Analysis of the implementation of a process improvement program based on the six sigma methodology in an auto parts company

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Abstract

This article is a technical report about the implementation of an improvement program based on a methodology for fault management in the company Mahle Metal Leve S / A in order to reach the root causes of the possible flaws found. To this end, steps will be implemented consistent with the proposal of six sigma methodology in order to make possible the study of faults detected. So, it becomes possible to determine corrective actions to be taken and propose actions for improvement in this process. Failures in the delivery of services or products as well as unintended effects, bringing losses for many companies such as rework time, lost productivity and customer dissatisfaction. By definition, the six sigma methodology uses statistical methods and non-integrated statistical in a logical sequence usually through a project management approach which achieving high levels of performance. Therefore, an appropriate way to present this type of problem solving, since it is a large company that produces large batches.

Keywords: Six Sigma; Auto Parts Company; Root Causes.

1 Introduction

This article is a technical report about the implementation of an improvement program based on a methodology for fault management in an auto parts company pertaining to a Global Group and it is responsible for the manufacture of piston rings and bushings, which plant is located in Itajuba, Minas Gerais. The goal is to reach the root causes of potential failures encountered in this organization. To this end, steps shall be implemented consistent with the proposal of the six sigma methodology. With this, it becomes possible to determine corrective actions to be taken and to propose actions to improve this process.

Failures in the delivery of services or products, as well as undesirable effects, brings losses for various companies such as time of rework, productivity losses and customer dissatisfaction. These failures are results of nonconformities in the processes, and must be treated and controlled. They are connected to the trustworthiness, that is, the capacity of a system to operate as expected on predetermined conditions. Therefore, in order to inspire confidence, it is necessary to avoid the pitfalls, which is through the understanding and treatment of its causes.

According to Rotandaro (2008), Six Sigma is a philosophy which enables to achieve, maximize and maintain the commercial success through understanding of customer needs (internal and external), focusing on the client and product. It is a methodology structured that increases quality using continuous improvement of processes involved in a product or service, take account of all important aspects of a business.

The major advantage obtained by performing this kind of study involving a foreign element in the production process, due to the fact that if the expert himself to investigate the process, a lot of information may no longer be represented. Routine activities of the specialist elements also may seem to him of little relevance and no significant effect to the process, and it is, in fact, wrong. According to the journal of a group of employees of the enterprise in question, when it comes to sustainable improvements in performance, the key to success is in improving the processes of purchasing, production and logistics of delivery and reduce costs at fault. Thus, in order to collaborate with the fulfillment of these goals, it is noted that this proposal is of great importance for the company.

After planning the methodology to be used in this study, it was defined the strategy for conducting the project. The generation of data for such planning emerged from brainstorming sessions with management of the sector in which the study was conducted.

2 Theoretical basis

2.1 Company and its context in market

The group which the company take part (object of study) is among the thirty largest global suppliers of systems for the automotive industry, owns 100 locations spread across four continents, and its head office is located in Stuttgart - Germany.

The Engine Systems and Components business unit includes, such as:

• Aluminum pistons for gasoline and diesel engines;

• Articulated pistons and steel pistons for commercial vehicle engines; • Complete power cell modules;

• Piston rings;

• Piston pins;

• Cylinder liners;

• Bearings and bushings;

• Complete valve train systems and their components;

• Turbocharger parts.

In Brazil, there are five factories located in the cities of Mogi Guaçu (SP), Queimados (SP), Indaiatuba (SP), São Bernardo do Campo (SP) and Itajubá (MG), and a distribution center located in Limeira (SP), which supplies the domestic replacement market and exportation, especially Latin America, Africa and the Middle East. It also has departments of Applications Engineering, Product Engineering, Sales and services provided by the modern Technology Centre Research Group in Jundiaí (SP), in direct connection with the Technology Center Stuttgart, Germany. The plant is located in Itajubá responsible for the production of piston rings and bushings, to meet both domestic and international supplier of original equipment (OE) and replacement parts (direct sale), and then can be verified guidelines that guide the management of the affairs of this plant:

• Its vision is to make a profit and be committed to results, to be competitive in all segments in which it operates, be agile, flexible and aligned with market realities; always be customer-focused, be prepared to face the challenges of national and international competition , using modern processes and streamlined workforce trained, capable and motivated.

• Its mission is to provide components, assemblies, services and high technology solutions for mechanical applications related to the generation and transmission and filtering systems, is a supplier of 1st level with a strong global presence, gain and maintain leadership position in all markets it serves.

Since its founding, the company is constantly concerned with the quality of its products, services, and the motivation of your employees so that they develop their skills and knowledge, and their contribution in achieving the goals of the group. It has an efficient controlling system in all its branches, recognized worldwide for their most demanding customers and supported by various certifications, among which stand out ISO/TS 16949, ISO 9001 and ISO 14001.

The size of this company, its position in the world, and yet, the existing high level of competitiveness in the automotive market make this study relevant.

2.2 Methodology Six Sigma

According to Breyfogle (1999), Six Sigma can be considered both a business strategy and a science that has the aim of reducing manufacturing and service costs, and creating significant improvements in customer satisfaction and bottom-line savings through combining statistical and business process methodologies into an integrated model of process, product and service improvement. This strategy has aims of improving productive effectiveness. Traditionally Six Sigma employs a structured five-phased DMAIC methodology. Six Sigma teams are created to tackle specific problems to reach Six Sigma levels of performance.

DMAIC is a development cycle of improvement projects originally used in Six Sigma. Initially designed for projects related to quality, DMAIC is effective in reducing defects, and comprehensive projects to increase productivity, cost reduction, improvement in administrative procedures, among other opportunities. The acronym represent a sequential step in the process of evolution of a given project: Set, Measure, Analyze, Improve and Control. The steps are described below:

2.2.1 Define (D)

According to Senapati (2004), the step "Define" consists of properly define the problem to be treated, that is, having a clear development plan for the project, as well as the ratio of the critical processes involved in the work. One of the most appropriate tools to be used is the SIPOC (Supplier - Input - Process - Output - Customer), which aims to identify the boundaries of the project, i.e., which suppliers and customers of the process under study, and also what the main "inputs" to be processed and the relationship of the most critical to clients on "outputs" generated. Antony and Banuelas(2004) present the tasks to be developed in this phase of work:

• Define the scope of the project boundaries.

• Define exactly the concept of "problem" to be treated.

• Set the time and the project leader.

• Estimate the financial gain from the project.

• Obtain approval from senior management on the development of the work.

Thus, it is expected that after completion of phase "sets" the Six Sigma project team has a figure, reasonably clear, the problem being treated.

2.2.2 Measure (M)

According to Antony and Banuelas(2002), this phase the aim is to ensure that the way the process is being measured is correct. Before working analysis and improvement, it is must take the exact picture of the size of the problem being treated. The tasks to be developed in this phase of work include:

• Making the "process map" to be improved and identify key "inputs" and "outs".

• Making the "matrix of cause and effect."

• Performance measurement capability of the current process under study.

• Definition of a target process capability to be achieved.

Thus, it is expected that after completion of phase "M", the Six Sigma project team has a figure, reasonably clear, the size of the problem being treated.

2.2.3 Analyze (A)

According to Kwak and Anbari (2004), the phase "Analyze" has as main goals to conduct the analysis of the causes of defects and identification of sources of process variation. Also, the determination of the factors that impact the "outputs" in the study and prioritization of opportunities for future improvements. Antony and Banuelas(2004) present the tasks to be developed in this phase of work:

• Development of FMEA (Failure Mode and Effect Analysis);

• Identification of "inputs" critical potential;

• Developing a plan for the next phase.

Thus, it is expected that after completion of phase "Analyze" the team of the Six Sigma project has a figure, reasonably clear, of the causes of the problem under study.

2.2.4 Improve (I)

According to Kwak and Anbari (2004), the phase "Improve" has as main objectives the improvement of processes in order to eliminate variations and development of creative alternatives and implementation of improvement plan.

This way, it is expected that after completion of this phase, the Six Sigma project team may have directed the actions best suited to solving the problem under study.

2.2.5 Control (C)

According to Kwak and Anbari (2004), the phase "Control" has as main objectives of the control process variations to meet customer needs, develop a strategy to monitor and control the improved process and implement improvements to systems and structures. Antony and Banuelas(2004) present the tasks to be developed in this phase of work:

• Implement control plane;

• Ensure long-term capability of the system;

• Ensure the implementation of continuous improvement process;

Thus, it is expected that after completion of phase "Control" the Six Sigma project team may have directed the actions most appropriate to ensure the maintenance of good results.

It is too observed that DMAIC is a structure for the six sigma improvement on existing processes by increasing the capability of critical parameters to customers.

3 Conduction strategy of the project

Initially, using the Pareto chart, there was a brief survey of what kinds of defects present in the rings generated a higher percentage of scrap in MFACC. This way, it was set the widely problem to be studied. The problem investigation was performed using the Ishikawa Diagram, after brainstorming with people involved in the process, and it was sought to list their main causes.

The prioritization of the causes was given by a statistical analysis on the contribution of each of the manufacturing processes of the rings with respect to the incidence of waste, and the flow together during this data collection can be viewed below:

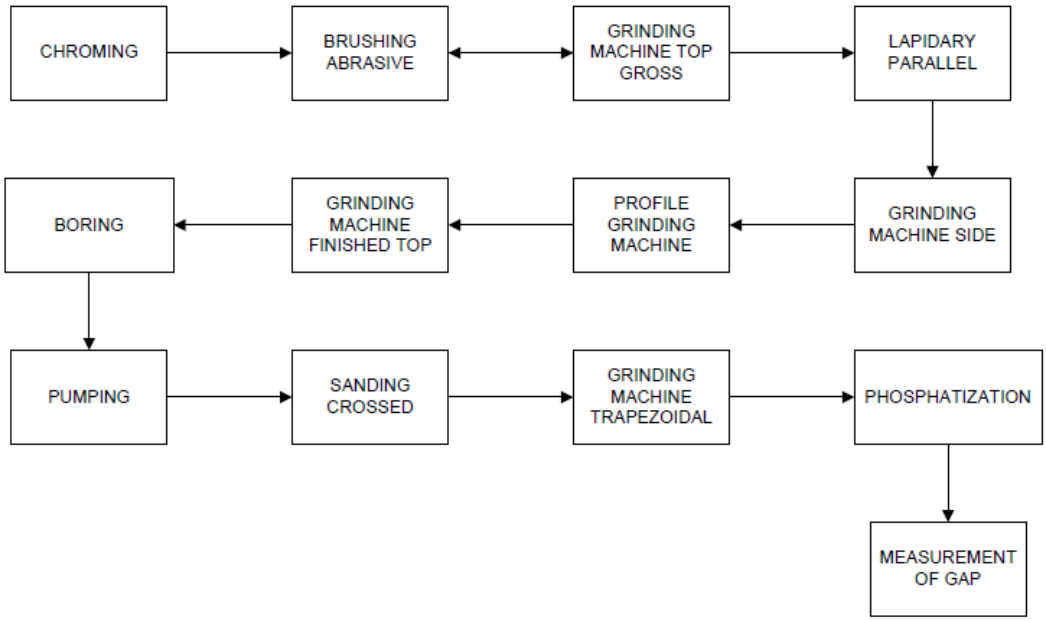


Figure 1. Production Process Flow in which he conducted the monitoring.

Simultaneously with this survey, it was mapped out the process, dividing it into small processes. Thus became possible to know the differences between the standard and what is practiced daily by the operators, besides knowing the parameters of machines capable to influence the appearance or not chips. This way, it became possible to identify where in the production process of this family of rings was generated the highest percentage of scraps, defining the system in a process that should work correctively.

Data collection was performed from direct involvement in the activities of the organization, as well as through interviews with professionals whose knowledge about the product and production process is relevant. Meetings between researchers and participants of the organization centralized all the information collected, and generate discussion of interpretations. The results were recorded to ensure the knowledge management.

4 General Analysis

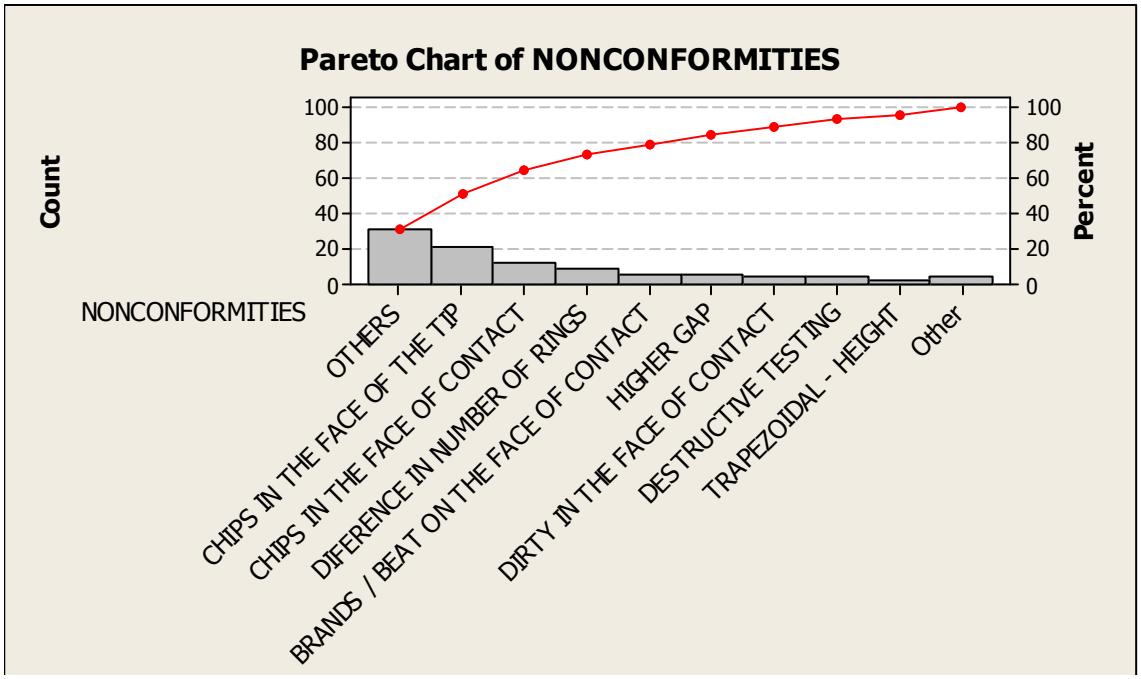
4.1 Identification and Prioritization of Problem

In order to identify the most significant waste for the process in question, the Pareto Chart was applied. The data were taken from the Enterprise Resource Planning (ERP), for the periods from January to December of 2011 and they are in the table follows:

Table 1. Nonconformity - 2011 Period

Pareto Non-Compliance – 2011					
	Description	Refuse	% Refuse	% Refuse versus Volume Produced	% Cumulative
1	Chips in the face of the end	13835	20,74%	7,24%	20,74%
2	Chips in the face of contact	8457	12,68%	4,42%	33,42%
3	Diference in number of rings	6109	9,16%	3,20%	42,58%
4	Brands/beat on the face of contact	4012	6,02%	2,10%	48,60%
5	Higher gap	3485	5,23%	1,82%	53,83%
6	Dirty in the face of contact	3018	4,53%	1,58%	58,35%
7	Destructive testing	2946	4,42%	1,54%	62,77%
8	Trapezoidal - height	1595	2,39%	0,83%	65,16%
9	Setting machine	1418	2,13%	0,74%	67,29%
10	Dirty in the inside face	1252	1,88%	0,65%	69,16%
11	Others	20566	30,84%	10,76%	100,00%

So, it was possible plotting the graph 1.



Graph 1. Pareto of nonconformities - Period 2011

According to the chart, it is possible observe that the appearance of chips in the rings is critical and accounts for approximately 33.42% of waste produced in the factory, and of these, 20.74% are chips on the face of the tip of rings. This way, it was decided to work with the problem of the chips on the face of the tip, analyzing its causes and consequences, thus seeking a solution to this problem. However, due to the fact that the production of rings has a high scope of products, it was necessary to define a family of rings in which the incidence of defects present the highest possible relevance, aligned with the volume of production of the same family of rings. Getting to the result, it was decided finally that the perimeter which should concentrate efforts: emergence of chips on the face of the tip of the rings belonging to the family MC-236 (type of coverage chrome).

4.2 Problem Investigation

Through brainstorming, factors that could possibly generate the appearance of these chips throughout the production process of the Rings (macro process) were listed. The tool was used during the monitoring and investigation of the process conducted, and had the support of experts of the process, quality, and manager responsible for plant. During the organization of information collected, the mentioned points generated a diagram Cause and Effect (or Ishikawa), and can be viewed below:

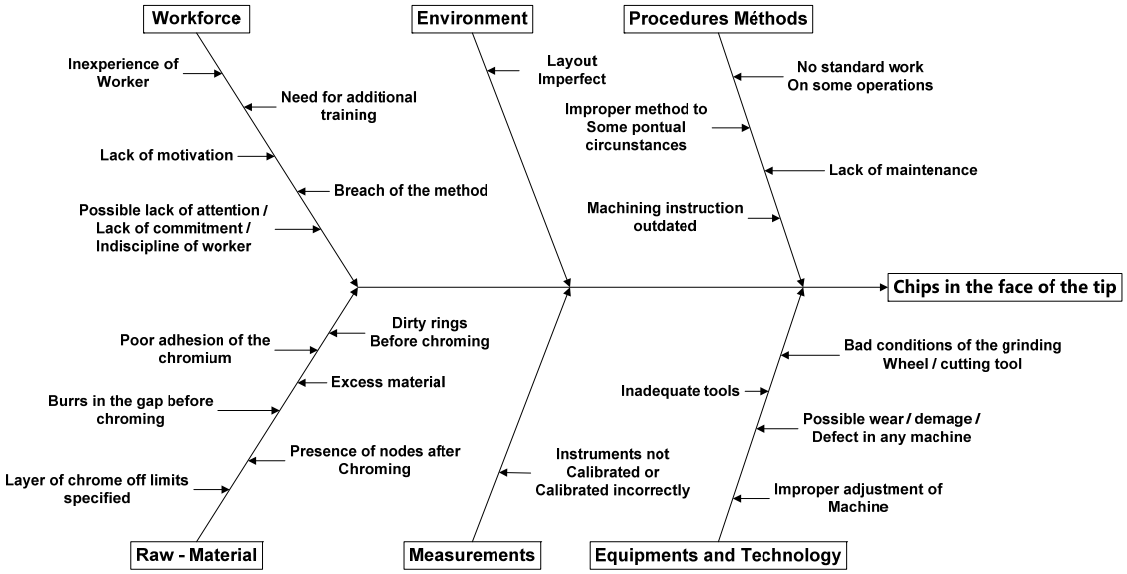


Figure 2. Cause and Effect Diagram related to the appearance of chips in the tip of the face - Macro Process.

This is a survey of possible causes that might contribute in some way with the emergence of these chips chrome bath, considering the production flow of the whole ring (macro process).

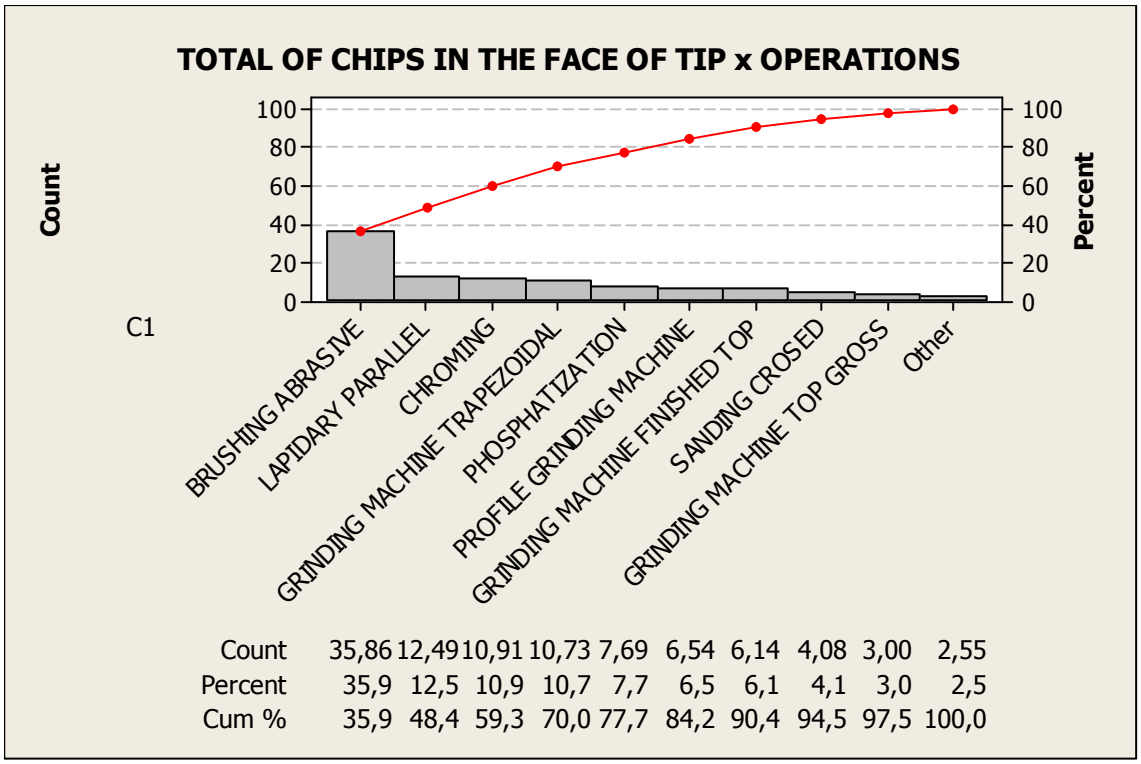
4.3 Prioritization of Causes

During follow-up sample (about four thousand rings), the incidence of the scrap in question after each operation was registered. Note that in order to ensure the reliability of the experiment, there was 100% visual inspection of rings before and after each operation. The results are shown in table below:

Table 2. Percentage of chips in the face of the tip per operation.

	Chipping on the face of the tip		
Operation	No burrs	With burrs	Total
Chroming	6,32%	13,26%	10,91%
Brushing abrasive	1,74%	56,44%	35,86%
Grinding machine top gross	10,45%	0,00%	3,00%
Lapidary parallel	19,18%	8,08%	12,49%
Without burrs	0,00%	0,00%	0,00%
Profile grinding machine	15,81%	3,25%	6,54%
Grinding machine finished top	14,27%	3,31%	6,14%
Boring	1,79%	0,83%	1,02%
Pumping	0,00%	1,64%	1,01%
Sanding crosed	5,34%	0,82%	4,08%
Grinding machine trapezoidal	17,89%	4,93%	10,73%
Phosphatization	7,21%	6,61%	7,69%
Measurement of gap	0,00%	0,83%	0,51%
Total	100,00%	100%	100,00%

Plotting the data in the chart, there are obtained:



Graphic 2. Pareto of chips in the face of tip per operations.

According to Campos (2004), the Pareto diagram is a simple picture that aims to give a graphical representation of the stratification. The Pareto principle was adapted to the problems of quality by Juran, from the theory developed by the Italian sociologist and economist Vilfredo Pareto, and establishes that most of the losses resulting from problems related to quality come from a few but vital problems. Of all problems, between 20% and 30% should make up 70% to 80% of losses (few causes are actually conditioning the effect). This can provide information to make evident the prioritization and visual problems and projects, and to allow the concentration of efforts to improve the areas where the greatest benefits can be obtained (WERKEMA, 1995).

Through statistical survey conducted, a summary of which is represented by the Pareto diagram above, it's possible see that the Brushing Abrasive generated 35.85% of the increase of waste, the Lapidary Parallel 12.49% to 10.91% Chroming, as well as Grinding Machine trapezoidal was responsible for 10.73%. Therefore, it was possible to portray what operations are responsible for approximately 70% of this waste. It is worth noting that were accompanied by 13 different operations, and that these, four were observed in this prioritization (that means 30% of operations caused 70% of waste in this process, thus validating the theory).

By comparing Table 2 and Pareto above, note also that the gap in the sample which had burr was the most influenced the appointment of the operations mentioned. This greater influence can be explained by the fact that the burr generates a high material removal compared with rings without burr in the gap. As the ideal is to portray reality in a study like this, one must consider that the presence of burr was only identified because inspections were performed during the conduct of data collection, and that the rings followed without burr were submitted to brushing operation only for the study were more completely, which leads to conclusion that the presence of burr is common to the general process.

5 Final Considerations

The presence of chips in the compression rings can cause serious damage to the engine if it is assembled using a damaged part. Among this damage may be mentioned:

- Scuffing (Micro-melt from overheating);
- Risk in the cylinder;
- Damage to the gas sealing system (Blow By);
- Adhesive wear (micro weldings);
- Breaking during assembly of the piston due to the chip on the external face;
- Breaks during operation;
- Breaks during operation caused by the occurrence of one or more damage mentioned above.

Whereas if there is a defect able to cause serious damage to other engine components, and also the importance of seeking to reduce the main scrap of the plant in question, it is evident the need to concentrate the effort to achieve this goal.

It can be stated that the Brushing Abrasive stood out among the other operations with it's frequency of approximately 35.86% of chips in the face of the tip due to the presence of burr in the gap of the ring, because the chroming just "copy" the surface of the ring (in this case there were burrs off limits accepted, verified by measurements performed by the laboratory), therefore, when leaving the chroming and passing through the abrasive brushing that is capable of removing material where there is too the presence of burrs, thus generating the chips.

Therefore, it is proposed to include the operation brushing prior to chroming. There was already an initiative like this, and this survey contributed to making a final decision, since there were no records of data collection in this regard earlier.

About lapidary parallel, it was noted that factors such as chromium layer or even gap of rings larger/smaller than the specified characteristics are commonly found in the input of the operation and it generate these chips in the rings.

The creation of chroming in chips (the third most important operation as seen in Pareto) can be attributed to the same factor. During the dismantling ring trees, which could cause chipping even without the presence of burrs, their presence increases the appearance of these chips due to the same principle? In the tree, the rings are closed and there are counted between the tips, for example, to open them. Thus, it may be the removal of material (chromium layer + Burr) generating chips.

Finally, it is possible to list some possible causes for the appearence of these chips related both to labor and method, and justify this scrap in any of the operations listed above, among which may be cited:

Inexperience of the operator; possible lack of attention; incorrect selection of the necessary tools to the machine, the operator in a hurry because of the urgency of delivery of the consignment; negligence by following the guidelines present in the instruction of machining, machining instruction inadequate or not updated; unavailability of the proper tools; misidentification of the tooling.

During this study, it was noted the need to obtain some additional information thus recorded are two possible topics to be addressed in future work:

a. Statistical with sufficient number of samples (about ten samples), which are accompanied rings have shown burr before the chroming and those that have been brushed, in order to validate the hypothesis that the presence of burr causes the appearance of chips by testing hypotheses.

b. Study about the size of chips. The goal would be to determine what size of chips generated in the abrasive brushing would be recovered in the next operation (grinding machine top gross). With this, it would be desirable to detect root causes that cause chips above that size (after all, only these chips come be effectively scrap). It must be taken into account also that some residue could be removed by grinding the top finished, determine the size of this residue as well.

Finally, in order to obtain the effect of reducing the incidence of scrap in question, it is suggested that the subsequent step is performed in this study was carefully observing the steps set out by Six Sigma. It is the application of this methodology in the process priority in this study, which constituted the application of this methodology in the micro process (Define, Measure, Analyse, Improve and Control).

Acknowledgments

To the Institute of Production Engineering and Management (IEPG), by the support of teachers and employees to execute the activities.

To the company where the study was conducted by the permission of generating scientific knowledge through the work realized in the organization.

To the Foundation for Research Support of Minas Gerais (FAPEMIG).

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