool to be used in the design phase is DFSS theory and its instrumental tools: the DMADV cycle and the ones that developed from this.

These new cycles, were born, in alternative to the DMADV, to answer the unique characteristics and special needs of each company, in a way that ensures the creation of an effective and efficient culture to the DNP (Dias, 2015).

3. Case Study

3.1 Company 1

The following case study, concerns to a company that will be designated from now on as enterprise 1 due to issues concerning confidentiality.

The enterprise 1 is a SME of the industrial maintenance sector. Works for other companies and provides electrical maintenance services, maintenance of rotating and static equipment. Usually do the replacement, repair or calibration, and especially in rotary do the conditioned maintenance because it has this valence. Concerning the DNA, the company mostly does continuous improvement actions of products that exist, so there is no substantial innovation.

It is a company with about 15 permanent employees and at the work peaks can reach 100. The correspondent in terms of time, to have 40 people working

(100 floating employees and 15 permanent ones gives the equivalent of 40 working per day). Only when the company has about 30 or 40 people working permanently, it becomes possible to make a routine that allows applying the DFSS tool. The approximate turnover is about 3 million euros per year.

The enterprise 1 doesn't have implemented the Six Sigma program, but this program is known by it. It is periodically updated and is certificated by the standards ISO 9001, ISO 14001 and OHSAS (18001).

It doesn't have a quality department but has a responsible person in this area. It is common in SMEs not to have a specific department for quality. The system is structured from bottom to top, it cannot be done by the book (implemented from top to bottom), involving the participation of all employees in the implementation of operational and technical procedures. All the basic part of the quality structure is mounted from the participation of all people, therefore the person responsible for the quality, translates what people do in a procedure, so that there is uniformity, where the spirit of the people is evident. This happens in a later stage, when crossing other levels of procedures, in company's senior management or business management, people are prepared to receive training or awareness, because they participated in the bases of the system. Thus, it becomes easier to judge the introduction of a given system. One of the people interviewed, a board member of the business group, quoted: "When you want to apply something that was previously done to someone who has an education or more basic training, this only brings waste time for the person, rest or nap and isn't useful for nothing."

Enterprise 1 has used the DFSS tool and recognizes that it would be beneficial to use more this tool, although it is not possible to do in a permanently way. The major problem of the company, which is common to most Portuguese SMEs, is the reduced number of employees and the lack of technical qualifications, so it is difficult to make this implementation. In a theoretical and organizational point of view, the use of DFSS tool would be important to the companies, but as they are "crushed" by the market, they focus on meet established plans. Often quality programs are introduced in order to release the pressure imposed by customers. Sometimes, companies are required to present the security and environment procedures that must be in accordance with the large company for which they work, whether the operating place is or where large companies operate. There is a wide variety of mechanical equipment, because of that, the company is being restricted to implement DFSS tool.

In enterprise 1 there are situations where it's not necessary to use the DFSS tool like when there is a very specific contract to a particular project, with a specific thing or a simple project. There are two types of SMEs: the companies like enterprise 1 with intensive production and capital-intensive, which produce a large number of units. These companies can apply to DFSS tool, just do not have the technical ability to use the tool when the project has few dimension; and small but technology-based companies with highly qualified people, focused on project development, and these are the companies that are emerging too in Portugal. To implement DFSS system and to involve more qualified people, it's easier for a company like enterprise 1 that has manufacturing units, answer the needs of a large company like Autoeuropa, for example.

According to the interviewed the costs of using the DFSS tool in a management system should be considered as investments. That will result in efficiency and improving the quality of a production process. As in the area of quality, when it made the implementation of a system, it can first be seen as a cost, but when it's start to find what was the cost of production of a company before and after applying that system, it's found that the company that is organized according to this methodology (six sigma program) starts to produce better, cheaper and with deadlines, which is very important.

When there is a need for training, people take courses that have a short term, in which the person leaves the company, makes the course and is suitable in terms of knowledge to use DFSS tool property. Usually this kind of people must have good knowledge in the quality area as a whole, in order to use DFSS tool. Otherwise, the course will not be worth it. There're two main problems for the companies: one, is the lack of capacity of the managers, and two, the low-skilled people, therefore when there is no organization and people do not have training, companies do not work. First people must be sensibilized and only then can be trained.

Also, according to the interviewed, the DFSS tool forces the company to retain a client, and with this, the company knows that the project will bring profit, usually a margin of 5% or so. The profit on the work that was done is not very high, but can be certain in order to know exactly the margin. There are situations which because of the urgency to perform a job, the work is much better paid, so the margin is higher. The margin variability depends on the urgency of the delivery of the work or service (corresponding to shorter deadlines). The company over the years managed to get

better, even lowering the value of the contract. This is possible with the observation, which is a very important factor when working with a large company, see the progress of work, see whether there are delays and try to find a way and tools to produce faster and at lower cost. This process of improvement could be made using the innovation, but this has never been done in the enterprise 1. A large volume (e.g. half a million), can give a margin of 2 to 3 percent to the company, which in the industrial maintenance area, which is very good.

As a conclusive note, after the interview, is concluded that the companies that provide services can be considered as production companies, as enterprise 1. They repetitively do a series of activities and jobs. To use the DFSS methodology tool, the first step is to see, within the company, which is identical and different in order to arrange like the methodology asks. The essential is the dimension. It is a concern if the company does not implement ways to work well, according with deadlines and being competitive in market. There were a several improvements over the years in this company, that have been implemented until now, but with these improvements, the margins can be "crushed" because often the large companies, year after year, when jobs are repeated, try to see if it can "squeeze" the kind of service that is done by the SMEs, reducing the cost, the value of the contract and see if they can do the same thing for less money. There are cases where the work that was done ten years ago, nowadays can be made by three quarters of the price. As margins decrease is necessary to look for other ways to overcome this situation, and the solution for a particular job is not the DFSS tool, it should look for another similar that best suits the type of service. As the large diversity of works that are made by the company, it must have a very accurate idea of the company's own value chain to be able to see in which situation it can use the DFSS tool.

4. Final Conclusions

It was possible to demonstrate that the application of DFSS, through its strongly structured methodology, achieves significant gains in terms of the quality of product optimization already in its development process, to avoid higher costs of further product modifications when it's already in a production phase and answering the consumer's needs (voice of costumer).

The enterprise analyzed in the case study uses, punctually, the DFSS tool in order to attend their customer's needs, which in most cases are big named companies that can have the Six Sigma program implemented. The fact that the DFSS and the Six Sigma methodologies are independent, however complementary, makes possible the punctual use of DFSS in some companies, like the one studied. Therefore the DFSS tool presents itself as a good way to help SMEs in order to make these capable of integrating themselves in client companies that present high standard project requirements.

In another point of view, it's possible to a company that uses DFSS in the DNP context, to substantially decrease the costs associated to the product, service or process life cycle, since that DFSS presents a preventive approach that looks for failure occurrence to prevent errors due to these failures. For this reason and for the complexity of some instrumental tools used and its connection, DFSS projects can be time-consuming and of higher risk compared to SS projects, which are contemplated in the production phase in course. This being the only disadvantage associated with the use of DFSS.

Lastly, it's possible to assert that the implementation of Six Sigma methodology is a benefit to some companies, although it's not affordable to most of Portuguese SMEs given that in Portugal, companies of high technological level and qualification, are increasing. The use of DFSS it's a good alternative to answer the high standard levels of potential clients.

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