The Productivity Mapping, Classification and Analysis of a Mining Company Electrical Maintenance Team.

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Abstract

With the advent of a globalized and increasingly competitive economy, companies have been looking for new ways to produce by improving their effectiveness and efficiency by reducing losses through unscheduled maintenance shutdowns by increasing the reliability and availability of their assets. In pursuit of this objective, engineering plays a fundamental role contributing to the optimization and improvement of materials and resources, whose main objective is to achieve the goals of growth of companies, one of these goals being the increase of productivity, be it operational or support teams, is the case of the maintenance sector that is directly responsible for the reliability and availability of productive equipment or not. This work is in line with this objective, since it analyzed through a descriptive research approaching the concept of productivity and quantitative, presenting data in the form of number and graphs of the productivity of a maintenance team, providing a basis for the formulation of analyzes and conclusions. With the application of quality tools it was possible to map and classify the main deviations that interfered with the productivity indicator of the sector. After this analysis and identification it was possible to propose and apply simple actions, such as, optimization of meeting, adjustments and definition in coffee time, which provided a significant productivity gain in the sector. This can be proven by analyzing new data collected six months after the first report was prepared.

Keywords: *Productivity; Appointments; Devices; Maintenance.*

I. INTRODUCTION

Recently, the productive sectors of a company have been developing as advanced technologies are implemented, consequently, there is the need to present new attitudes towards to the high challenges has to come as the economy is more globalised and competitive..

These changes occur surprisingly fast; in this context the maintenance sector, which is one part of activities in the productive process in companies, there is the necessity to follow a management model where it contains a proactive behaviour, letting the impromptu actions aside and being sensitive when it comes to reliability, availability, flexibility, and productivity.

The industry's output emphasis, related to the competitiveness, is linked to the market globalisation. Such as [1] said, in a competitive overview, which organizations are facing, without process productiveness or efficiency, they will hardly be successful or even be maintained in the market.

Taking this context into consideration, this project aims to discuss and analyse, using qualified tools for it, the productivity of an electrical maintenance team in a relevant company based in "Minas Gerais". This review includes the mapping, classification, and measurement of all detours and facts which directly interfere in the productive display, pointing and applying better conditions that will impact straight to the industry's results.

II. LITERATURE REVISION

A. Workforce Productivity

1) ***The Concept of Productivity:*** Definitions of productiveness in its great part, focus on the term as profitability, efficiency, effectivity, value, quality, innovation and a quality of life in working place, as well as can be combined specific variables of human effectiveness and organisational. [2]

According to [1], the productivity concept for a physic system of production is defined as a relation between what is obtained from the departure and what is consumed in the arrivals of this system.

To understand this issue means to know its extension and purpose for the establishment, trying to include not only the capacity explanation of a verified productiveness but also the prognosis of it for future services. [3]

2) ***Productivity Index:*** [4] stated that the increase of Brazilian worker productivity is one of the challenges for twenty-first-century organisations of the country, once such variable appears as success factors to competitive advantage development anti scenario of globalised competitiveness production of good and services**.**

Reference [5] insisted that the man/hour indicator assigned in maintenance order will inform how many official maintenance hours percentage in the Maintenance Planning and Control (PCM – Planejamento e Controle de Manutenção) bureaucracy, and its necessity is formed by the following factors: verification of the level of maintenance system use and the percentage information of indirect maintenance services, additionally about idleness or staves' overload. This calculation will be done by a formula shown in Fig. 1.

$$\%\ \text{HH allocated in order of maintenance} = \frac{\sum \text{HH indicated in order of maintenance in the period}}{\sum \text{HH installed in the period}}$$

Fig. 1: Formula calculation for HH allocation

Maintenance software usually performs this calculation, being able to do a relation between the hours installed in its staff, in other words, the sum of available HH in a team for a month with the total of hours which they totalised in the maintenance orders in that period. [5]

B. Maintenance

Maintenance is defined by the ABNT (Brazilian Association of Technical Norms) as the combination of all technical and administrative actions, including supervision ones which are related to "keep" and "reallocate" an item in a way that can perform an applied function. [6]

The actual concept of maintenance is to guarantee reliability and availability in the equipment and installations functions in order to serve a production or service process, with security, as well as conservation of the environment and suitable costs. [7]

C. Quality Tools

Reference [8] explained that "the seven tools of quality control are resources to be used to apply the problem-solving methodology".

Reference [8] these tools, according to him, are made to manage the processes quality, being them: stratification, verification procedure, Pareto analysis, cause and effect diagram, correlation diagram, histogram and letter of graphics control.

The quality tools have problem-solving as objective, however, for this to happen, there is the necessity to obtain capable people who acquired knowledge to use it. [9]

III. METHODOLOGY

A. The Kind of Research

The study is classified as descriptive because it permits to analyse how important is the results for a company the increase of productiveness in the electrical maintenance sector.

Reference [1], a descriptive research usually uses collected data and it is defined by speculative hypotheses which do not specify casual links.

It was opted to use in this project a quantitative approach, given the fact that will present data which can be quantified as numbers, graphics, tables, etc. Obtaining this kind of information will be formulated some analysis and conclusions.

Quantitative research aims to validate hypotheses by using structured data, statics, with analyses of a high number of representative cases, recommending to be a final course of the action. It quantifies the data and generalises the results of the samples to who has interest. [1]

B. Methods and Materials

Firstly, to support this study it was made a theoretical basis for the productive manpower concepts, maintenance, and quality tools.

As a subject for this research, the chosen area was the electrical maintenance of a mining company based in "Minas Gerais", aiming the growth of HH (men hour) of each employee allocated in maintenance execution, for this reason, develop actions which would make feasible a rise of the staff's productiveness.

To stratify the data, it was used the System Application and Products software, SAP, which is a management and services of IT that develops solutions to simplify the company's processes, additionally, it is where are made entire maintenance team's notes for the study. In this collection was considered all the ones which the electrical maintenance staff has done from January/2017 to December/2017.

The stratification consists of a group division in many subgroups based on appropriate facts which are known as stratification factors. Some examples of used factors as stratification are: shift, machine, operator, day, month and etc. [10]

By using this system as a data collecting method is due to the necessity to obtain how many hours are effectively wasted while executing a maintenance activity and the average productivity in the sector.

Table 1 indicates an index and variable that will be a base for this project development.

Table 1: Variable and index

Variable	Indicators
Labor	Time (HH) available
	Time (HH) executed

productivity	Type of activity
	Activity time

- Time (HH) available, related to the total of men hour (HH) available in the sector;
- Time (HH) executed, related to the total of men hour (HH) effectively applied;
- Type of activity, related to the classification of activities which were identified;
- Activities time, related to the number of hours identified in each activity.

The productivity of the sector will be calculated using the Microsoft Excel software, applying the formula depicted in Picture 1 from this article.

Basing on the information acquired will be mapped the detours which are going to be classified and measured through Pareto graphic, aiming to identify detours with major relevance that can impact directly to the team's productivity. Based on Pareto's ideas, an Italian scholar used to say: "a few cases are vital, being the majority of them trivial". His graphic is used to demonstrate the most significant causes quantitatively, in decrescent order, identified through the stratification. [11]

The mapping activity in Pareto's graphic will be classified through an effort matrix and impact which is a generated diagram gathered in brainstorming, where ideas are identified according to the impact that it will cause in the project, or in the problem solving, as well as the effort necessary to accomplish it [12]. In this situation, the detours laboured in this study will be the ones that have the lower effort and higher impact quadrant. Afterward, with better process opportunities been raised through ideas, it will be created an action to be implemented to be possible an improvement in the electrical maintenance productivity sector.

IV. RESULTS AND DISCUSSIONS

For this project to be built, there was an analysis of the entire electrical maintenance team's note of a mining company in "Minas Gerais" which was done between January and December of 2017. Data was collected by the system SAP (System Application and Products) where all the notes of the staff studied are daily inserted keeping it as a reliable database. Consequently, in Fig. 2, it was possible to relate each employee with the activity done in their time, respectively.

The electrical maintenance team is one of the sectors responsible for keeping the availability and also the reliability of actives, for this to happen according to intern standard rules of the company is necessary that 90% of working hours of each employee are allocated in maintenance activity execution.

Sector	Electrical Maintenance						Total
Text Activities	Employee						
	1	2	3	4	5	6	
7S	14,2	23	36,8	4,98	21,9	32	132,77
Opening PPT				21,7			21,71
Administrative Activity		5,86	17		97,5		120,33
Activities SSMA	6,03		2	2,42	117		127,39
Personal Transportation Delay	0,67		1,92	0,57			3,16
Power lock	3,34	5,46	76,9	40,4	4	79,3	209,41
Coffee	2,89	65,3	36,1	62,3	0,17	48	214,75
Rain			7,36				7,36
Consultation / Medical		2,17	1,33		12,7		16,17
Power unlock	2,92	3,51	42,1	6,74	4,34	46,9	106,54
Displacement	0,75			0,58			1,33
DHSMQ	165	107	155	101	14,5	132	673,29
Make another Center available	46,5	234	25,9	7,17	8,33		322,35
Writing and Editing			13,8				13,75
Report Issuance				7,27			7,27
Performing Maintenance	1665	1297	1552	1468	1347	1343	8671,18
Tool Inspection			2,08	1,25			3,33
Release of Hours				1			1
Filling Order / Micro Work	9,11	14,5	97,2	26,2	17,5	70,5	234,91
Preparing / Saving Tools				0,83			0,83
Preparing Material				32	4		36,02
Tools Preparation				1,7	6,25		7,95
Meeting	6,5	1	9,65	20,1		2,55	39,77
Working another center				17			17,03
Training / Course	11,3	46,3	54,2	67,2	24,5	23,4	226,95
Trave			4				4
Grand total	1933	1805	2135	1890	1679	1777	11220,6

Fig. 2: Activities x Inicial Notes

By analysing the collected data from the system, it was possible to calculate the productiveness of each worker, using the formula shown in Fig. 2. The results can be verified in Fig. 3 where depicts that the average productivity in the area of electrical maintenance is 84%, lower than the standards demanded by the company.

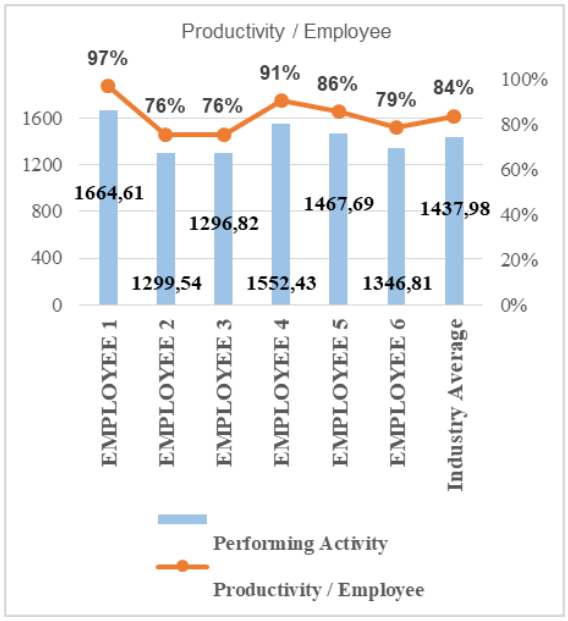

Fig. 3: Productivity x Initial Employee

To calculate the productivity of each employee, it was used Fig. 4, considering 52 weeks in a year, with 5 working days, discounting the vacation 30 days and 16 holidays and bridges, this calculation summed 214 working days and multiplying for eight hours, there is the value of available 1712 hours for an employee.

Total hours available = {(Weeks x Days of the week)-(Vacation-Holidays and bridges) x Hours available}

Fig. 4: Available hours calculation

The obtained data were gathered and classified in a Pareto's diagram, Fig. 5, applied in this tool can be noticed that the main detours which caused the productivity lost were the notes related to DHSMQ, CT availability, Filling the Order/Micro Work, Training/Course, and Coffee. These notes sum as 57% of the classified detours, making clear the necessity to solve these causes in order to increase the productivity sector.

After classifying the note with the Pareto's graphic, the detours were classified in an effort matrix and impact, checking which of these had lower effort and higher impact in the productiveness improvement.

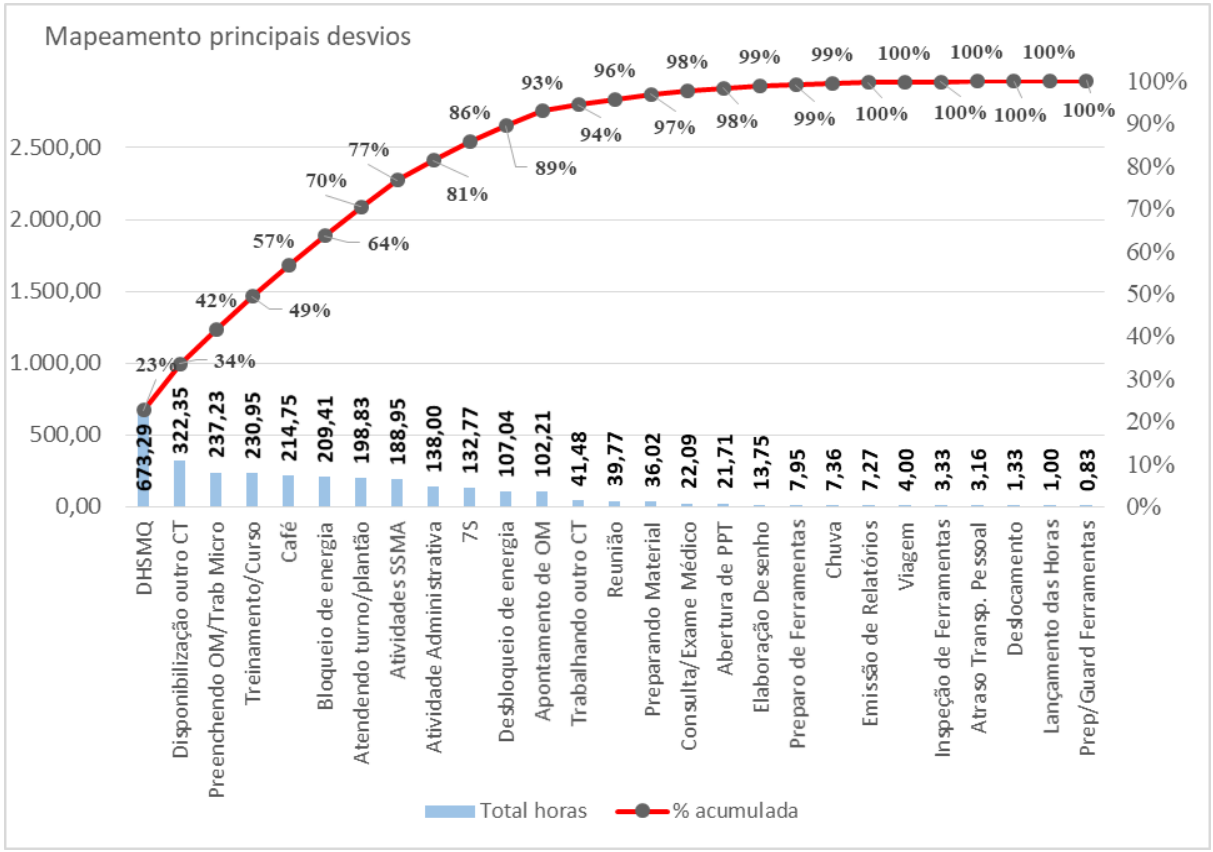

Fig. 5: Pareto Diagram with the mapping of the deviations

EFFORT MATRIX x IMPACT				
EFFORT	HIGH	Filling Order / Micro Work	Activities SSMA	HIGH
		Training / Course	Preparing Material	
		Meeting	Tools Preparation	
		Consultation / Medical Examinatio	Personal Transportation Delay	
	LOW	Displacement	DHSMQ	LOW
		Power unlock	Make another Center available	
		7S	Coffee	
		Opening PPT	Atividade Administrativa	
		Power lock	Working another center	
		Rain	Writing and Editing	
		Report Issuance		
		Trave		
		Release of Hours		
		Preparing / Saving Tools		
		Tool Inspection		
		LOW	ALTO	
		IMPACT		

Fig. 6: Effort Matrix x Impact

Fig. 6 can be highlighted six detours which were classified with low effort for deals and high impact in the electrical maintenance staff's productivity, being:

- DHSMQ: Which is an objective meeting to deal with subjects related to daily employee's activities, used to make everyone aware of security, environment, healthy and quality. Could be noticed that this meeting was being used to deal with other situations, for this reason needing more time to finish it. This detour represents 23% of the time wasted in tasks that were not directly related to the maintenance execution.
- Availability of another CT and working in a different CT: Representing 11% and 1% respectively in team's productivity lost, were redundant activities regarding the notes made by the team when these ones act supporting the operational team and industrial mechanic in activities inherent to the execution of the electrical maintenance.
- Coffee: There are notes where the time wasted in having a coffee and snack offered by the company at the beginning of the work shift, where the time demanded available for it is 10 minutes. It was seen that it was wasted in a superior time stipulated by the company, causing a loss in productivity by 8%.
- Administrative activity: Notes in this area represents 4% in loss of productiveness mapped in Pareto's graphic.
- Drawing process: The notes which were carried on activities of electric diagram preparation is 1% of productivity lost in the graphic of Pareto.

A. Implemented Actions

After mapping and classifying detours, it was prepared a meeting with all the team with the objective to deal with the topics mentioned as low effort and high impact. It was decided that would be dealt with how to see and act the DHSMQ detours, availability of another CT and working in a different CT and coffee.

- Action 1: It was stipulated a schedule to begin and finish eh DHSMQ with 15 minutes duration, slower issues would be scheduled in other time disregarded in the weekly maintenance team's programming, in other words, this will not impact the productivity calculation.
- Action 2: A meeting was held to inform once more the staff about the time to have a coffee offered by the company of 10 minutes and should follow strictly. This period would be monitored by the supervisor, and in case of default, will be dealt directly to each employee.
- Action 3: It was stipulated a time for support request services of another work centre (CT), mainly in relation to blocking activities and energy unblocking would only be accepted according to the electrical maintenance supervisor.

The application of these actions was done in January/2018, being considered at the end of July a new report was made to verify the efficacy of them. The result can be seen in the graphic in Fig. 7.

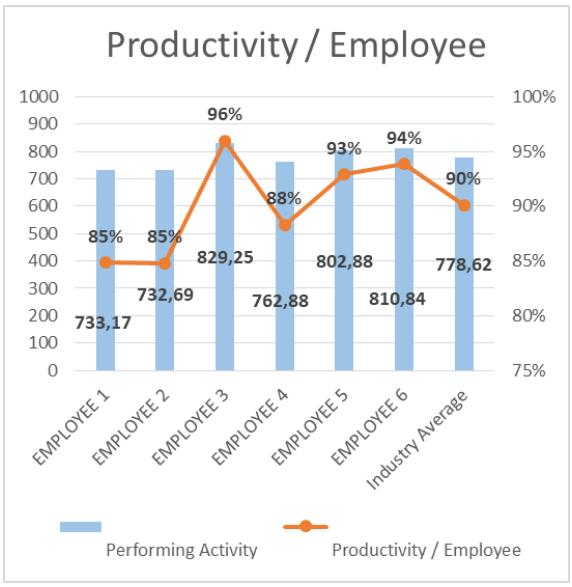

Fig. 7: Final Productiveness Graphic

It can be understood that six months later the implementation of the actions there was an improvement in the notes of execution maintenance and an increase of 6% in the staff productivity index.

V. CONCLUSION

By applying demonstrative methods in this article is possible to obtain extremely reliable data about the note of the company's electrical maintenance team studied. In this report, there was the possibility to know more about the notes and their main detours, in other words, how much working time of staff is really wasted in maintenance execution, which ones are they and their respective wasting time.

Can be substantiated that the highest lost were in the DHSMQ activities, Availability in other CT, which are part of the routine of the enterprise, being unable to be extinct, but it can be optimised.

This optimisation was proposed to be applied in the company with simple and no-cost actions, basically formed by alignment meeting, definition, implementation, and monitorisation of new guidelines for the electrical maintenance team.

The new report with the productivity index was done after six months of the actions' application done and it has stated that a significative improvement in the staff productiveness, bringing the average value of it to reach the intern standards the enterprise demanded, which is 90%.

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