Assessment and enhancement of the performance level of an algerian company

Hichem Aouag[1] , Mohyiddine Soltani[2], Mohammed Djamel Mouss[3]
[1,2,3] Productic and Automation Laboratory, university of Mostafa Ben Boulaid
Batna, Algeria
[1] h.aouag@univ-batna2.dz; [2] soltani.mohyiddine@gmail.com; [3] d.mouss@univ-batna2.dz

***Abstract*— The work presented in this paper investigates an application of Six Sigma approach for the purpose of assessment of the competitiveness capability of an Algerian company through a period of three years. To do this we use a weighted DPMO and Six Sigma level approaches. Firstly the weighted DPMO was used to calculate the proportion of quality defects. Secondly, Sigma level was introduced to evaluate the competitiveness of the company. The proposed methodology is applied in a real case study, the obtained results are discussed.**

Keywords—Six Sigma, DPMO, Sigma level, weighted DPMO.

I. INTRODUCTION

Algerian industry encounters difficulties in the management of industrial facilities. In addition, Algeria has recently witnessed the bankruptcy of many industrial establishments due to poor management and poor quality of services and product. However, it has witnessed new private investments in different industrial kinds such as automotive, metal, pharmaceutical which in turn will create a sharp competitive market. Consequently, it requires taking precautions to avoid the fate of previous companies. Therefore, this framework aims to propose a simple solution, which we try to find solutions for treating the problems discussed previously. Therefore this paper investigates an application of an assessment approach for the objective of improving the product quality and controlling the competitive situation of an Algerian company.

Hence, the proposed approach will try to attend the following key objectives

- Calculate the proportion of quality defects via weighted DPMO;
- Quantify the competitiveness of firms via Sigma level;

The remainder of this paper is organized as follow: section 2 provides a brief background on Six Sigma approach. Section 3 presents the proposed methodology. Section 4 describes the data used and the implementation of Six Sigma approach. Section 5 discusses the research results and Section 6 presents the conclusion of this work.

II. LETIRATUR AND REVIEW

Six Sigma is an American approach developed by Motorola in 1980. Six Sigma aims to reduce process variation and increases the competitiveness level of a company. According to [1] "Six Sigma is an approach that combines the understanding of customer needs; the rational using of statistical methods based on data collection and analysis, and careful management processes". Six Sigma has a well-organized structure, which is generally performed based on five improvement steps that are grouped under the acronym define, measure, analyze, improve, and control (DMAIC). Statically, Six Sigma is an improvement strategy that aims at reducing the number of defects to as low as 3.4 parts per million and 99.99966 per cent process yield [3][2]. To achieve this purpose, several metrics can be used such as defect rate parts per million (PPM), Six Sigma level DPMO.

A. DPMO

DPMO is a metric which used to express the proportion of quality defects over the total number of opportunities in a set of data [5], DPMO is calculated by dividing the DPO per million according to the equation 1:

$$DPMO = {}^{DPO}/_{10^6} \quad (1)$$

The weighting approaches can be used to improve the estimation rate of DPMO and Six Sigma level. Various weighting models are found in the literature, for example: [4][3] proposed a weighted DPMO and Sigma level approach based on the costs to assess the competitiveness level of companies. Another weighted DPMO approach developed by [5] [4] based on the costs of poor quality that aims to evaluate the competitiveness and the defect rate of firms.

The result of DPMO allows to assess the quality level of firms, as shown in Table 1:

TABLE I: Performance assessment based on DPMO

Sigma	Quality %	DPMO
1	30.9%	691462
2	69.1%	308538
3	93.3%	66807
4	99.38%	6210
5	99.977%	233
6	99.9997%	3.4

B. Six Sigma level

Six Sigma level is a criterion that used to measure the competitiveness of a company and assess the improvement achieved after the implementation of a Six Sigma project [5]. There are two kinds of Six Sigma level, which are; short term and long term. The Short-term Six Sigma level based on the data that are collected for a short period. The Long-term Six Sigma level is used in the case where the data are related to a long period of time [5], The calculation of Six Sigma level allows to determine in which class the company belongs, as shown in table 2:

TABLE II: Classification of an organization using Sigma levels [3], [4]

Sigma level	Defect per million (DPM)	World class
6	3,4	World-class
5	230	
4	6200	Industry average
3	67000	
2	310000	
1	700000	Noncompetitive

III. METHOD

The methods used in this case study are weighted DPMO and Six Sigma level. Weighting DPMO has been used for determining the proportion of defects; Six Sigma level has been used for assessing the competitiveness level of companies.

The content of this part was applied by [4] using the data of the year 2012, and we repeated it in the same company with the values of the years 2014 and 2016 respectively for the purpose of assessing the improvement achieved by the company. To do this we based on DPMO and Six Sigma level calculations, starting with the following equations (1):

$$DPMO = \sum_{i=1}^{n} DPO_i / 10^6 \quad (2)$$

Sigma level can be obtained by using the NORMSINV function available in Microsoft Excel [6]. Based on the following equation:

$$sigma\ level = 1{,}5 + NORMSINV(1 - DPMO) \quad (3)$$

The weighted DPMO and Sigma level have a positive influence on the estimation of the results. For this reason, we use the same weighting approach and the same demarche that developed by [4] for a fair comparison of results. The weighting ratio is presented with the equation (4):

$$W_i = \frac{CPQ_i}{\sum_i^n CPQ_i} [4] \quad (4)$$

Where:
W: denotes the weight of each process;
CPQ: denotes the cost of poor quality;
i : denotes the stage in the manufacturing process;
In this case, the weighted DPMO is calculated using the following formulas [3] [4]:

$$DPMO_{total} = \sum_{i=1}^{n} (W_i \times DPO_i) / 10^6 \quad (5)$$

IV. CASE STUDY

This study has been conducted in Algerian manufacturing organization located in Batna that produces gas bottles using a manufacturing process which composed of three workshops, which are; mechanical workshop, welding workshop and finishing workshop. Knowing that our Work was focused on the mechanical workshop.

A. Assessement of the competitiveness of the mechanical workshop

The objective of this part is to calculate the total weighted DPMO and the Six Sigma level, in order to assess the degree of competitiveness of the mechanical workshop in the years 2012, 2014, 2016 respectively.

The DPMO and Sigma level are calculated based on the information provided by the quality control, accounting and production services. Therefore, to simplify the calculation process we respect the consistent steps that used by [4], in which the mechanical workshop is divided into five (05) operations which are:
Op (1): Operation of flanks;
Op (2): Operation of the lower deep drawing;
Op (3): Operation of the higher deed drawing;
Op (4): Operation of foot;
Op (5): Operation of collar.

a) DPMO calculation

Table III shows the number of defects per opportunity in each operation of the mechanical workshop of the years 2012, 2014 and 2016 respectively.

This part deals with the data concerning the year 2016, for explaining the calculation methodology.

TABLE III: Number of defects per opportunity in the mechanical workshop

Years	2012		2014		2016	
	Number of production	Defect per opportunity	Number of production	Defect per opportunity	Number of production	Defect per opportunity
Op (1)	839406	1105	863276	1163	1009398	1616
Op (2)	276018	1059	289132	859	466575	1045
Op (3)	278881	923	293087	876	463419	1141
Op (4)	284834	1088	306555	783	465529	2346
Op (5)	277770	577	305689	624	414175	697

a) Calculating the weighted DPMO of each operation in the mechanical workshop

The cost-based weight of each operation is computed using equation 4 and the results are presented in table IV:

TABLE IV: the weight of each operation

Mechanical workshop	Cost per unit	Ratio
Flanks	429.00	25.9%
higher deed drawing	458.43	27.6%
lower deep drawing	458.43	27.6%
Foot	167.17	10.0%
Collar	147.84	8.9%
Total	1660.87	100%

At this point, the weighted DPMO is calculated using the equation (4)

$DPMO_{mechanical\ workshop}$ =(0,259*1616+0,276*1045+0,276 *1141+0,10*2346+0,089*697)

$DPMO_{mechanical\ workshop}$ = **1318**,513.

$DPMO_{mechanical\ workshop}$ =0.00131851.

a) The Sigma level of the mechanical workshop

Based on the result obtained from DPMO calculation, the Sigma level is calculated using the equation (2), as follow:

$Z_{mechanical\ workshop} = 1.5 + NORMSINV(1 - 0.00131851)$

$Z_{mechanical\ workshop} = 1.5 + NORMSINV(1 - 0.00131851).$

$Z_{mechanical\ workshop} = 1.5 + NORMSINV(0.998781).$

$Z_{mechanical\ workshop}$ =4.51

The obtained value of Sigma level is equal to 4.51, which indicates that the mechanical workshop belongs to the middle class

With same manner the data of the years 2012, 2014 were treaded, and the obtained results are discussed in the following section.

V. RESULT AND DISCUSSION

The obtained results of the years 2012, 2014 and 2016, show that the company did not make any improvement, and the mechanical workshop remained in the same word class. The results are represented in the following table:

TABLE V: the result of DPMO and Sigma level calculation

Years	Weighted DPMO	Level Sigma	Word class
2012	0.0009886	4.59	Middle class
2014	0,00091391	4,61	Middle class
2016	0,00131851	4,51	Middle class

In this case, it is important to propose keizen events that enable to reduce the quality defects and increase the competitiveness level of the company. Therefore, the proposed action plan contains the following improvement opportunities:

TABLE VI: improvement opportunities

Methods	Benefits
5S	It is an organization workplace method that can be used to reduce the defects of quality resulting from poor ergonomic conditions.
Control chart	It is a powerful tool for monitoring the quality of product in a real time and decreases the quality defects.
Poka yoke	It Is a simple improvement process that used to reduce the defect rate and facilitate performing the process tasks without error.
Quality function deployment	It is a method that used to increase the level of product quality and ensure customer satisfaction.

VI. CONCLUSION

Six Sigma is one of best improvement approaches, which contains tools and methods that help the firms to achieve good results in cost reducing, customer satisfaction, improving and controlling the competitiveness of companies.

Our framework is devoted to the assessment of the competitiveness of an Algerian company in the years 2012, 2014 and 2016 respectively. The evaluation was performed using a weighted DPMO and Sigma level approach. The results obtained show that any improvement achieved and the classification of the company remained in the middle class. For this reason, we propose a set of improvements opportunities to improve the product quality and reduce the quality defects in order to increase the competitiveness level of the company. This study is provided to Algerian industry with a simple approach to assess and control the competitiveness of their manufacturing processes. For future work, we propose to validate this work in other Algerian manufacturing processes to prove the effectiveness of the proposed approach

VII. REFERENCES

[1] K. Linderman, R.G. Schroeder, S. Zaheer, and A.S. Choo, “Six Sigma: a goal-theoretic perspective,” Journal of Operations Management vol.21, pp.193–203, 2003

[2] U. Rehman Hakeem, M. Asif, A. Saeed Muhammad, A. Akbar Muhammad, and U. Awan Muhammad, “Application of Six Sigma at cell site construction: a case study ,” *Asian J. Qual.*, vol. 13, pp. 212–233, 2012.

[3] J. Ravichandran, “Total Quality Management & Business Six-Sigma Milestone : An Overall Sigma Level of an Organization Six-Sigma Milestone : An Overall Sigma Level of an Organization,” no. December 2014, pp. 37–41, 2007.

[4] H. Aouag, A. Kobi, and A. Mechenene, “Analysis of competitiveness level in an industrial company using a continuous improvement-based approach,” *Int. J. Six Sigma Compet. Advant.*, vol. 9, no. 2/3/4, p. 87, 2015.

[5] U. R. Hakeem, A. Muhammad, A. S. Muhammad, A. A. Muhammad, U.A. Muhammad , "Application of Six Sigma at cell site construction: a case study", Asian Journal on Quality, Vol. 13 Iss 3 pp. 212 - 233, 2012

[6] J. M. Lucas, “The essential Six Sigma,” pp. 27–31, 2002.