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OEE: Using the Concepts to Measure the Effectiveness of a Maintenance Team

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Currently, work as Service Specialist, in the start up and commissioning of new production lines, developing technical documentation, spare parts lists and training.

Miroslava Hamzagic *received the B.S. degree in architecture from Universidade de Taubate, Taubate, in 1984, the M.S degree in regional development and planning, from Universidade de Sao Paulo, Sao Paulo, in 2010. Her expertise is in logistics, planning and production control, customer and supplier relationship management, purchasing, import/export activities. She had worked as a Professor in the Postgraduate Programme in Mechanical Engineering at Universidade de Taubate.*

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PRESENTATION

Case study on implementation of an indicator, the OEE´s format for equipment, check at the same time the efficiency, performance and quality of a maintenance team. In Partial Fulfilment of the Requirements for the Degree of **Master of Engineer**

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OEE: USING THE CONCEPTS TO MEASURE THE EFFECTIVENESS OF A MAINTENANCE TEAM

This paper proposes, using the concept of OEE (Overall Equipment Effectiveness), present a case study about the application of OTE (Overall Team Effectiveness), where efficiency, performance and quality of services provided by a team industrial maintenance, components of this indicator, that measure the reality of services. Also demonstrates the importance of knowledge of information about human resources performance indicators and how this approach can be extremely effective to provide competitive advantage in the aspect of lean philosophy process, applied within the industrial maintenance. The result obtained was that the utilization of OEE in application of OTE can help to define the production situation of the maintenance team and frequently answer common questions from managers “How am I working?", "Where can I improve?" or "How's my performance?" And “Why productivity does not increase?

Keywords: OEE, Overall effectiveness, People Management

1. INTRODUCTION

Companies around the world discuss daily the new demands of consumer markets, globalization, increased competitiveness, technological developments and scarcity of resources and how this has required significant changes in the management of the business. Seek, over time, the improvement of its processes and results through various tools, to become increasingly competitive.

In the context of the manufacture, the OEE – Overall Equipment Effectiveness helps better understand how is the performance of the productive area and identify which effectively possible (HANSEN, 2006). The OEE it´s a quantitative approach and a reference as systemic indicator to measure the main production losses of equipment/systems and measurement from three aspects. OEE is presented as Index (1).

OEE = EFFICIENCY X PERFORMANCE X QUALITY (1)

It is proposed the development of an indicator, in the OEE´s format for equipment, check at the same time the efficiency, performance and quality of a maintenance team, in the other words, the effectiveness of this team. So, we have the OTE – Overall Team Effectiveness, showed as Index (2)

OTE = EFFICIENCY X PERFORMANCE X QUALITY (2)

The main purpose of this article is to present a case study on implementation of OTE, contributing to the incorporation of a strategic culture, based on the formulation of performance indicators that, in some ways, contribute to identify the value of human resources in the results of the company under the aspect of lean thinking applied in industrial maintenance process. In focus, productivity biggest asset of this process – human resources – through a new language of measurement, expressed by numerical values that quantify the effectiveness of management.

The absence of a strategic indicator to define clearly the situation of maintenance team, which can be a parameter and that when analyzed can answer questions of managers of "As I'm working?", "where can I improve?" or "How's my performance?" and "Why does not increase productivity?"

This study presents and analyzes the OTE, developed in energy company, in São José dos Campos – São Paulo (Brazil) between the months of February and July 2012, in which participated the factory maintenance crew and supervisors in the area. The study limits itself to monitor the indicator OTE maintenance team, operating under the right of administrative work, 8 hours / day, 5 days / week.

Literature review was conducted in different media, such as books, magazines, bulletins, newsletters, websites, monographs, allowing to extract a lot of information about this methodology, enriching the main body of this paper. The quantitative research based on the use of the tools was the OEE approach adopted in this study. Its applied nature stems from the possibility of immediate use of knowledge generated on the application of the tool to assist the maintenance sectors, under measure the effectiveness of the workforce. From the point of view of the research procedures developed may be classified as a case study.

2. LITERATURE REVIEW

2.1 Business strategy

Second Silbiger (1996), strategic thinking involves a comprehensive analysis of a company relative to their business, competitors and the business environment in the short and long terms. But in the final analysis, strategy is the plan of a company to achieve your goals, but not strategic plans can be formed in a vacuum.

The McKinsey 7S Model developed by Tom Peters and Robert Waterman, at the time both worked as consultants at Mckinsey & Co., offers a structure with which one can make an analysis of the company as a whole, composed of 7 key variables that can affect the performance of the institution and are necessary for an organization to operate more efficiently as possible:

- **Structure:** How the organisation plans and divides its business?
- **Strategy:** What are the plans that organization has for the development of the external environment?
- **Style**: With the Administration facing and what is true in your culture?
- **Staff:** Who are the people and how they are treated?
- **Skills:** What the company does best?
- **Systems:** Which formal and informal procedures the company has?
- **Superordinate Goals/ Shared Values:** What is most important to the organization?

The 7S model is a valuable tool to organize your thoughts (SILBIGER, 1996), companies will succeed only when they reach an integration between all of them.

Highlighting the "Staff" factor, focus of this article, we can see many times that top management isn't very important by attributing to the human resources department the dealings of people management, experiences and skills, recruitment, training mode and performance evaluation.

In this context, we highlight that monitoring the performance of the team through key indicators that provide a sense of participation on the actions taken, moreover, allows you to search for better quality and continuous improvement. (REZENDE, 2003). Stands out this way "the

importance of the human factor as an agent of transformation and sustaining competitiveness and performance takes his most significant outline," Rezende (2003, p. 200).

2.2 Strategic management team – indicators

In the light of globalization and fierce competition, organizations must invest in human capital surpassing restrictive factors that present themselves – People Management needs to be replaced by Management with People, with good sense and emotional balance and empathy (ARAUJO, 2009).

In this way, the concern to ensure the best indexes of productivity, cost, and quality comes requiring the constant search organisations in assessing human resources, measuring its results through performance indicators, consolidating the strategic importance of managing people in organizations.

Hansen (2006) points out that the most important element of a factory are its human resources, in this way the management evaluation with people in an industrial organisation is important as a competitive differential, both external as internal, in the globalized market and if applied in tune, the indicators will reveal whether efforts and results are being achieved. And despite the cause-and-effect relationship be something complicated to measure and some reviews appear subjective character, this type of tool can be the only option available and present some actual result.

There are hundreds of indicators that are used by the HR area, besides the possibility of customization of indicators for specific demands of organizations. The most common data used in the construction of indicators are:

- Number of employees ("Headcount"):
- Absenteeism
- Index of input, output, Index turnover Index
- Training investment (ROI)
- Admission investment (ROI)
- Organizational Climate
- Payroll
- Billing
- Expenses
- Profit

Most of the indicators are rates (reasons), that is, any number divided by another, and they may be recording or other fees. For this reason, the indicators are commonly expressed in the form of percentages or fractions.

Another feature that most common indicators feature is the fact that they are indirect measures of the results achieved. For example, a firm manages a training to increase decrease mistakes (or better, increase the number of corrects) on a given activity – this is a direct and indirect measure measure the profit achieved.

There are indications of workmanship which define the situation partially, but do not provide a systemic vision of the situation. According to Branco Filho (2006):

> ...” the contents of labor and personnel should not be viewed in isolation, because the examination of just one variable can lead to misleading interpretations. So is deeply recommended that if you have a set of indexes that are periodically surveyed and compared”.

2.3 Lean manufacturing concept

In the 50, the Lean Thinking, initially conceived by the Toyota Production System, in Japan, aimed to produce more efficient cars in the post-war country. In the years 90, this line of thinking was presented by James Womack and Daniel Jones for mass production companies also become lean, adding new elements to the initial design of Taiichi Ohno, creator of the Toyota Production System. The philosophy has expanded around the world, in repetitive manufacturing companies of high and low volume and service operations systems (GIANNINI, 2007), and several are the settings, as shown below:

> “The elimination of waste and unnecessary elements in order to reduce costs; the basic idea is to produce only what is necessary, at the time required and quantity required (OHNO,1997).”

> “There is to check the maximum number of functions and responsibilities to all employees who add value to the product line, and to adopt a system for processing defects immediately fires each problem identified, able to achieve their root cause (WOMACK,1992).”

Rotondaro (2010) emphasizes the set of principles and techniques characterized by “Lean production system", which has how ideal produce increasingly with fewer resources – less human effort, less equipment, less time and less space-and, at the same time, approaching increasingly to offer customers exactly what they want at the right time. In this way, specify value, aligning the best sequence actions that create value, perform these activities without interruption whenever someone requests and perform them increasingly effective.

According to OHNO (1997), in the *Lean* production system that adds value to the product, seen in the eyes of the customer, is waste, adding cost and time – all waste is the symptom and not the cause of the problem. However, eliminate waste and not jobs, that is, the main purpose is the generation of value for the customer through the Elimination of waste, making the Organization more competitive on the market.

The Lean philosophy identifies 7 great sources of losses, suggesting techniques for disposal or optimization of activities that do not add value to the customer (FERNANDES & RAMOS, 2006). Second Kmita et alli (2003), advocated by the Toyota Production System, the 7 wastes are:

1) Transportation;
2) Inventory;
3) Motion;
4) Waiting;
5) Over-processing;
6) Over-production;
7) Defects.

Jim Womack idealized the "Occidentalization of the Toyota Production System", recognizing also the eighth waste:

8) Waste utilization

In this work, will be restricted to description of the wastes considered for the study: underutilization of the workforce.

The concept must necessarily be applied in all areas of the company, from sales to purchases, from finance to human resources, as well as operational area. Always prioritizing where there is more waste and offering greater opportunities for improvement with substantial impact on the outcome of the business.

2.4 OEE

The analysis of efficiency of production systems is considered a topic of relevance to industrial companies. The measurement and monitoring of productive efficiency of physical resources, can meet their real efficiencies, with the goal of developing action plans and solutions to the main reasons for inefficiency in production. As the information for the correct calculation of efficiency of resources are not always available in the corporate systems of the companies, it is necessary to collect and analyze the data of productive resources (PASSOS et al., 2004).

The adoption of a correct measurement system and the management of key parameters is able to contribute to the increased productivity of both functional areas as plant (HANSEN, 2006).

One of the most important tools in the TPM is efficiency philosophy overall Equipment effectiveness (OEE). The OEE is the result of the multiplication of three parameters that have a relevant role in philosophy TPM (FUENTES, 2006). Bariani & Del'Arco Junior (2006) define the parameters like:

- **Availability:** is the amount of time that a equipment was available to work compared with the amount of time that has been programmed to work.

- **Performance:** how the equipment works close to the ideal cycle time to produce a component.
- **Quality:** it´s the total number of good parts produced, compared with the total number of parts produced.

Figure 1 presents each index and major flaws that interfere with your performance.

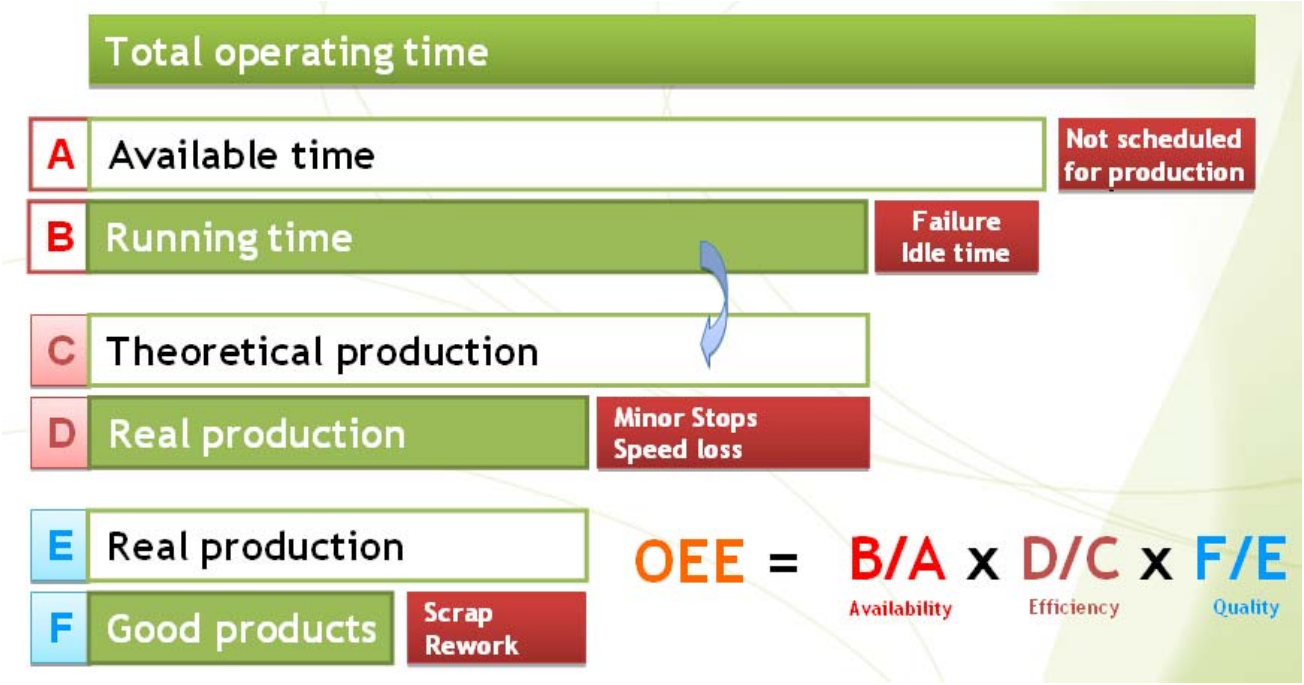


Figure 1 – Calculation of the OEE
Source: Adapted Santos (2007)

Table 1 also presents each index and major flaws that interfere with your performance as Figure above.

Table 1 – Indexes and major stops
Source: Adapted Castro (2010)

Índices	Major Losses
Availability	Identifiable Charts Equipment failures and wear of tools Losses with adjustments and setups
Performance	Losses with reduced speed Downtimes and small stops
Quality	Quality defects Process losses

The measurement of the overall efficiency of the equipment can be applied in different ways and objectives. According to Jonsson and Lesshmmar (1999), the OEE allows indicate areas where improvements must be developed and can be used as a benchmark, allowing quantifying the

improvements in equipment, cells or production lines over time. The analysis of the OEE and the production of a group of machines of a production line or a manufacturing cell identifying the resource with less efficiency, enabling thus to focus efforts on those resources.

3. CASE STUDY

3.1 Project description

This project had as its aim the development of an indicator in the molds of the OEE for equipment, check at the same time the efficiency, performance and quality of the maintenance team. This team consisted of 4 (four) professionals who have acted in the maintenance of productive means: machining, testing of turbines, engines and test utilities. The data collected refer to the months from February to July 2012 and were applied immediately generating action plans for the next few months.

3.2 OTE

The EFFICIENCY takes into account the losses caused by scheduled and unscheduled events and it´s calculated as shown in Index (3):

$$\text{EFFICIENCY} = \frac{Total\ Hours\ Team - \Sigma\ Events}{Total\ Hours\ Team} \quad (3)$$

Figure 2 shows that in the efficiency all events, scheduled or unscheduled are logged. For example, training (scheduled), absence (not programmed), meetings or any events that can measure and that is traceable.

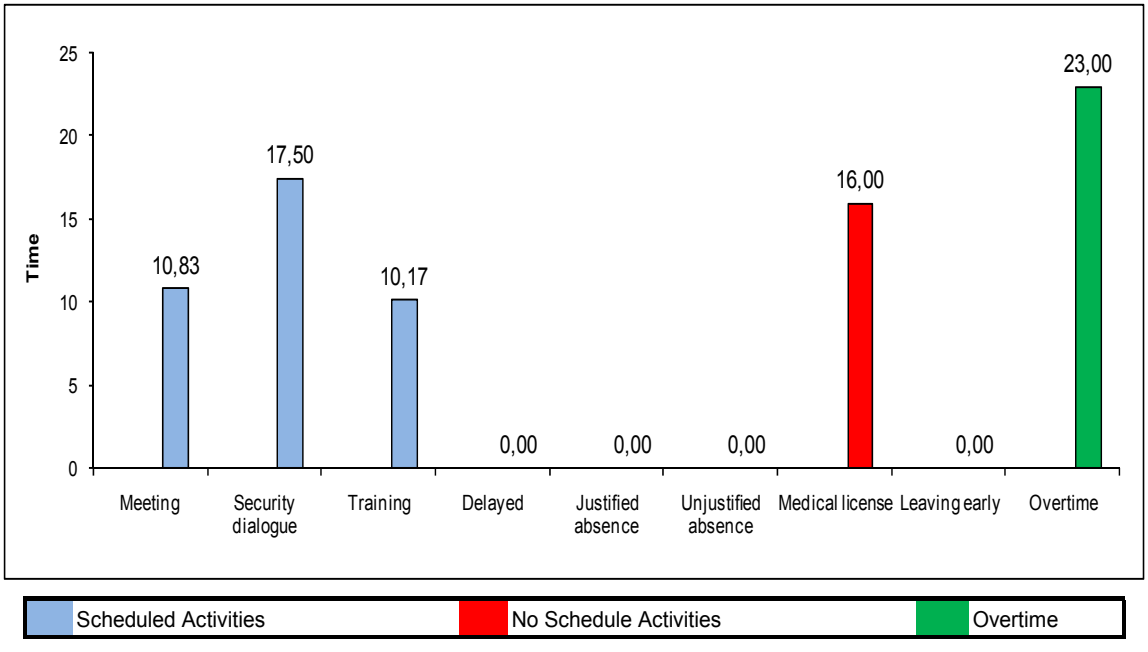
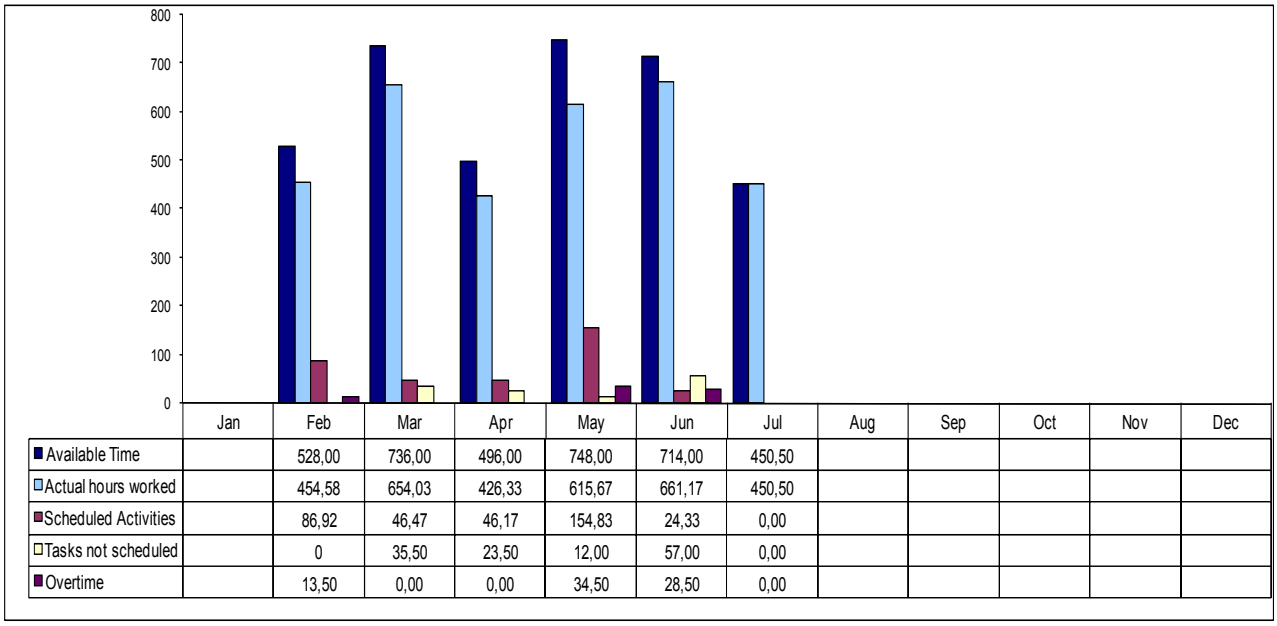


Figure 2 – Stratification of events

The records shall allow, as shown in Figure 3, the stratification in terms of shutdowns and unscheduled at the second level and what are these charts in the third level. One can also, depending on the database level, stratify in accordance with employees.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Available Time		528,00	736,00	496,00	748,00	714,00	450,50					
Actual hours worked		454,58	654,03	426,33	615,67	661,17	450,50					
Scheduled Activities		86,92	46,47	46,17	154,83	24,33	0,00					
Tasks not scheduled		0	35,50	23,50	12,00	57,00	0,00					
Overtime		13,50	0,00	0,00	34,50	28,50	0,00					

Figure 3 – Scheduled and unscheduled activities

Still must make it possible to view the monitoring team's monthly, as shown in Figure 4.

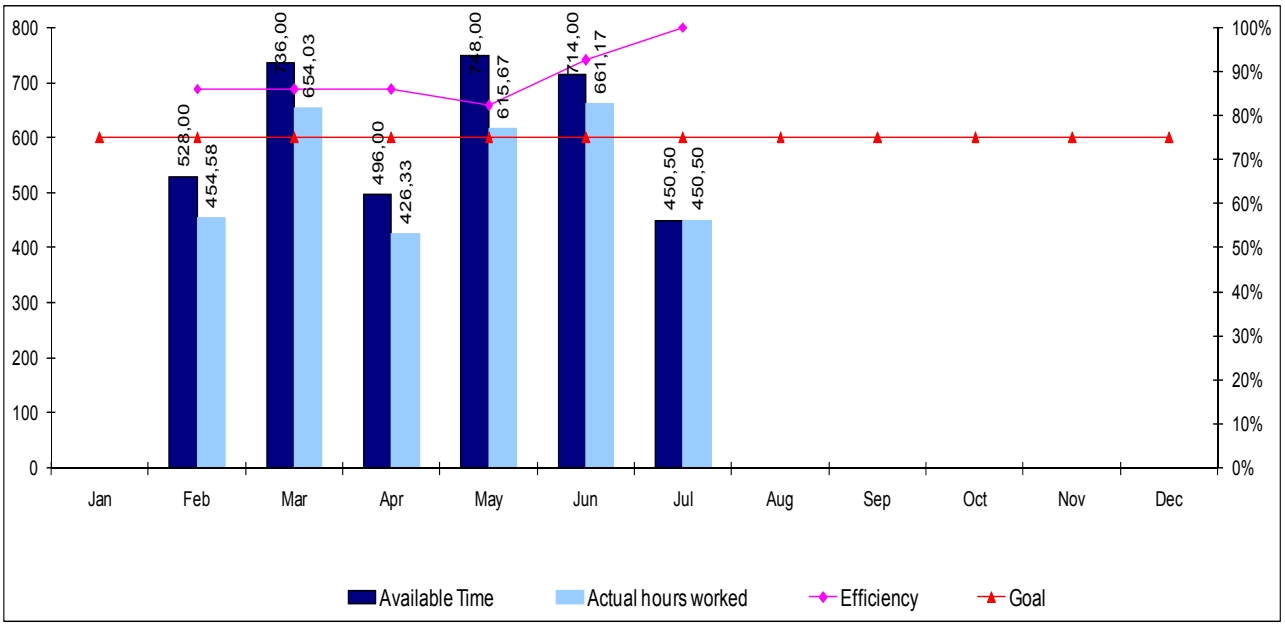
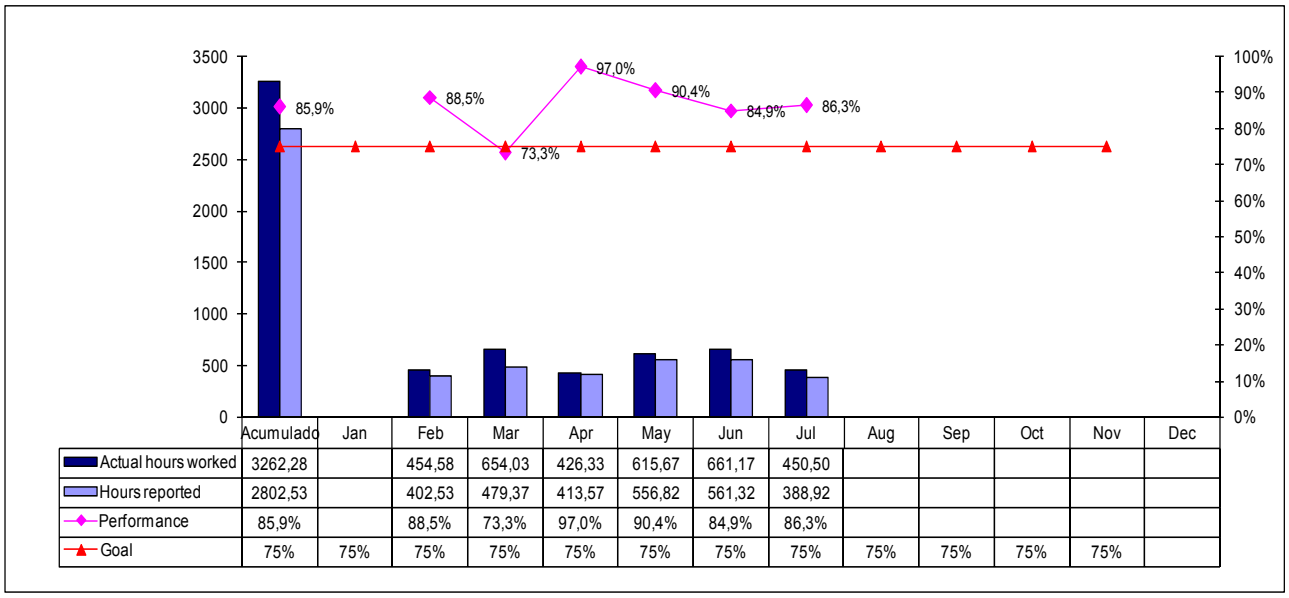


Figure 4 – Monthly monitoring of team efficiency

The PERFORMANCE is the rate between the hours reported and as actual workedhours obtained by the Index (4)

$$\textbf{PERFORMANCE} = \frac{Hours\ reported}{Actual\ workedhours} \quad (4)$$

Figure 5, emphasizes the performance monthly of PERFORMANCE

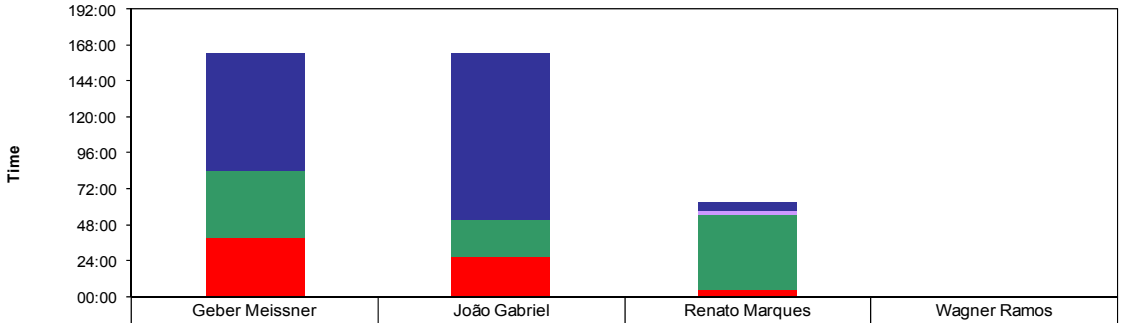


	Acumulado	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual hours worked	3262,28		454,58	654,03	426,33	615,67	661,17	450,50					
Hours reported	2802,53		402,53	479,37	413,57	556,82	561,32	388,92					
Performance	85,9%		88,5%	73,3%	97,0%	90,4%	84,9%	86,3%					
Goal	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	

Figure 5 – Monthly monitoring of performance team

Figure 6 shows the actual hours worked stratified by type of service and per employee, allowing the maintenance planning and control a better analysis:

- Average times by type of service;
- Levelling of resources by service type;
- Scheduling of maintenance activities;
- Appropriate prioritization of work.



	Geber Meissner	João Gabriel	Renato Marques	Wagner Ramos
Preventive	78:45	111:00	05:30	00:00
Predictive	00:00	00:00	00:00	00:00
Research and development	00:00	00:00	00:00	00:00
New facilities	00:00	00:00	00:00	00:00
Improvement	00:00	00:00	03:00	00:00
Planned Corrective	44:20	24:20	50:00	00:00
Unplanned Corrective	39:40	27:10	04:40	00:00

Figure 6 – Stratification by type of attendance-per employee

In Figure 7 is shown to assess the quality of services have been established specific questionnaires-CSS (Customer Satisfaction Survey) – where the direct client defined periodically (monthly) their satisfaction on the services provided.

Customer

Evaluation Period

	Strongly Disagree						Fully Agree
Check with a "X" on scale below							
PLANNING							
1.1) Planning´s Meeting are done according to schedule							X
1.2) Services are performed according to schedule							X
1.3) Team is concerned about services´s delay						X	
1.4) Schedule maintenance plan is performed							X
PERFORMANCE							
2.1) Requests are met and agreed deadlines are met							X
2.2) Urgency and emergency have priority treatment							X
2.3) There is agility and efficiency on resource organization							X
2.4) It´s flexible the negociation about divergent point							X
QUALITY							
3.1) Satisfactory response from customer complaints						X	
3.2) Services performed without rework						X	
3.3) Work area clean during and after the service performed							X
3.4) Team is qualified to perform the tasks						X	
PRODUCTIVITY							
4.1) Commitment with production´s objective							X
4.2) Remain Available (indicators)							X
4.3) Iniciative in effective changes							X
4.4) Commitment to reducing intervention time							X
SAFETY							
5.1) Release of equipmentos performed according to procedures							X
5.2) Uniforms kepts clean							X
5.3) No accidents during activities							X
5.4) Use of apropriates personal protective equipment							X
COSTS							
6.1) Spare Parts and services budget as provided						X	
6.2) Helps to reduce production unit cost						X	
6.3) Overtime is acceptable and agreed							X
6.4) Good control over customer costs						X	
Indicating other items that you think are important for evaluation							
RESULT (%)	Previous					Current	
	90					96	

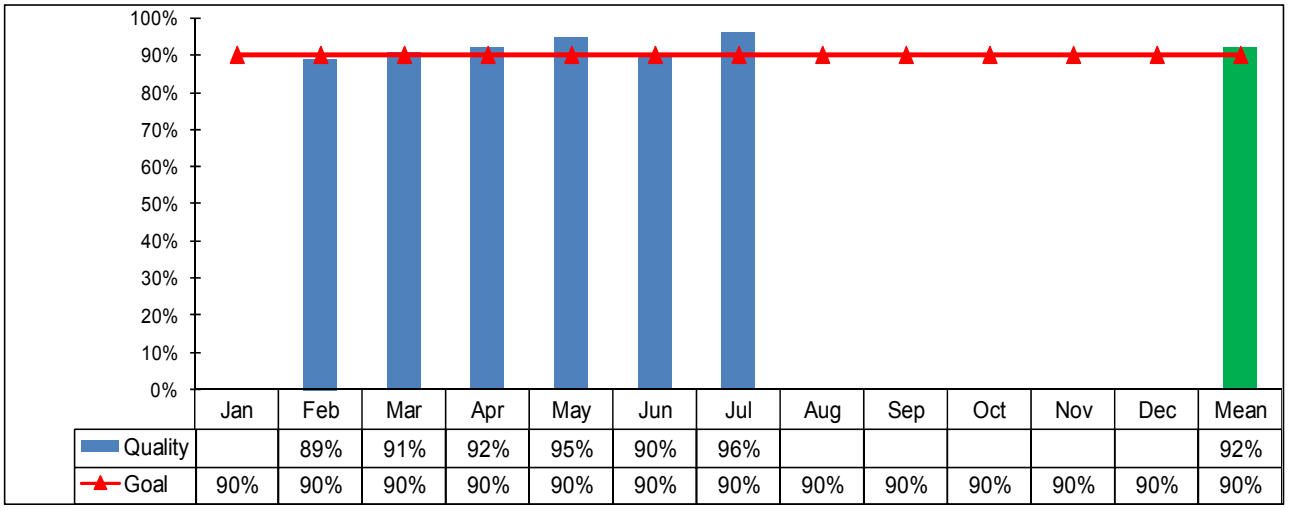
*Use the verse to expressa their **COMPLAINTS** and **IMPROVEMENT OPPORTUNITIES***

Date

Appraiser

Figure 7 – CSS (*Customer Satisfaction Survey*)

The result, with its stratifications showed in Figure 8 was demonstrated in a single indicator as is the team analyzed and their possibilities for improvement.



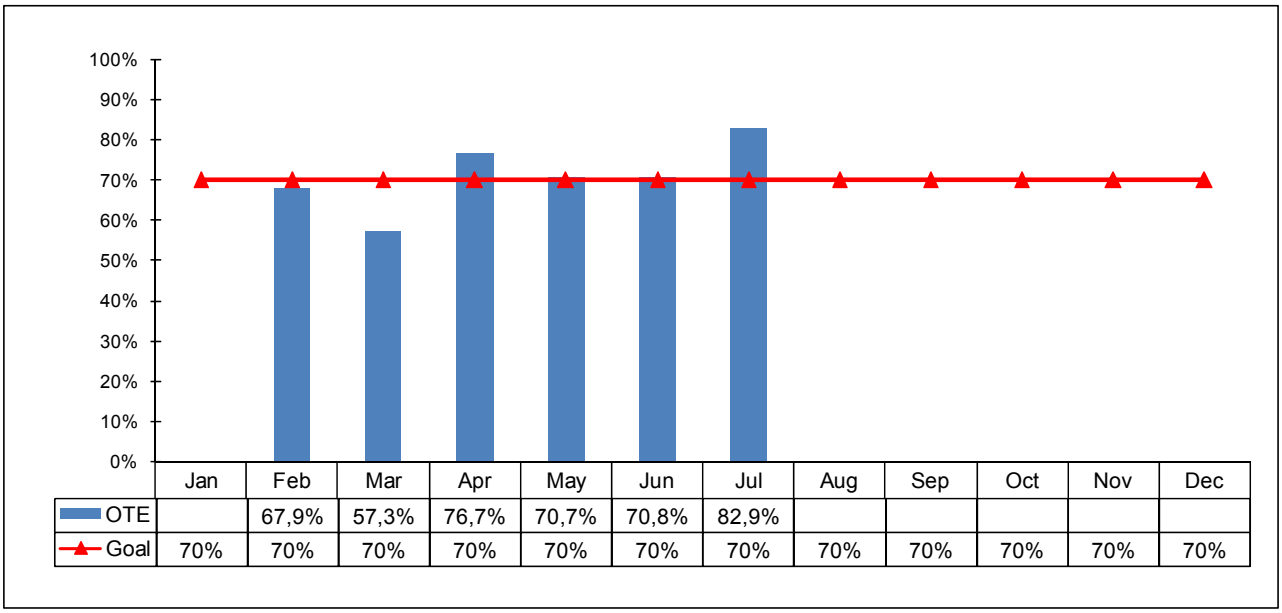
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Quality		89%	91%	92%	95%	90%	96%						92%
Goal	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%

Figura 8 – Montly quality relatory

Then we have the OTE (Global Efficiency Team) has already been shown Index (2):

$$OTE = Efficiency \ X \ Performance \ X \ Quality \quad (2)$$

The Figure 9 point out that in April the indicator reached 76.7%, reaching the goal in 2 (two) months after the start of measuring remaining stable until the month of July indicating a first layering possibilities of improvement in Performance indicator – the greatest difficulty encountered – show the importance of the record of the hours worked.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OTE		67,9%	57,3%	76,7%	70,7%	70,8%	82,9%					
Goal	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%

Figura 9 – Montly OEE relatory

Showing production managers that the scaling of the team and staff productivity of maintenance has been adequate and efficient.

4. CONCLUSIONS

Seeking to ensure the success of the project of OTE, monthly meetings were implemented for the evaluation of the results, together with those involved, where were singled out and corrected the main problems and several determining factors were identified during the implementation process. Among them are critical and positive aspects:

- Key factors: interpersonal relationships and personal crises, due to the breakdown of cultural and behavioral paradigms;
- Positive factors: the valuation of all involved, the adequacy of staff needs to seek 'to be' and 'to be' best ever (face of goal to do more with less).

In many instances, the simplest way seemed to be to return or abandon the 'new' and in fact the difficulties were found in the 'unlearning the old'. Certain that a great change is usually impossible unless all employees understand why change, it was invested heavily in training courses focused on teamwork and motivation.

Still, not everyone involved got a great while, however, others were able to see into the future and project it-seeking continuous improvement tirelessly, confirming that more than change the team was the fundamental change in people, because these claims is the success of any program/ methodology.

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