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ASSESSMENT OF THE IMPACT OF RAPID TOOL CHANGE (SMED) ON REDUCING SETUP TIMES IN MACHINING CENTERS

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ABSTRACT
Several strategies are applied to improve operational results. Through the application of action research, this work aimed to implement the rapid tool change system and reduce the setup time of machining centers. As a result, after applying the TRF, setup times were reduced by 62.6% (from 02:01:36 hours to 45:30 minutes). This work is justified because, in addition to reducing the time in setup changes, it also reduced the number of products delivered late by 90% (from 12,425 to 1,227 parts) after 4 months of implementing the activities.

Keywords: TRF. Waste Reduction. Delay Reduction. Production Engineering. Meeting. Operations. Sustainable.

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INTRODUCTION

In the highly globalized and competitive scenario in which organizations are immersed, one of the main focuses of most organizations regarding their production system is cost reduction and industrial flexibility. This aims at greater competitiveness and adaptability to meet production demand according to the fluctuations and needs imposed by the market (SABALE; NAGARE, 2021). This objective can be achieved through several paths, among them many options arising from the basic concepts of the Toyota Production System (ANTUNES et al., 2008).

One of the approaches applied is methodologies aimed at managing workstations (GPT), which seek to assist in decision-making focusing on results. This thinking of better organization and understanding of workstations, in which Antunes et al. (2008) the GPT approach consists of seeking better use of the assets available in the manufacturing environment, for example, machines, facilities, locations, people, among other factors linked to the company, seeking to optimize them and increase production capacity and flexibility without the need for large capital investments, or even in certain cases, with a reduction in invested capital. Through this tool, the organization can monitor existing workstations, identifying critical points or resources that greatly influence the company's production capacity. After a global understanding of the company, it is possible to use tools such as GPT itself, among others, to generate actions that will corroborate the optimization of production stations. The measurement of success or failure to define new actions and understand the efficiency of these actions is carried out through the equipment's Global Operational Index (IROG). Considering the importance of this tool in the production environment and the approach raised above, a study was carried out in a company that manufactures household appliances located in Rio Grande do Sul to evaluate the Global Operational Performance Index (OPI) and apply the GPT concepts in a rolling mill assembly line. The work is justified due to the importance of in-depth research and understanding of this methodology for the academic and industrial areas, which directly impact the reduction of costs and losses in the production process. Its possible results can be used both in academic and industrial environments due to the possibility of similar replications in several other industry sectors (SOLTANALI et al., 2021).

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BACKGROUND THEORETICAL

Some of the fundamental concepts were sought to assist in the construction and understanding of the work. These will serve as guidelines for the study.

WORKPLACE MANAGEMENT

Taking into account the lean thinking of the Toyota Production System, Shingo (1996) and Ohno (1997) mention the importance of effectively managing workstations, in parallel with this, managing people and machines, and together with this, they suggest the adoption of a systemic, unified and integrated management vision focused on process improvements. Workplace Management (WM), according to (ANTUNES et al., 2013), aims to enhance the organization's assets (people and machines) and to implement WM, it is necessary to:

- Identify the items that establish restrictions on the production process;
- Calculate the Overall Operational Performance Index (OPI);
- Verify the causes that lead to failures in the equipment under analysis;
- Apply STP tools to recognize waste, increase machine efficiency, and serve the end customer better.

IROG

The application of the IROG tool emerged strongly in Japanese industry in the 1960s and 1970s, when Japan began to adopt innovative measures to compete in the international market, aiming to recover from economic ruin. One of the tools that stood out in generating results was IROG. It is a powerful tool for measuring performance, helping to determine different types of losses present in production, in addition to pointing out points for improvement in processes; in short, it refers to loss management, an indicator that acts on losses existing in direct and indirect processes that, when added together, end up contributing to the cost of products. (MUCHIRI; PINTELON, 2008).

Some literature, especially international ones, uses the term OEE instead of IROG but with the same objective and mathematical modeling. Busso and Miyake (2013) mention that OEE can be calculated using Equation 1:

Equation 1 – Equation to calculate OEE

OEE = Availability x Effectiveness x $Quali$ty

Source: Busso and Miyake (2013)

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The equation has factors that need to be understood. For example, availability losses are set up due to adjustments and failures in the machinery, performance losses are stops related to anomalies in the process that alter the pre-established production rate, and quality losses are stops when the product is produced outside the specification, generating scrap and rework.

According to Nakajima (1989), the IROG (Equation 2) can be calculated by multiplying the Operational Time Index (OTI) by the Operational Performance Index (OPI) by the Approved Products Index (API).

Equation 2 – Steps in the working method

$$\mu_{global} = \mu_1 \times \mu_2 \times \mu_3$$

Source: Nakajima (1989)

Where:

μ1 = Operational Time Index – ITO;

μ2 = Operational Performance Index – IPO;

μ3 = Approved Products Index – IPA.

METHODOLOGY

This section is organized into a research method, a case study, and the steps for carrying out the research in the work method section.

RESEARCH METHOD

This work used a case study as a method. The data collection technique used participant observation, documents, spreadsheets, and reports on the qualitative aspect, which demonstrate the use of tools that assist in monitoring the continuous improvement of processes and enhancement of IROG. The results were analyzed qualitatively.

WORK METHOD

The study was carried out through stages, as shown in Figure 1

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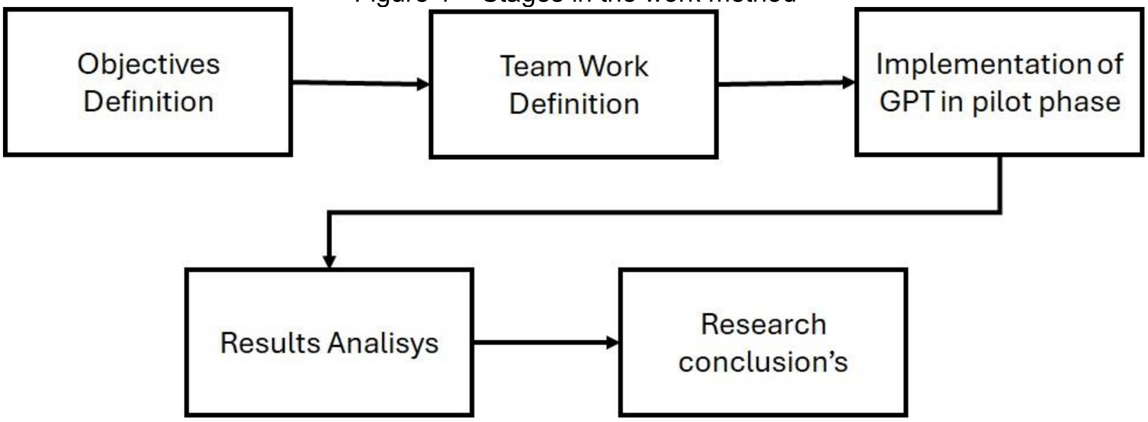
Figure 1 – Stages in the work method



Source: Prepared by the authors

The unit is made up of a company located in Rio Grande do Sul, which manufactures various types of products for domestic use (barbecue grills, rolling pins, graters, laminators, etc.). The work team consisted of 7 employees: one for machine maintenance, two for process engineering (analyst and manager), one for quality, and three for machine operators. To implement the project, it was decided to start with the manufacturing line for the laminator family. The choice of this line was because this product represents the company's largest sales volume and is a strategic product for the business.

RESULTS

The first step was to identify the current IROG of the laminator line. The line consists of five workstations (one of which is packaging), where the products are finally ready for shipment. The times for each workstation were known. The logbook concepts were applied to identify the losses recorded during the productive period and, consequently, the IROG of the production line. The IROG results from April to August 2024 are presented in Table 1.

Table 1 – Historical of the indicators

Period (2024)	OTI	OPI	API	IROG
April	78%	78%	100%	61%
May	83%	85%	100%	71%
June	71%	82%	100%	58%
July	78%	82%	100%	64%
August	88%	78%	100%	69%

Source: Prepared by the authors

The organization has set a global IROG target of 80%, derived from the indices of 87% for OTI, 92% for OPI, and 100% for API. The results show a history of at least 10% below the planned, mainly impacted by the IPO and ITO indices.

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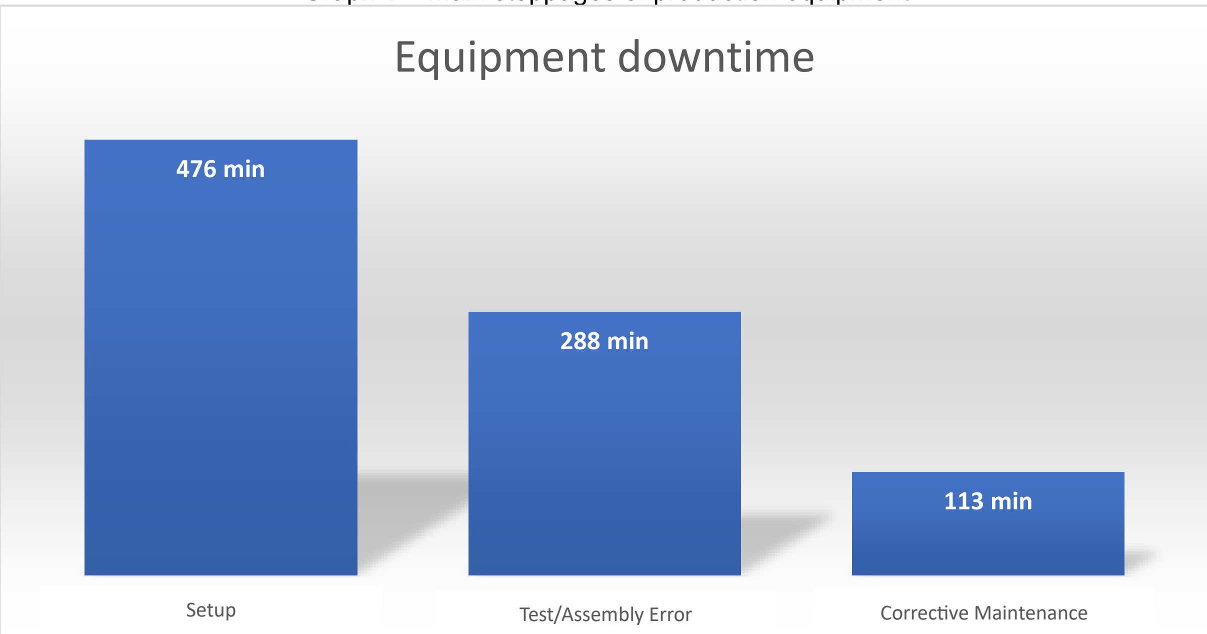
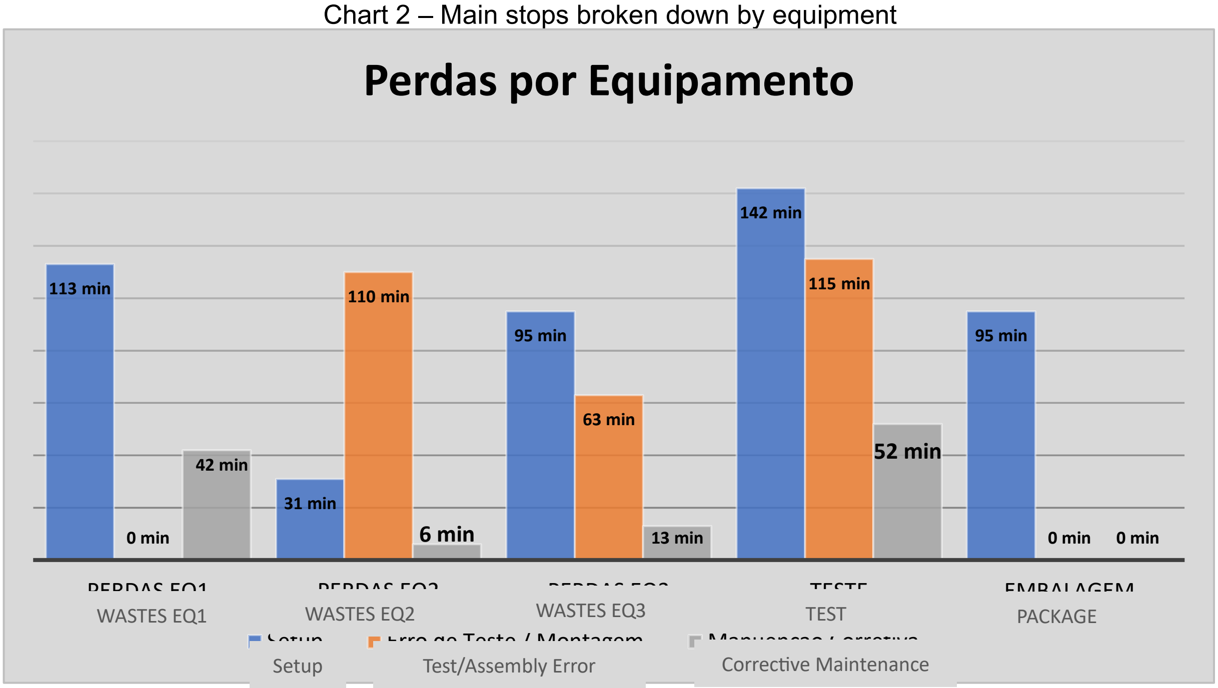
A thorough evaluation of the logbooks identified the main losses for the set of equipment in the production line and individually for each piece of equipment, which are available in graphs 1 and 2 (average results for the period analyzed).

Graph 1 – Main stoppages of production equipment



Source: Prepared by the authors

Chart 2 – Main stops broken down by equipment



Assessing Graph 1, it is clear that the three main factors identified in the ITO losses were related to setup and corrective maintenance and that the IPO losses were related to

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testing and assembly errors. Graph 2 shows that the greatest losses are in testing activities and a certain parity between the other equipment (excluding packaging).

Based on the data presented, projects were developed to improve the results of the IROG presented. The main actions were developed and are detailed below:

- Testing Errors – In addition to testing, pre-tests were performed on the equipment called "Eq1; Eq2; Eq3", in which the entire review of procedures and reprogramming of the equipment was carried out to reduce failures
- Reviewed setup procedures on all equipment. The review included standardizing setup methods, transforming internal setup activities into external setup activities, and training operators.

These activities were developed during December and January. After the activities were carried out, the equipment's IROG was evaluated, as shown in Table 2.

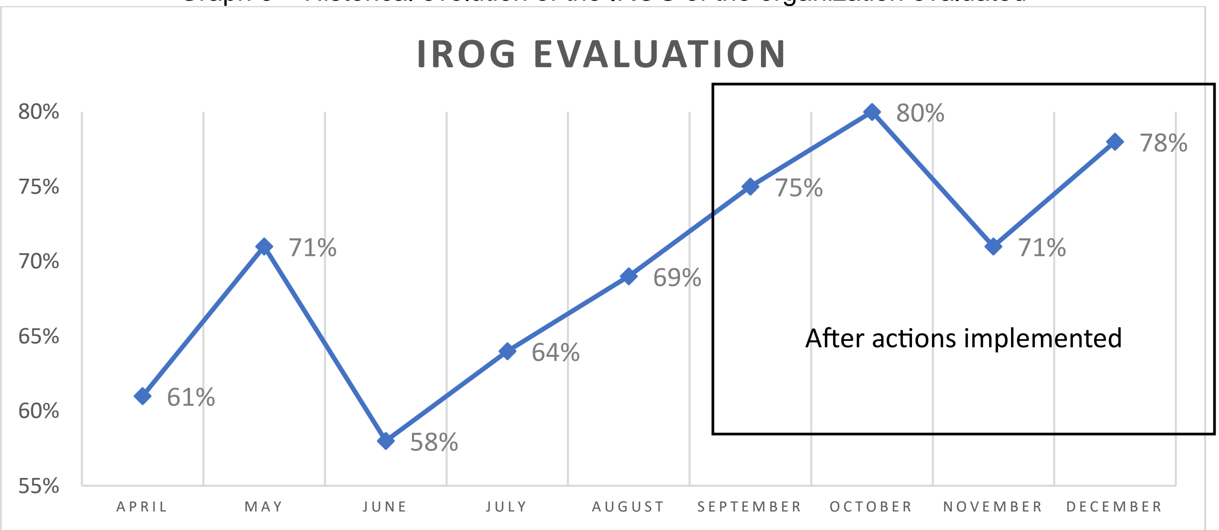
Table 2 – Evaluation of the history of the indicators after the actions

Períod (2024)	OTI	OPI	API	IROG
September	85%	88%	100%	75%
October	88%	91%	100%	80%
November	81%	88%	100%	71%
December	88%	89%	100%	78%

Source: Prepared by the authors

Evaluating the data in Table 2, it can be seen that the organization's goal (80%) was achieved in only one of the four months evaluated. Graph 3 shows the historical evolution of the organization's IROG.

Graph 3 – Historical evolution of the IROG of the organization evaluated



Source: Prepared by the authors

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Graph 3 shows an evolution in the IROG indexes through the moving average of two periods and the main data. Even though the company did not meet the established target, comparing the average of the IROG results from April to August and from September to December shows an increase of 17.6% in the IROG of this product line.

ANALYSIS OF RESULTS AND CONCLUSIONS

This study evaluated the Global Operational Performance Index (GROI) and applied the GPT concepts to a rolling mill assembly line. In addition to the results, it is possible to conclude that the study's objectives were achieved. The search for better results in the process is always one of the organizational objectives. Through evaluating the processes and applying the GPT, it was possible to identify the main losses and support the decision-making of the process actions. The application of the GPT in this case was able to support the improvements through the identification of the waste of the evaluated equipment.

Even though the organization could not consistently achieve the indicators, the equipment's GROI increased by an average of 17.6%. The application of the GPT (Antunes et al., 2013), the identification of losses, and combined (SHINGO, 1996) with the application of the Toyota Production System tools generate positive results in the equipment's GROI.

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