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TOTAL PRODUCTIVE MAINTENANCE IN THE RAILWAY SYSTEM

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Graphical abstract

	Phase I	Phase II
Production Time	6.00 hours	6.40 hours
Programmed Time	8.00 hours	8.00 hours
Availability	76.00%	80.00%
Theoretical cycle time[1]	6.00 hours	5.27 hours
Real cycle time[2]	6.84 hours	5.61 hours
Rate of speed	88.00%	94.00%
Quality Rating[3]	100.00%	100.00%
OEE	66.67%	75.15%

Abstract

This study aims to evaluate the need for a change in the maintenance philosophy used for the permanent route of the railway concession that provides the service for rail passengers in a metropolitan region. It also examines the need for production improvement, due to the requirement for a change in the rolling stock. The technique of total productive maintenance and its indicators are applied to evaluate the procedure for replacement of sleepers in narrow gauge lines. The history of the railway in Brazil is also presented, together with citations on the components of railway systems, the permanent way and a case study showing the strategy chosen in order to reduce the time for improvements by more than 10%.

Keywords: Total production maintenance, railway system, permanent way, OEE

1.0 INTRODUCTION

After six candidatures, the Brazilian dream to host an Olympics has finally been realized. One great challenge to overcome in order to achieve success in these events is the fragility of the transport system in the metropolitan region of Rio de Janeiro and the need to transform it into a reliable system in a short period. As in the majority of other Brazilian cities, a great part of this fragility occurs because of the concentration of investments in the road transport network, narrowing possibilities and a situation that is increasingly impaired by the unrestrained increase in the vehicle fleet.

With around 1,355,000 kilometres of highways, roads are the principal form of freight and passenger transport in the Brazilian traffic system [1]. Since the beginning of the republic, governments have always prioritised road transport to the detriment of rail and water transport. President Juscelino Kubitschek, who conceived and built the capital, Brasilia, was another supporter of roads. Currently, however, the Brazilian government, in contrast to those before it, is seeking to encourage other means of transport, principally, the railways. An example of this incentive is the Rio-São Paulo High Speed Train project, a bullet train which will link the two main metropolises of the country [2].

In the face of the increasing need to improve the quality of the transport services and linking it to an increase in client satisfaction, much have being done to improve passenger rail transport service in the region [2, 3].

This work will show the complete operating scheme of the railway system, all of its components, procedures and techniques, in order to be able to offer a reliable and continuous service of the quality that will meet both the requirements of the bodies that make up the organisations for these events and the expectations of the population.

The total productive maintenance method will be used to analyse the maintenance of the permanent way in the narrow gauge lines with the aim of providing better conditions for passengers and the possibility of an increase in the flow of freight transport via the railway.

2.0 TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is considered as the natural evolution from corrective maintenance to preventive maintenance. Total Productive Maintenance is supported by elements such as cultural change, seeking to optimise the general performance of equipment, systems to prevent losses, involvement in continuous improvement activities, education and the training of collaborators. It involves efforts to avoid quality defects caused by wear and the poor use of the equipment [4, 5, 6].

The TPM programmer is supported by eight basic pillars presented in Fig. 1. TPM is an integrated system with the aim of reducing costs with a change from corrective maintenance to spontaneous maintenance, carried out by the operator himself, a philosophy of zero loss, and equipment operating without breakdowns or interruptions.

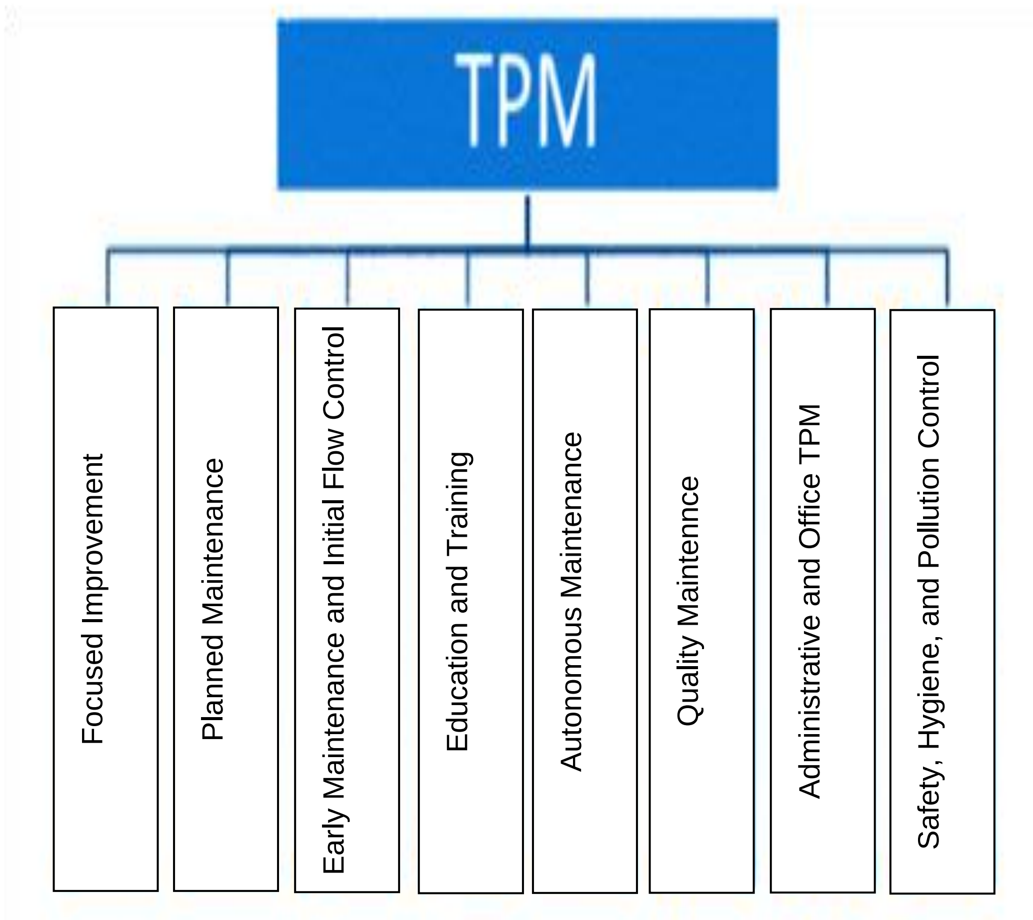

Figure 1 The pillars of total productive maintenance

3.0 OVERALL EQUIPMENT EFFICIENCY (OEE)

According to [7, 12], the principal indicator of a process is the Overall Equipment Efficiency (OEE), encompassing the three main indicators to evaluate the effect of losses, namely: Availability, Speed Rate and Quality Rating. The product of the three indicators (Eq. 1) gives the OEE:

$$OEE = Availability \times Speed\,Rate \times Quality\,Rating \quad (1)$$

Indicators characterised by good performance must have an availability and speed rate greater than 90% and a quality rating greater than 99%.

For good operational performance, the OEE must be greater than 85%. When it presents a value less than that considered good, this indicates equipment to be prioritised in the improvement activities [13]. Availability (Eq. 2) evaluates the percentage of time effectively used for production.

$$Availability = \frac{programmed\,time - stoptime}{programmed\,time} \quad (2)$$

The speed rate (Eq. 3) evaluates the relative speed of the equipment compared to its maximum theoretical speed.

$$SpeedRate = \frac{theoretical\,cycle\,time}{real\,cycle\,time} \quad (3)$$

Being:

- Theoretical cycle time – ideal minimum time per unit produced
- Real cycle time- production time/ total units produced

The quality rating (Eq. 4) evaluates the percentage of units produced in the period.

$$Quality\,Rating = \frac{Good\,units\,produced}{Total\,units\,produced} \quad (4)$$

4.0 RAILWAY SYSTEM COMPONENTS

The main components present in the railway system are, according to [12, 13]:

a) Overhead Electrification Network– line of contact fed with electricity by the traction substations, responsible for driving the Electric Train Units;
b) Rolling Stock:

- Locomotive – a type of railway vehicle responsible for driving other vehicles
- Electric Train Unit (TUE) – locomotives propelled by electric traction motors.

c) Signalling – signalling forms the interface between the location of the train in the network (signals, switches) and the OCC.
d) Operational Control Centre (OCC) – physical installation where the circulation of trains in the network is controlled and carried out.
e) Permanent Way – the principal characteristic of the railway as a whole is the existence of two parallel steel rails, anchored permanently upon a bed, on which the train runs;
f) Tracks – these are the elements responsible for the contact between the wheels of the rolling stock and the permanent way.

5.0 RESULTS

The permanent way is the train "highway", the area responsible for the maintenance and quality of the line where the rolling stock circulates. Poor conservation of the permanent way is capable of causing serious problems such as derailing or less serious problems such as excessive rocking, causing passenger discomfort. This may also result in a change in the manner of transport, such as a restriction on speed, the worse conditions of the permanent way and the slower the passage of the multiple units along the stretch of track.

Given the importance of the permanent way, this work will present changes in the procedure for changing sleepers arising from the adoption of the total productive maintenance method by the Permanent Way team operating on the narrow gauge lines, with the intention of a change in the type of rolling stock.

The planning sector receives the service requests, analyses what needs to be done and how, the specialities and the groups involved, and the material and equipment to be used. This results in an action plan, the list of materials to be used or stock purchase and other complementary documents such as a set of service specifications, service orders etc.

Field observations and discussions held with specialists in the maintenance area who had experience in carrying out or accompanying this type of service were made in order to prepare the standard procedure.

In the stage involving the preparation for applying TPM, the people responsible for each process and their respective targets were determined. The following targets were set for the narrow gauge lines (Table 1):

The calculation of the OEE was carried out in the standard procedure phase (Phase I) and after the implementation of TPM (Phase II) and the comparison of the indices is presented in Table 2.

Through the standard time analysis of each step of the process, the OEE base indices were calculated for the procedure of substituting 56 sleepers per day, the average collected in the measurements, as the team is composed of seven operators with a target of eight sleepers per day.

Table 1 Guidelines and targets

Guidelines	Targets
Integration between all 1000 mm gauge areas	Increase of 15% in OEE
Better performance	Reduction of 15% in total time of project
More reliable permanent network	Increase of 10% in speed of current rolling stock
More reliable rolling stock	Gravel #0

Table 2 Comparison between the OEE in phase I and II

	Phase I	Phase II
Production Time	6.00 hours	6.40 hours
Programmed Time	8.00 hours	8.00 hours
Availability	76.00%	80.00%
Theoretical cycle time[1]	6.00 hours	5.27 hours
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Quality Rating[3]	100.00%	100.00%
OEE	66.67%	75.15%

1 – Theoretical cycle time was consideredthe average time spent to carry out the replacement of one unit multiplied by the daily target (8 sleepers per day).

2 – Real cycle time included an error added to show losses in performance and speed of operation due to sun, rain, fatigue (individual performance).

3 – As there is no possibility of a non-identical replacement, the quality-rating index was considered 100%.

It was observed that, despite not reaching the performance level considered good, (greater than 85%), after the implementation of TPM in phase II, the OEE presented an increase of close to 12%. The company target has also not yet been reached, but it was considered satisfactory in an initial analysis. There has been an increased of 7% in production time, generating a reduction of 10% in the total time of the project, with the total time needed for the complete revitalization of the two branch lines at seventy months. It also presented an improvement of approximately 7% in the speed of the current rolling stock.

6.0 CONCLUSION

In the light of the analysis, the planning for activity in the two lines considered most critical was carried out. The strategy chosen will result in a completely reformulated branch line in a period of twenty-one months, a time that will make the improvements possible for the Olympics 2016.

In a comparative analysis of the costs of the two phases, a greater value was observed in phase II. However, the process was shown to be advantageous, as the increase is due to the increase in production. This is because the cost of the sleepers and the service of changing the sleepers was included in the measurements; the more sleepers that are changed, the more material that is used and the more service that is charged, producing a greater value. Nevertheless, the duration of the project is reduced by eight months.

The targets for increase in speed of the rolling stock and zero breakdowns cannot be analysed at the moment. These targets can be better planned and achieved, or at least, approximated in a future work.

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