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A Case of Improvement in A SME Using Six Sigma Approach

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Summary
Quality, understood as a Business Strategy, must turn into an essential part of any type of organization, incorporating their concepts, approaches and methods in any of their processes. Those methods include, as a basic element, the use of statistical tools. In this sense, SME require to update strategies to achieve higher quality standards that allow them to survive in increasingly competitive markets. This paper deals with implementation of Six Sigma concepts and methods in SME, presenting a case of application in a small manufacturing company. Each step of the process is presented, and its results analyzed.

Key words: *Quality. Six Sigma. Small and Medium Enterprise (SME).*

1. INTRODUCTION

Six Sigma is a useful approach to quality improvement in organizations worldwide. This tool has been used in many types of organizations, but mainly in big companies and corporations, and with less frequency in medium companies. Its application in small companies faces challenges related with the size of the company, the frequent lack of technicians and a management with low motivation by the quality, and with so many problems that the practical interest in quality efforts occupies a low position in their priorities.

In this paper we present a case of application of Six Sigma methodology in a small textile company. The quality problems faced by the company are first identified and evaluated, and with this information an improvement project is selected. The situation is then evaluated using Six Sigma tools, and a strategy for improving the situation is defined and implemented. Finally the results are evaluated and some conclusions are derived from the process.

2. THE COMPANY

The study was developed in Manufacturas Quality Ltda.[1], a manufacturing company producing undershirts. The company was created in 2003 by two engineers, C. Montoya and J. Cuesta, and is located in Ibague, the capital city of the Department of Tolima, in central Colombia. The company has a section dedicated to produce t-shirts, with a maximum capacity of 150 units per hour. The staff is integrated by seventeen persons: Five in the managerial staff (Marketing Manager, Production Manager, Accountant, Marketing Assistant and Quality Supervisor), and twelve in the production staff (one person in cutting section, ten in making section and one in maintenance). Figure 1 shows this structure.

As in many SME, the management and staff structures are reduced to the minimum, trying to maintain functionality while adapting to the size of the company (Universidad de los Andes, 2005; Pérez, 2003).

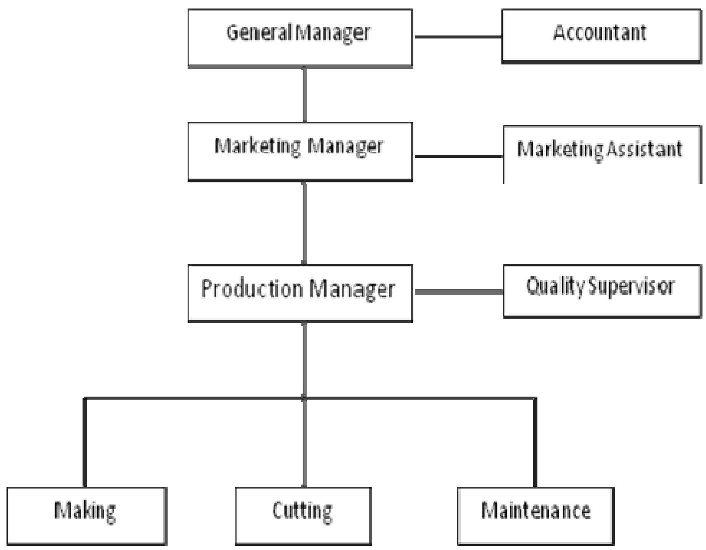

Figure 1. Manufacturas Quality Ltda Structure.

At present, the equipment installed in the production area includes a total of ten machines for cutting, sewing and assembling shirts. In what refers to commercial aspects, the main customer, from the creation of the company, has been Fandestol, but now Manufacturas Quality Ltda is opening new commercial lines centered in direct selling, obtaining better flexibility for the production process. Future investments will be oriented in this direction. Company's Mission and Vision can help to better understand the improving efforts of the company.

Company Mission: "To be a company in the textile making sector characterized by its high quality and efficiency indexes, with clear design, production and commercialization politics inside and outside Colombia, basing in an optimal organizational climate for all stakeholders, following all legal and regulatory standards".

Company Vision: "To position us in the domestic and international market, with a fully independent mark, achieving the Excellence in our offers to customers, with new concepts in design and processes improvement, with recognized quality and environmental technology and a qualified human resource".

[1] Names of companies referred in this paper have been modified by confidentiality reasons.

3. SIX SIGMA PROCESS IN MANUFACTURAS QUALITY LTDA

In the following paragraphs, the process used to develop the Six Sigma process will be presented, starting with the team member's selection.

3.1 Six Sigma Team Members

Six Sigma Project started in November 2004, as a cooperation project between Manufacturas Quality Ltda and the Faculty of Industrial Engineering of the Ibagué University. Some meetings were organized to present to the Top Management of the company all aspects related with Six Sigma approach and the nature of the improvement project. A Guide to Six Sigma was prepared and distributed in the meetings. The general aspects of the project were presented to all the company's personnel, explaining what was planned and which will be their role.

In the following weeks Six Sigma team was selected. The small dimension of the company conditioned the team structure. After analyze skills and profile of managers and employees, the decision was that Marketing Manager will act as the Champion, and that Production Manager will act as Black Belt, considering his previous experience in Quality and his deep knowledge of the process. Quality Supervisor was selected to act as Green Belt.

The absence of an engineer in the production area, requested to incorporate to the Six Sigma Team a member of the University project team. Thus, C. Tavera, from the Ibagué University, was appointed as Master Black Belt with the mission of training Black Belt in statistical and non-statistical improvement tools. Other University project member, D. Segovia, has the responsibility for training and helping Green Belt.

3.2 Improvement Projects Identification

In the third week of December, the team started the analysis of the organization, for better understanding its present situation, customers, products, problems, etc. This week and in subsequent meetings, possible problems affecting quality were evaluated. To do this, DMAIC process was used, and some tools corresponding to Define phase were applied (Escalante, 2003; Gitlow, 2007).

The first tool used was Brainstorming. Six Sigma team members expressed their opinions about present quality problems in the company. Critical quality characteristics were identified tentatively. The need for a process flow diagram was recognized, and that for the basic T-shirt was prepared (Figure 2).

The Brainstorming produced a list of quality problems, possible candidates to the improvement process:

- large amount of error in basic T-shirt production,
- delays in delivery dates,
- lack of adequate inspections in supplies at the start of the basic T-shirt process,
- some minor and isolated problems, as shortage of supplies, energy disruptions, etc.

3.3 Data Measurement

To define which of these problems was more relevant, a Pareto analysis was developed. The frequency of the different problems was controlled, and the results show that the first one (large amount of errors in basic T-shirt production) was the most important, representing 55% of the total incidence of quality problems (see Table 1).

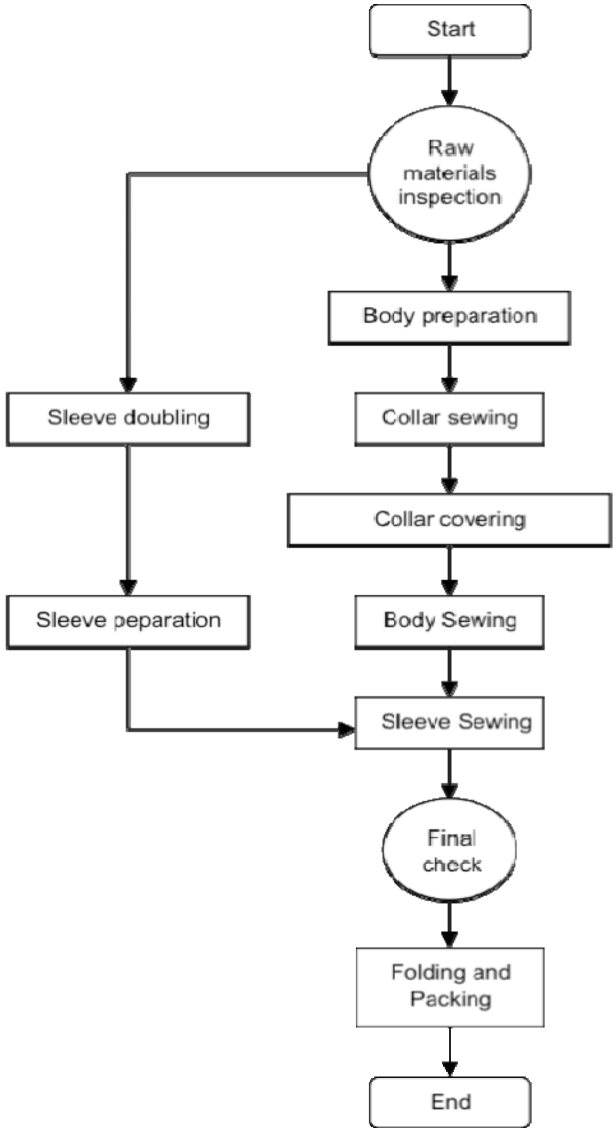

Figure 2. Process flowchart

Table 1. Pareto analysis of quality problems

ID.	Problem	Frequency [%]	Cummulative [%]
A	Large amount of errors in basic T-shirt production	55%	55%
B	Lack of adequate inspections in supplies at the start of the basic T-shirt process	22%	77%
C	Delays in delivery dates	15%	92%
D	Others	8%	100%
Total	100%		

A Pareto chart was prepared, Figure 3, to communicate and enhance the relevance of this problem, and to justify its selection as Improvement Project.

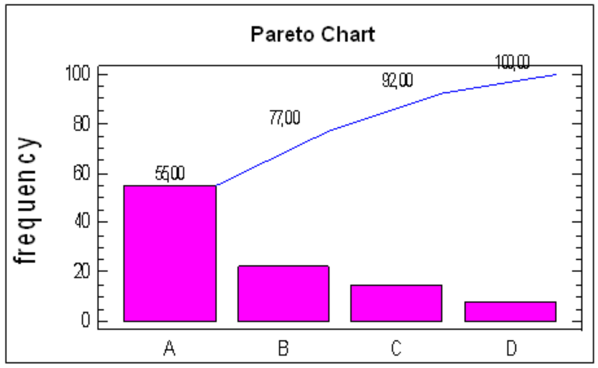

Figure 3. Pareto chart for quality problems

The selected problem is of high importance for the company, as its main customer, Fandestol, has presented frequent complaints related to the number of nonconformities in delivered T-shirts, causing lots rejections and important costs for the company. The errors present in T-shirts are related with cutting and sewing processes, affecting collar, sleeves and body. A total of 8 different errors can qualify a T-shirt as defective, with the presence of at least one of them.

Criteria used by Fandestol to evaluate and reject lots were clarified. A sampling method using Military Standards was used. Fandestol applies NTC ISO 2859-1:1999 (equivalent to MilStd 105D), with AQL 2.5%. With the standard sampling conditions, and a lot size of 600 units, sample size was 80 and the acceptance number is 5. With this data, results of the following lots were tracked, obtaining the results presented in Table 2. These ten lots covered a period of two weeks.

Table 2. Defective units in last ten lots (each with sample size 80)

Lot	1	2	3	4	5	6	7	8	9	10	Mean
Errors	5	4	5	5	5	6	6	6	5	6	5.3

It can be noted that the lot rejection percentage was 40% and that the mean number of defective units was greater that the acceptance number defined in the sampling plan. To analyze the meaning of these data, tools from the measuring phase of the DMAIC process were used, starting with evaluation of the Sigma level (Gutiérrez, 2004).

Measurement unit selected is the basic T-shirt, as the defects in this item are the basis for lot acceptance or rejection.

3.3.1 Sigma Level Calculation

With the results from acceptance sampling we can obtain Sigma level:

$$DPU = \frac{Defects}{Sample} = \frac{5.3}{80} = 0.06625$$

Each T-shirt can contain up to eight different defects, each causing rejection. These defects are related with cutting, sewing and assembling operations. Then:

$$DPO = \frac{DPU}{\#Oportunities} = \frac{0.06625}{8} = 0.00828125$$

The computation of the DPMO is now only a change of scale:

DPMO = *DPO* * 1000000 = 8281.25 defects per million of opportunities

With the value of DPMO, we can obtain Sigma level from the corresponding adjusted Normal Tables, resulting that this level is 3.89, corresponding to an error probability of 0.83%

3.3.2 Process Performance

From the results of the lot acceptance sampling we can obtain process performance:

$$PERFORMANCE = \frac{\text{Accepted lots}}{\text{Total lots}} = \frac{6}{10} = 0.6 = 60\%$$

3.4 <u>Data Analysis</u>

Even considering that we are in attribute situation, the evaluation of the process capability is important to have a complete view of the situation. At least potential capability index can be computed:

$$Cp = \frac{1}{3}\Phi^{-1}\left(\frac{DPO}{2}\right) = 0.88$$

As can be expected, process is not-capable. The Cp index, lower than 1, confirms the bad data of previous indexes (Montgomery, 2004).

In the path to process improvement, identifying root causes of the problem was the logical next step. Cause and effect diagram was used (Marsh, 2000). Brainstorming produced the following list of possible causes, structured in causes related with persons, with measurement and with methods.

3.4.1 Related with Manpower

A) high absenteeism degree, due to:
a. low employees motivation for production and quality,
b. lack of sense of ownership,
c. the plant is far from the city,
d. dissatisfaction with salaries (employees are receiving the minimum salary),
e. employees habits from other companies (many employees come from bigger companies, where transport service was provided the company, causing dissatisfaction with the present situation).
B) Excessive time-outs, due to:
a. no control over employee's performance or quality in production. Nobody is taking data at about,
b. absenteeism causes that some employees have to move from one work place to another to cover absences.

3.4.2 Related with Measurement

C) No data collection about production process, due to:
a. there isn't a Production Supervisor, with knowledge and responsibility about production and quality,

b. lack of interest about production in General Manager (more related with commercial area),
c. lack of knowledge in General Manager about quality tools and principles.

3.4.3 Related with Methods

D) High degree of demand about the compliance of the orders, but null control of individual performance
a. low communication between Management and Production,
b. managers insouciance in what respects to employees.

With this list of possible causes, the Cause and Effect diagram was prepared (Figure 4).

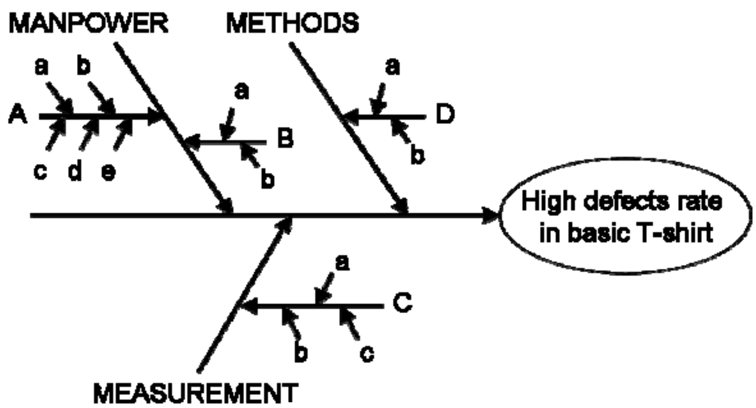

Figure 4. Cause and Effect diagram

Six Sigma Team concludes that in this case not only one root cause can be identified, but is the combination of the various factors described what caused process low performance.

3.5 <u>Improvement Process</u>

Once root causes are identified, the team proposed a multi-front improvement plan with the following actions:

- Give motivation training to personnel to increase the sense of ownership, and reduce absenteeism. All employees received a two hours presentation of some quality issues, enhancing the importance of their role in producing quality.
- By means of meetings with employees, Top Management convince them that for the moment company cannot increase salaries, but the General Manager compromises to consider the option to offer incentives by performance in the production area. These incentives didn't exist in the study period.
- In subsequent meetings, employees are informed that company is moving in the short term to a new location, more convenient far all.
- Process data collection is established. A historic database of production data is constructed, allowing process monitoring. Quality supervisor is in charge of this database.
- Control over production employees is increased, to avoid distraction and idle time during the labor hours. Presence of managers (general manager and production manager) in the production area has been incremented.
- Training of key employees will be reinforced, so they can afford with increased tasks if absenteeism reappears. These employees have received training in professional skills to allow them to work in any of the jobs of the process.

4. RESULTS

The application of those actions, and the use of the Six Sigma philosophy basics in the way of facing problems, helped the company to improve the situation. The main results achieved two months after improvement actions were taken are:

a. Basic T-shirts lot rejection was reduced by 50%. In a new series of ten lots only two were rejected (Table 3).

Table 3. Defective units in a new series of ten lots (each of size 80)

Lot	1	2	3	4	5	6	7	8	9	10	Mean
Errors	6	6	5	5	5	5	5	5	4	4	5

b. The mean of defects per lot was reduced from 5.3 to 5. Even the improvement was not very high, the trend detected in table 4 data is highly encouraging: The mean for the second part of this new lot series is 4.6

c. Absenteeism is reduced by 80%.

d. For the new ten lots series, Sigma level is improved, as the defects rate is reduced. New Sigma level calculation is as follows:

$$DPU = \frac{Defects}{Sample} = \frac{5}{80} = 0.0625$$

$$DPO = \frac{DPU}{\#Oportunities} = \frac{0.0625}{8} = 0.0078125$$

DPMO = *DPO* * 1000000 = 7812.5 defects per million of opportunities.

Sigma level is now 3.918, with an error probability of 0.78125%. A little improvement referred to the original value (sigma level 3.89) can be appreciated.

e. If only the second part of the lot series is considered, assuming that the improvement trend is real, improvement is more consistent:

$$DPU = \frac{Defects}{Sample} = \frac{4.6}{80} = 0.0575$$

$$DPO = \frac{DPU}{\#Oportunities} = \frac{0.0575}{8} = 0.0071875$$

DPMO = *DPO* * 1000000 = 7187.5 defects per million of opportunities.

Sigma level is now 3.948, with an error probability of 0.71875%. A little improvement referred to the original value (sigma level 3.89) can be appreciated.

f. Process capability also increases, and is now Cp=0.887 (0.896 for the last five lots), implying that the process is still not capable. The fact that defects mean is on the acceptance limit makes the effect of this small improvement very significant in lot rejection reduction (50%).

g. Process performance increases from 60% to 80%, considering the new lot acceptance rate of 80%.

$$PERFORMANCE = \frac{\text{Accepted Lots}}{\text{Total \# lots}} = \frac{8}{10} = 0.8 = 80\%$$

5. RECOMMENDATIONS

After develop and validate a Six Sigma Guide for Manufacturas Quality Ltda., it is convenient to give the following recommendations:

- Expand process control procedures.
- Follow and control established improvements.
- Adopt Six Sigma philosophy as a tool for continuous improvement in daily work.
- Continue the effort to increase Sigma level, with the final objective of reaching 6 Sigma (but being realistic).
- Company should improve its technical staff. It can be of interest to hire a Production or Industrial Engineer to act as Production Supervisor.
- As complement, educations and training of employees must be improved. A training plan should be prepared.
- Top Management should improve its knowledge and interest about production questions.
- It can be convenient to measure in economic terms the impact of the improvements, as a way to demonstrate to Top Management the interest and profitability of the effort. The return of investment (ROI) can be a very useful way of evaluating achievements.
- It is recommended to provide a computer for production area, to have quick and flexible access to quality and production data, and allowing the use of quality statistical tools.

6. CONCLUSIONS

The SME environment is completely different from that of big companies. Especially for the small companies, this difference can have dramatic effects on the availability of trained people, equipments, time and even the will to improve. The day-to-day urgencies absorb most of the manager's efforts, causing many times an excessive focus on the commercial aspects of the company life.

With this in mind, quality professionals have to deal with the fact that these small companies are in the same world and in the same markets that are big companies, having similar quality requirements and facing the challenge of satisfying customers.

For this case, a Six Sigma Guide was prepared, with a selection of useful but simple statistical and non-statistical quality tools, but preserving all principles of this philosophy.

Six Sigma methodology has proved to serve also in this environment, so different to that where it was developed. The objective of reaching 3.4 DPMO can still probably be the target of the effort, but managers and technicians have to be realistic to avoid the sensation of failure and the lack of motivation, if finally this ambitious target is not achieved (and they should consider also if this quality level is really needed).

In companies with low technological level, low skilled employees, and with labor/social problems, reaching so demanding objectives can be very difficult. Been realistic is again mandatory.

Improvements achieved in this case are important not only by the absolute impact in business figures, but especially for the fact that, for the first time, company has adopted a rigorous rational approach to the efforts for satisfying customer requirements. If this change is maintained in the future, we can speak of success in the project.

In a labor/social environment as that of the company studied, communication, dialog between managers and employees, training and motivation are key elements if any improvement is desired.

As situations similar to that presented in this case are not infrequent, quality professionals, technicians and managers should do extra efforts to improve the global level of small companies. Among other actors in the Community, Universities must be part of this effort, bringing support and knowledge to small companies.

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