HOW TO ADAPT LEAN SIX SIGMA TO IMPROVE PERFORMANCE OF SMES OF MANUFACTURING SECTOR?

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1. Introduction

At the time of the financial crisis, the small and medium-sized enterprises more than ever need to apply solutions that ensure an efficient use of the resources as well as the products satisfying the customer requirements in the terms of quality, price and time. There are many reasons that oblige the SMEs to apply a continuous improvement principle: either a necessity to adapt them to the changing market, a need of the development and competitiveness or a demand for using the modern management methods as a cooperation condition coming from their clients – the large companies.

These requirements may be met by using the Lean Six Sigma (LSS) concept adapted to the small and medium-sized enterprises specificities, such as a lack of the financial resources, qualifications, time available and also a low level of the sector maturity. The mentioned conditions and a choice of the functional and flexible tools for the SMEs were specified in detail in the publications by P. Grudowski and E. Leseure in 2010 [Grudowski, Leseure, 2010, p. 121-130] as well as by P. Grudowski, E. Zajkowska, M. Bigand and E. Castelain in 2009 [Grudowski, Zajkowska, Bigand, Castelain, 2009, p. 276-281].

The main objective of the paper is to present the utilitarian effect of the adaptation of the Lean Six Sigma concept and its implementation in the small and medium-sized enterprises of the manufacturing sector. The original methodology was developed on the basis of research carried out in the Polish and French enterprises from 2009 to 2011.

In the case of SMEs, the use of the concept of Lean Six Sigma is much less common, as evidenced by the scarce literature on the subject. Analysis of the cases of implementation of Lean Six Sigma in the SMEs of the manufacturing sector reveals the common barriers faced by these companies using this concept.

This paper presents a framework of the methodology proposed as well as a case study of its application in the SMEs sector.

2. Lean Six Sigma

Both the concept of Lean Management and Six Sigma have to ensure customer satisfaction. The purpose of the Lean is the optimal use of available resources, reducing inventories and shortening the production cycle. Flexible approach to the organization of production in the case of the Lean concept is conducive to rapid response to fluctuations of orders [George, 2002, p. 4].

In the Six Sigma framework the principle of customer focus materializes, first of all, thanks to a reduction in the variation of the processes most important from the client point of view-Critical To Quality(CTQ) [Antony, Escamilla, Caine, 2003, p. 40-42], [Linderman, Schroeder, Zaheer, Choo, 2003, p. 193-203], [Gowen, Tallon, 2005, p. 59-87]. Within the Six Sigma concept, striving to a level of quality corresponding to 3,4 defects per million opportunities, takes place with the application of one of the two main models of continuous improvement: DMAIC or DFSS [Montgomery, 2005, p. 25-27], [Mader, 2002, p. 82–86].

As a results of the Lean and Six Sigma evolution, a hybrid Lean Six Sigma concept was created. Its mission is to affect the whole organization system in the most complex way in order to achieve the goals of the two concepts at the same time. The combined application of the principles of Lean and Six Sigma allows them to complement and strengthen synergistically their effectiveness in improving the organization [George, 2002, p. 3-4], [Arnheiter, Maleyeff, 2005, p. 5-18]. This approach supports the "win-win" scenario for both parties - the organization and its customers.

3. LSS Plutus methodology

Both the efficiency and the effectiveness of Lean Six Sigma for improving the manufacturing SMEs of the different branches of the industry was confirmed by the individual and the network cases of implementation of this concept [Grudowski, Zajkowska, 2007, p. 216-220]. Previous experiences of the small and medium-sized firms as well as a methodological gap justify a call for a model of the Lean Six Sigma application designed for the manufacturing SMEs. Consequently, the model should correspond to the specificity of the sector and be based on the criterion of the minimal number of the simple, efficient and effective tools.

In response to the required methodological support for the manufacturing SMEs and taking into consideration its specificity, the **LSS Plutus** ("Plutus" - in Greek mythology, means God of Wealth and the abundance of the harvest. In this way the name LSS Plutus highlights the benefits for companies connected with the implementation of Lean Six Sigma methods**)** methodology was established. LSS Plutus methodology was available and verified within the so-called "LSS project", being a Lean Six Sigma design, implement and control model.

LSS Plutus methodology follows the Deming cycle concept, where an efficient and constant progress is possible only if repeating the improvement activities according to the PDCA sequence [Hamrol, Mantura, 1998, p. 107-112].

Deployment of the Deming's continuous improvement paradigm in the proposed methodology constitute the DMAICS model, where elements of the acronym mean: D - define, M – measure, A – analyze, I – improve, C – control and S – standardize and maintain [Pillet, 2008, p. 18]. The DMAICS model is an extended version of the commonly used in Six Sigma projects DMAIC model, which was complemented in the M. Pillet monograph with a sixth element named "S-standardize" – establish the standards and maintain the applied solutions after the end of the project [Pillet, 2008, p. 373-395].

In the LSS methodology, the Deming cycle steps correspond to the four stages of the LSS-based enterprise improvement project (figure 1). A complementary element of the LSS Plutus methodology is a conceptual V-model [Forsberg, Mooz, Cotterman, 2005, p. 108-116, 242-248, 341-360], that is used to minimize the risk of taking the incorrect decisions while a realization of the LSS project.

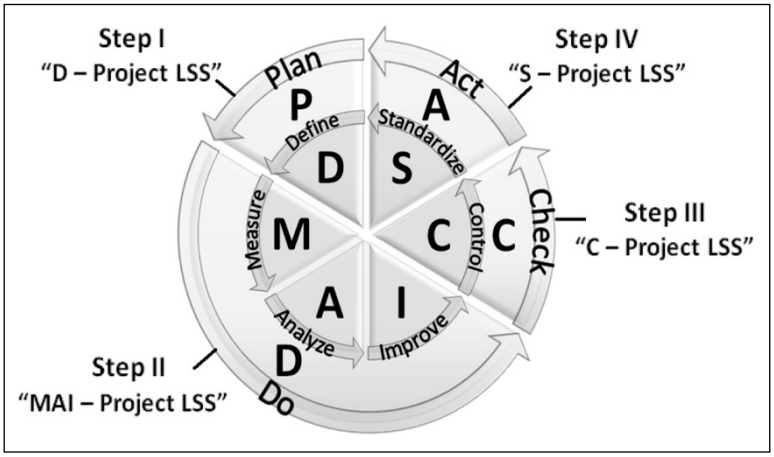

Figure 1. Applying the Deming cycle concept and the model DMAICS in the LSS Plutus methodology

In the next part of this paper, authors synthetically describe the stages of the proposed model, which employs the Lean Six Sigma method.

Step I – Define the purpose of the LSS project

According to the continuous improvement model DMAICS, the purpose of the first step of the Lean Six Sigma project is to establish an appropriate goal of this initiative. A well-defined objective should aim at meeting the requirements of the project client, who is usually represented by the customers, a client in the supply chain, the shareholders, a parent company, a top management, an enterprise department or the employees.

Defining the project direction, the customer satisfaction should be ensured and the scope of the improvements has to be adapted to the requirements as well as to the internal and external limits of the enterprise.

In addition, it is necessary to support the project organizationally, which includes the establishment of organizational group of LSS and top management support and commitment to implement improvements.

Step II – Conduct the improvement activities using LSS

Second step, named MAI – LSS Project, constitutes a practical application of the Lean Six Sigma improvements and it serves to realize a previously defined goal of the project. For correct problem identification and an appropriate choice of the tools to resolve it, a methodological rigor should be maintained. The MAI – LSS Project step begins with implanting Lean Management concept within the sub-step MAICS – Lean, and then implementing changes according to MAICS – Six Sigma. In order to apply the LSS Plutus methodology in the SMEs sector, only these Lean Six Sigma tools should be selected to the project, which correspond to the specificity of these enterprises [Grudowski, Leseure, 2010, p. 121-130].

The sub-step MAICS – Lean is being used to improve the enterprise performance, eventually including its reorganization to streamline the production processes. To carry out the changes, the Lean method identifies a value stream and focuses on a waste considered as the processes and the operations not generating the added value from the client point of

view [Womack, Jones, 1996, p. 5], [Hines, Taylor, 2006, p. 8 – 9]. This stage employs also the enterprise modeling procedure in order to map the processes and the flows of the materials, information, documents and money. A conceptual model of the sub-step MAICS – Lean, illustrating its main processes, was presented in the figure 2.

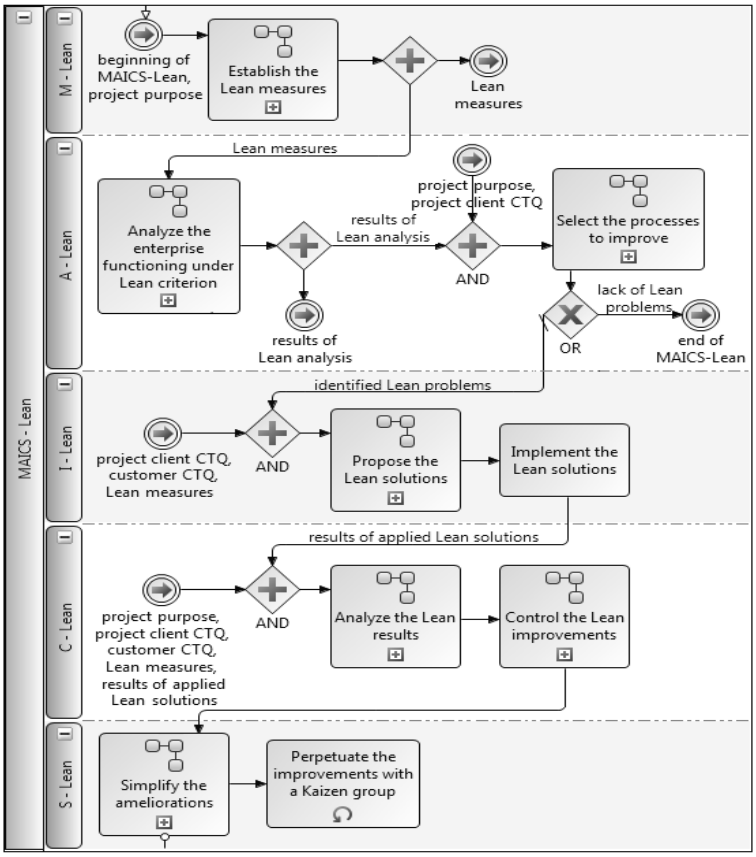

Figure 2. Conceptual model of the sub-step MAICS - Lean

When the key processes are stable, the flows are arranged and the production is lean, an implantation of the Six Sigma elements may begin. The second sub-step is composed of the activities that lead to a radical quality improvement thanks to an application of the statistical process control to monitor and control the processes, which determine a client satisfaction, being the most important from his point of view [George, 2002, p. 17-18], [Arnheiter, Maleyeff, 2005, p. 5-18]. In addition to the statistical tools, the Six Sigma-based problem solving techniques can be used to achieve the remaining improvements. Similarly to the sub-step MAICS – Lean, also the Six Sigma application is based on the five phases of the DMAICS model, including analogically the following phases:

- Identify the problem,
- Establish the 6σ measures,
- Analyze the enterprise functioning under 6 σ criterion,
- Select the parameters of the process to improve,

- Propose the 6σ solutions,
- Implement the 6σ solutions,
- Analyze the 6σ results,
- Control the 6σ improvements,
- Perpetuate the improvements with a Kaizen group.

The effect of application of Lean Six Sigma methodology, is centering and a gradual reduction of the random variability of selected stable processes. [Kwak, Anbari, 2006, p. 708-715]. All these improvement activities drive to lean a value chain and to reduce a number of the non-conformities according to the "zero defects" concept.

Step III – Evaluate the results of the LSS project

The penultimate step in the proposed methodology is to evaluate the effects of changes and verify the degree of achievement of the stated objectives. Thus the obtained results of the project are compared with the goals established in phase D – LSS Project.

Moreover, the verification if the conformity of the accomplished changes to the project client needs and the voice of the customer should be conducted. The initiative is recognized to be successful, if the expected targets were achieved, but also if the satisfaction both of the project client and of the final customers was gained.

Step IV – Standardize the applied LSS improvements and maintain the enterprise development

In the last step of the project, a special attention should be paid to the valorization activities leading to perpetuate the achieved improvements. The standardization process, though often underestimated, is essential to sustain the changes. In the successful LSS project, an important role is given to modern human resources management, sustaining the employees engagement and encouraging them to transform their experiences into the explicit knowledge. Apart from preserving the changes, a supplementary purpose of the step S – LSS Project is to develop a self-learning and seeking for the excellence enterprise [Grudowski, Zajkowska, Bigand, Castelain, 2009, p. 276-281].

4. Verification of the LSS Plutus methodology in the French enterprise

In this part of the paper, a medium-sized French enterprise New Bath Allibert was chosen in order to verify if the proposed LSS Plutus model allows applying Lean Six Sigma efficiently and effectively in the SMEs and to confirm a correctness of the methodology. The New Bath Allibert exists since 2005, specializes in designing, developing and producing the wide range of the standard and luxury bathroom equipment. Its annual turnover amounts to around 12 million Euros.

A general course of the Lean Six Sigma project based on the LSS Plutus methodology was carried out in the New Bath Allibert enterprise.

Step I "Define the purpose of the project LSS": D – Project LSS

The LSS project was launched as soon as the requirements of the project client became clear. In the New Bath case, the project client was represented by the top management, who expected the overall performance improvement in the terms of sales and savings.

The first action of this initiative was appointing a team to ensure an execution of the LSS project. The purpose of the project was defined in the context of the internal and external conditions of the organization. The analysis of the enterprise environment revealed

that New Bath constantly demanded to implement the modern management methods and to develop intensively its products.

These requirements were originated from the shareholders, a parent company Allibert and the large clients being in the durable relationship with the enterprise. Basing on the evaluation of the organization culture and maturity, New Bath was recognized enough prepared to run a LSS project at the advanced level.

Upon the enterprise environment, the voice of the customer and the project client, two goals of the project were defined: **an introduction of the new product to increase the sales** and **seeking for the savings without reducing the employment**.

Step II "Conduct the improvement activities using LSS": MAI – Project LSS

When the project targets were defined, the second step might begin. Firstly, Lean Management repository was implemented in order to establish those goals that were attainable with reducing the wastes and using the Lean tools.

The actions executed within the Lean Management application resulted in the new product idea that included an adjustment of the production line. Furthermore, the Lean analysis indicated the high raw material costs and the wastes of defective semi-products. The defects were coming from the bad working conditions in few operations, but this problem remained unresolved as being a low-priority issue. Otherwise, the Lean analysis did not reveal the reasons of the high raw material costs so that it became a major problem to improve within the sub-step MAICS – Six Sigma. Moreover, a searching of the savings was completed by the defects reduction. Analogically to the part of the project containing the Lean concept implementation, also the activities within the Six Sigma application followed the five phases of the DMAICS model.

Within the phase M – Six Sigma, the necessary information was collected to establish those goals of the project, where the Lean tools turned out insufficient. The measures were directed at seeking the savings by the costs and defects reduction.

The executed measures situated the enterprise at the quality level approaching 4.6 sigma, with 965 defects per million opportunities. Moreover, the bath-tubes appeared to be a product family the most strongly affected by the defects.

The Six Sigma analysis followed in the two directions: searching the savings both in the raw materials and in the defects. Therefore, an in-depth evaluation of the enterprise functioning was conducted within the four sets of activities: identifying the most important defects from the project client point of view, understanding its causes, analyzing the capabilities of the processes causing these defects as well as identifying the sources and the relations between the particular variations. The in-depth research was based on a usage of the wide range of the Six Sigma tools and indicators such as: Pareto analysis, interrelationship digraph, 5 Whys, Ishikawa diagram, gauge R&R, check sheet, histogram, control chart, measures of center and variation, Cm, Cmk, Cp, Cpk, Pp, Ppk, PPM, sigma level of a process, scatter diagram, DOE, ANOVA, process FMEA.

The analysis including stability, process capability and problem solving techniques resulted in determining the areas requiring the improvements. A principal conclusion indicated that the defects of the final products were mostly caused by lack of stability in the hot extrusion process due to the difficulties in the extruder adjustment. Also the same workplace was responsible for the high cost of the raw material usage because of an incorrect processing and an excessive plastic employment from the technological point of view to fabricate each semi-product. Moreover, the analysis revealed the influence of the high plastic price on the raw material cost. Likewise, in the sub-step MAICS – Lean, also

the research based on the Six Sigma method confirmed that an improvement of the working conditions at the thermoforming workplace was necessary to reduce the remaining important defects of the semi-finished products.

The phase I – Six Sigma contained searching for the solutions to the problems revealed in the Six Sigma analysis, choosing the appropriate tools and applying the improvements.

While seeking the solutions to accomplish the project goal, defined as a growth of the savings, it was found out that it was caused by an improper reject-making material usage and by producing the semi-products of the excessive thickness.

Firstly, the solutions aiming at a decrease in the number of defects were proposed. Therefore, the improvement actions focused on achieving the stability and capability of the hot extrusion process. However, upon the analysis in the phase A – Six Sigma, a difficulty in the optimal extruder adjustment consisted in the complex relations between the process parameters. Thus, to find the appropriate solutions, there were numerous technological, standardizing and control solutions proposed.

Afterwards, the other technological and control improvements were suggested to be applied when the extrusion process is stable. These improvements were directed at reducing the thickness of the semi-finished products in order to gain some material savings.

Bearing in mind the further searching for the savings, it was also proposed to introduce a cheaper plastic material to the part of the production when the extrusion process shall be stable.

Taking into consideration both the project client (CTQ) and the voice of the customer, the following solutions were chosen out of the numerous proposed to be established:

- an exchange of the used screw auger,
- the standardization charts for the changeovers as well as for the speed and temperature regulation in the extrusion process,
- regular control of the intensity of the electric current when starting the machine, and the temperature values of dissolved plastic-material production,
- the introduction of cheaper parts backed by the amended the machine using the DOE and ANOVA and thanks to the traceability of trial run.

The other propositions were considered to be too expensive and its implantation was postponed.

The improvements applied while the sub-process MAICS – Six Sigma allowed achieving one of the project goals, which was an increase of the enterprise savings. An additional benefit was a plant's productivity growth of 3.5% and an improvement of the company quality level from 4.59 to 4.65 sigma.

The main purpose of the phase S – Six Sigma was sustaining the applied solutions. Furthermore, the operators were encouraged to propose their own workplace improvements.

Step III "Evaluate the results of the project LSS": C – Project LSS

Within the penultimate step of the project LSS, the effectiveness of the accomplished improvements was examined in relation to the project goals. The requirements of the top management, being the project client, were met because both the sales and the savings grew.

The economical actions did not cause a worsening of the products quality, moreover a customer satisfaction was gained thanks to a new attractive product offer.

Step IV "Standardize the applied LSS improvements and maintain the enterprise development": S – Project LSS

While conducting the final stage of the project, the enterprise development plans for the future were defined. Furthermore, the top management decided to reconsider the proposed solutions which were not applied for the reasons of the important funding, that they required.

New Bath Allibert standardized the favorable changes and maintained the engagement, what enabled to lead the enterprise to the excellence and to gain its employees self-realization.

5. Conclusions and future research perspectives

According to the purpose of the paper, it may concluded that the presented methodology confirms the postulate of its adaptability in the SMEs conditions. The quoted case study illustrating its implementation in the French firm as well affirmed that LSS application in the medium-sized enterprise allows achieving the excellence goals and developing an organization. Furthermore, the study reveals a complementary impact of Lean Management and Six Sigma on the company performance.

LSS Plutus methodology is open to be used in the different situations and conditions. Defining the application of the methodology it must be emphasized that it exceeds the traditional scope of the enterprise performance improvement in the terms of quality, price and time. Another interesting point of the methodology is its ability to be applied in the service sector, where for example, a number of the defected products may be replaced by a number of the errors in the financial statement or a manufacturing cycle time by a reparation period. This in turn emphasizes the universal aspect of the LSS Plutus methodology to improve the SMEs functioning in the various sectors of the industry.

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