TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 61, Issue Special, September, 2018

APPLICATION OF THE AGGREGATED DMAIC-PDCA METHOD – CASE STUDY

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Abstract: *The turbulent environment in which production companies operate today forces them to constantly improve processes. Among the methods supporting the improvement of the efficiency of production processes, we can distinguish PDCA method derived from Japanese experience (Toyota Production System) and DMAIC related to the Six Sigma concept. Implementation of changes with the use of both methods has a positive effect. Literature can identify the factors determining the choice of one of them for implementation under specific production conditions. The authors of the article make considerations regarding the use of aggregated DMAIC and PDCA methods to create a sustainable environment of continuous improvement in a short time. Based on the company's study, the authors distinguish key elements that determine the effective combination of these methods. This connection is presented on the basis of the practical implementation of the production process efficiency improvement project at a workstation.*

Key words: *PDCA, DMAIC, aggregated PDCA-DMAIC method, production processes efficiency*

1. INTRODUCTION

Continuous improvement. How a production enterprise makes its habit to systematically ask the question about making things better each and every day. How to create such a system without enormous involvement of the people's time spent on additional tasks? How not to jeopardize currently working processes? How not only create and maintain such an environment but also make it easy to spread across organization? How to achieve this state in a short time and how to measure the outcomes?

Authors of this article presents case study. It relates to the production plant and answer questions mentioned above using aggregated DMAIC-PDCA method.

2. AGGREAGATED DMAIC-PDCA METHOD

Both DMAIC and PDCA methods have embodied efficient way of improving processes. Authors' present aggregated method to achieve business goals described above.

2.1 DMAIC

DMAIC as one of distinctive Six Sigma's approaches to process and quality improvements refers to five stages [1] which can be used as an improvement project steps.

Define

Define phase's objective is to identify project goals and project scope [2]. Various techniques can be used such as SIPOC, VoC, CTQ [3] and many more. One of the main products of this phase is the Project Charter which summarize chosen approach to resolving defined and described problem.

Measure

This phase's purpose is to set up the measuring process and gather the data that is relevant to the process outcome and the project goals [4].

Analyse

This phase focuses on the current state analysis, root cause analysis and verification of the hypotheses [5].

Improve

During improve phase the process being changed [6]. Activities are preceded by setting an implementing strategy [7] and risk assessment.

Control

Phase that ensure the improvements implemented during Improve phase will be valid, aligned and relevant to current business situation [8].

2.2 PDCA

Plan-Do-Check-Act method is similar in function as DMAIC and is called DMAIC's predecessor [9]. PDCA is associated with the Toyota Production System and Lean Manufacturing [10] and refers to four steps.

Plan

The purpose of the Plan phase is to plan corrective steps in order to achieve process improvements based on gathered data [11].

Do

During this phase previously planned improvements are implemented in order to eliminate the gap identified by the root cause analysis conducted in Plan phase.

Check

After the implementation comes the time to verify the results and to compare them with assumptions made in Plan phase. If the results meet the requirement the team may proceed to Act phase. If not, team run the Plan phase once again.

Act

Act phase's objective is to standardize implemented solution in order to achieve perpetuating profits from the improvement.

2.3 DMAIC and PDCA aggregation

Benefits from aggregation of DMAIC and PDCA methods are depending mostly on scope and timeframe of business goals. Described in the next chapter of this article business conditions specified considerable long timeframe of process improvement initiative aligned with company's strategy. Project team decided to dedicate their efforts to conduct improvement project which goal was to create, in short time, sustainable continuous improvement environment, starting with one specific workstation as a strategy execution pilot.

To be sure that this vision will transform into reality, project team decided that the project success will be fully functioning PDCA cycle on the workstation, without any involvement form the project team itself, with capability of workstation crew to gather and present evidence of their efficient improvement efforts. To achieve this goal, project team recognize the advantages of DMAIC approach to create such an environment.

The PDCA cycle is considered to be one of most fundamental continuous improvement concept strongly connected with organization's culture. DMAIC method is systematic and fact based, which provide helpful framework focused on results. The most important benefits from aggregation comes from iterative nature of implementing DMAIC project presented as a new tool [12]. Iteration might be conducted in a simple way which is provided by PDCA method and should be continued after DMAIC steps are completed. Additional factor, which defines success of the process transformation is strong link with the strategic objectives. This link helps to maintain high priority for the C-level executives which is critical in turbulent change management processes.

Although DMAIC statistical analysis may be more suitable for improving specific processes, PDCA might be considered better to use in broader scope of organizational changes [13][14]. Nevertheless this approach was not recognized as viable in presented business case.

3. BUSINESS CONDITIONS

3.1 Motivation to act

The company's management identified the need of changing the decision making process. Insufficient and unsupportive data and lack of standardized production processes caused several problems:

1. Decision were based mostly on intuition and practical knowledge of the production processes.

2. Top management was involved into repeatable and unstable data gathering activities, detailed process analyses and time consuming, hands-on changes implementation.

3. Employees could not work efficiently in processes that were changed on the basis of spontaneous decisions, and information about changes in the process was not clearly communicated.

4. The place of origin of quality errors was difficult to identify, which increased the risk of repetition of these errors.

5. The time of order processing was extended by inefficient relocation of employees between workstations, and the lack of clear information about the technological process that should be performed on a given position.

6. The implementation process of new employees lasted in the opinion of the management for too long.

3.2 Setting the direction

The above factors motivated the company's management staff to outline the direction of the implementation of organizational and technological changes. The long-term vision of the development of the improvement system was based on the following assumptions:

1. Conviction about the rightness of increasing the role of data that should be collected at production workstations in the decision-making process.

2. Building an environment to a greater extent involving production workers in ongoing improvement activities at workstations using Kaizen related method [14].

3. Work and improvement system based on standards that are easy to use and maintain.

By the decision of the team appointed to implement the changes, the project at the initial stage was limited to one workstation in order to demonstrate the effectiveness of a new way of managing and improving processes. This approach has been chosen to limit the concerns about change. At the same time, it was stated that the implementation of changes at the pilot workstation will be combined with an increase in the competencies of the company's staff to conduct improvement projects and will allow for easier expansion of the continuous improvement system to other workstations and areas in the company in the future. To conduct the implementation, the team chose the aggregated DMAIC-PDCA method.

4. IMPLEMENTATION

Clear objective and chosen approach enabled the project team to prepare and conduct project kick-off meeting [15]. During the meeting the project team discussed and concluded topics such as:

- company’s long-term strategy objectives;
- project objectives related to strategy;
- project development method;
- project schedule;
- project team;
- the way of communication;
- change management.

4.1 Define

Workstation and product selection

Although the project objective was already set, there was a necessity to chose one of the workstation to begin with. The project team used listed below criteria to select the best candidate:

1. Impact from improvements on the company’s profits.

2. Technological knowledge about process.

3. Process simplicity.

4. Workstation crew morale and predicted involvement.

5. Physical proximity of other workstation related to planned spreading of the continuous improvement method.

Specific workstation has been chosen. After that the project team focused on selecting the best product processed on the workstation for further analysis using criteria such as:

- production and sales volume;
- simplicity of technological process on the selected workstation;
- overall involvement of other workstations during product processing;
- number of quality issues;
- simplicity of data gathering;

● technological process repeatability in relation to other products.

Change management

After choosing the workstation and a product, project team conducted a questionnaire with production employees to be sure how to communicate changes and how to involve in particular the crew working at selected workstation.

Results shown that the most important gap between the current state and workers expectations were:

- possibility of skills development;
- income;
- appreciation for a job well done;
- appreciating the work associated with additional tasks.

Based on those results the project team decided to build a narration over empowering workers to have an impact on their workstations and to build for them the possibility to have measurable evidence of job well done. Also the continues improvement system would increase their chances to show the positive impact of additional tasks on their workplace and performance, which may be connected with the income.

The top management conducted a meeting on the factory floor with the workers. During this meeting the overall approach and benefits were presented and a leader from the selected for the pilot workstation was appointed.

The project team introduced the detailed project schedule to the workstation leader and choose tasks in which direct involvement of the workstation leader was possible and desirable.

Process map

The project team prepared the process map using BPMN. Map included material flow, information flow, roles, tasks, quality checkpoints, technological steps and documents. Process start was appointed as occurrence of the need to create a production order in the production planning department. Process finish was appointed as a prepared for the warehouse worker finished goods made by workstation, stacked on a pallet with document.

Aggregated DMAIC-PDCA Define phase's uniqueness

Knowing at start of the DMAIC project the solution, which is implemented and working PDCA cycle, might raise a question if it is a DMAIC project. Nevertheless a lack of the data and existing measuring processes led to a conclusion, that the solution was an unknown in its shape. Also the definition of a measurable outcome was not obvious and did not occur to a project team during Define phase even with process flow analysis. Those two conditions made DMAIC-PDCA approach particular useful with assumption, that measurable indicator of a process improvement would be established during Analyse phase and it would merge the overall DMAIC project goal with measurable PDCA cycle improvement efforts.

4.2 Measure

Measuring system was based on the process flow, mostly on technological and logistics processes and steps direct on the workstation. Project team gathered information by observation and measure of a:

1. Cycle time of each step performed on the workstation.
2. Working time of a machine presented in percentages, taking into account downtimes and changeovers.
3. Working time of the workstation crew presented in percentages in relation to working time of the machine and in relation to value-added and non-value-added activities.
4. Production outcome presented as a total volume produced at a workstation.

Machine's results:

- idle work, 76%, Non-Value Added;
- working, includes changeovers, 13%, Value Added;
- quality corrections: 7%, Non-Value Added;
- breakdown, 4%, Non-Value Added.

Worker's results during machine's working time:

- quality corrections, 31%, Non-Value Added;
- loading, 21%, Value added;
- walking/searching, 15%, Non-Value added;
- unloading: 11%, Value added;
- WIP cleaning, 8%, Value added;
- quality check, 7%, Value added;

• raw materials unpacking; 4%, Value added;

• machine configuration, 3%.

4.3 Analyse

Aggregated DMAIC-PDCA Analyse phase's uniqueness

Project team, to maintain focus on building the continuous improvement environment, held the root cause analysis of the results of the measurement phase to the point, when workstation crew could be a vital part of PDCA cycle. One exception was made, to prepare metric based on the performed measurement which can be used during PDCA cycle and which could resonate the workstation crew's improvement efforts. Project team choose two metrics:

• average time of one finished good production presented in seconds, 312 sec.;

• number of finished goods produced each day, average from one week, 41 pcs.

Both metrics were easy to capture and easy to understand by whole working crew.

4.4 Improve

Aggregated DMAIC-PDCA Improve phase's uniqueness

Most likely the DMAIC projects would instantly improve the process basing on the analysis of the measured process. In this case the project team aimed for creating long-term improvements efforts. Improve phase was divided into two main areas:

1. Creating PDCA cycle.
2. Improving process by generating and implementing solutions based on analysis of measured processes.

Second area would be conducted one time, because of time-consuming measuring process. Further improvements would be based on shorter cycles related to prepared and constantly measured two specific metrics created during Analyse phase.

Creating the PDCA cycle

After first step to create PDCA cycle, which was to choose specific metrics, second step was made. Its purpose was to prepare perpetuating, scheduled short meetings. During those meetings workstation crew could bring their ideas, estimate benefits, review necessary steps to improve the process and verify the benefits from previously implemented improvements.

Specific roles was assigned:

1. Production Manager was responsible for setting the time of the meeting, modulate the discussions, breaking the deadlock and setting up priority in case of any doubts.
2. Technologist was responsible for the benefits assessment, maintaining help during technological changes, measuring the outcome and visualization of chosen metrics.
3. Workers were responsible for bringing the ideas.
4. Whole team was responsible for conducting changes depending on specific tasks associated with their function in the organization.

Information was on the designed board put next to the workstation.

Improving process by generating and implementing solutions based on analysis of measured processes.

Using for the first time constructed PDCA cycle and using results from the Measure phase project team and whole workstation crew made a root cause analysis. During the moderated by Production Manager workshop, list of several root causes was made, among others:

1. Lack of raw materials to process, caused by lack of availability of forklift operator.
2. Usage of different and slower workstation due to lack of ability to operate and configure the machine efficiently.
3. Different tools setup for different operators due to lack of standards within the workstation area.
4. Discalibrated tools used to quality checks.
5. Lack of quality checks.
6. Low volume orders due to stock management practices.
7. Inefficient machine loading process due to transporter's pauses between different production orders.

In order to come with solutions, workstation crew invited to the regular meeting selected people from different departments. Question about necessity of invitation people from various departments became fixed point in the PDCA cycle meeting agenda. Introduced and implemented solutions were:

1. Establishment of time-windows for forklift operators and establishment of visual indicator on the workstation which was easy to noticed by logistics department.
2. Creating a mixed team of experienced and unexperienced operators to pass the best practice.
3. Introducing 5S on the workstation and implementing 5S checkpoints during PDCA cycle meetings.
4. Implementing quality checkpoint with register of repeatable issues.
5. Revision of the stock management process and decreasing number of production orders by calibrating MIN-MAX approach.
6. Reprogramming the machine by the IT specialist which led to elimination of pauses in loading process between production orders.
7. Assigning additional workforce to increase the time of loading process and to help with ergonomics.

During the implementation of the changes listed above other improvements were presented and implemented by workstation crew. Taking this into account the results of the improvements were:

1. Decreasing the average time of one finished good production from 312 to 137 sec.
2. Increasing the number of finished goods produced each day, average from one week, from 41 to 140 pcs.

In addition, the project team noticed use of workstation on the level of 50 percent of available time without any delayed production orders, which can lead to chance of generating more sales and increase of profits without any investment in workforce or machines.

4.5 Control

In order to maintain perpetuating PDCA cycle, the project team:

1. Designed system of gathering and revision of PDCA metrics to motivate workstation crew to self-control.
2. Developed a habit among the top managers to periodically visit the workstation and give their attention to the efforts workers are putting into their work area and measured results.
3. Designed a next steps to instil the PDCA cycles on the other workstations, which includes the leader of the pilot workstation as a experienced leader of change.

5. CONCLUSIONS

Using aggregated DMAIC-PDCA method led the project team to fast development of sustainable system of continuous improvement which included engagement from the workstation crew and increase of skills for spreading this system within the organization. Aggregated DMAIC-PDCA method quicksteps:

1. Define the goal of the project aligned with organization's strategy goals and based on continuous improvement initiative.
2. Select the area for improvement, prepare change management plan and perform measures.
3. Analyse results only to the point of choosing valid metrics which can be used during future PDCA cycles.
4. Implement PDCA cycle in the simplest manner.
5. Get back to the measurement results and perform root cause analysis.
6. Generate and implement improvements based on root cause analysis.
7. Implement other improvements based on the perpetuating PDCA cycles and metrics used to PDCA cycle revision.
8. Prepare the mid-term and long-term revision plan and involve top management to execute periodical audits.
9. Go to step 2 and check if the goal is still aligned with company's strategy.

6. ACKNOWLEDGEMENT

This paper has been the result of the study conducted within the grant by the Ministry of

Science and Higher Education entitled „Development of production and logistics systems” (project No. KSL 2/17) pursued at the Poznan School of Logistics in Poznan.

7. REFERENCES

[1] Rahman, A., Shaju, S.U.C., Sarkar, S.K., Hashem, M.Z., Hasan, S.M.K., Mandal, R., *A case study of six sigma define-measure-analyze-improve-control (DMAIC) methodology in garment sector*, Independent Journal of Management & Production (IJM&P), Vol.8, No.4, (2017).

[2] Ghosh, S., Maiti, J., *Data mining driven DMAIC framework for improving foundry quality - a case study*, Production Planning & Control, Vol.25, No.6, pp. 478-493, (2014).

[3] Improta, G. Balato, G., Romano, M., Ponsiglione, A.M., Raiola, E., Russo, M.A., Cuccaro, P., Santillo, L.C., Cesarelli, M., *Improving performances of the knee replacement surgery process by applying DMAIC principles*, Journal of Evaluation in Clinical Practice, (2017).

[4] Karout, R., Awasthi, A., *Improving software quality using Six Sigma DMAIC-based approach: a case study",* Business Process Management Journal, Vol.23, No.4, pp. 842-856, (2017).

[5] Jaworski, J., Kluz, R., Trzepieciński, T., *Investigation of Stability of Fabrication System of Casting Parts,* Archives of Foundry Engineering, Vol.14, No.1, pp. 5-8, (2014).

[6] ThanhDat, N., Claudiu, K.V., Zobia, R., Lobont, L., *Knowledge portal for Six Sigma DMAIC process*, IOP Conference Series: Materials Science and Engineering, (2016)

[7] Kuwaiti, A., Subbarayalu, A.V., *Reducing patients' falls rate in an Academic Medical Center (AMC) using Six Sigma "DMAIC" approach*, International Journal of Health Care Quality Assurance, Vol.30, No.4, pp. 373-384, (2017).

[8] Zasadzien, M., *Optimization of the soldering process by DMAIC technology, Production Engineering Archives*, Vol.11, No.2, pp. 6-10, (2016).

[9] Mast, J., Lokkerbol, J., *An analysis of the Six Sigma DMAIC method from the perspective of problem solving*, Int. J. Production Economics, Vol.139, pp. 604-614, (2012).

[10] Wojakowski, P., Warzolek, D., *Application of lean tools to measure and improve work in assembly cell: a case study*, Research in Logistics & Production, Vol.7, No.1, pp. 41-51, (2017).

[11] Parkash, S., Dr. Veerender Kumar Kaushik. *Supplier Performance Monitoring and Improvement (SPMI) through SIPOC Analysis and PDCA Model to the ISO 9001 QMS in Sports Goods Manufacturing Industry*. Logforum 7.4 (2011).

[12] Sokov, M., Pavletic, D., Kern Pipan, K., *Quality Improvement Methodologies - PDCA Cycle, RADAR Matrix, DMIAC and DFSS*, Journal of Achievements in Materials and Manufacturing Engineering, Vol.43, (2010).

[13] Paris J.F., *State of Readiness: operational excellence as precursor to becoming a high-performance organization*, 1st edition, Greenleaf Book Goup Press, Austin, Texas, (2017).

[14] Agmoni, E., *The role of Kaizen in creating radical performance results in a logistics service provider*, LogForum, Vol.12, pp. 225-245, (2016).

[15] Pisz, I., Łapunka, I., *Fuzzy logic-decision-making system dedicated to evaluation of logistics project effectiveness*, LogForum, Vol.12, pp. 199-213, (2016).

APLICAREA METODEI DMAIC-PDCA AGREGAT - STUDIU DE CAZ

Rezumat: Mediul turbulent în care companiile de producţie operează astăzi le obligă să îmbunătăţească în mod constant procesele. Dintre metodele care sprijină îmbunătăţirea eficienţei proceselor de producţie, putem distinge metoda PDCA derivată din experienţa japoneză (Toyota Production System) şi DMAIC referitoare la conceptul SixSigma. Implementarea schimbărilor prin utilizarea ambelor metode are un efect pozitiv. Literatura poate identifica factorii care determină alegerea uneia dintre ele pentru a fi implementată în condiţii de producţie specifice. Autorii articolului fac consideraţii privind utilizarea metodelor agregate DMAIC şi PDCA pentru a crea un mediu durabil de îmbunătăţire continuă într-un timp scurt. Pe baza studiului companiei, autorii disting elemente cheie care determină combinaţia eficientă a acestor metode. Această conexiune este prezentată pe baza implementării practice a proiectului de îmbunătăţire a eficienţei procesului de producţie la o staţie de lucru.

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