

Results of the application of autonomous maintenance in the mitigation of waste generation: Case study in a footwear company in Jaú/SP

Resultados da aplicação da manutenção autônoma na mitigação da geração de resíduos: Estudo de caso em empresa calçadista de Jaú/SP

Marcos Antonio Bonifácio¹ , Antonio Cesar Germano Martins¹ 

¹Universidade Estadual Paulista – UNESP, Programa de Pós-graduação em Ciência Ambiental, Campus Sorocaba, Sorocaba, SP, Brasil. E-mail: bonifacio@process.com.br; amartins@sorocaba.unesp.br

How to cite: Bonifácio, M. A., & Martins, A. C. G. (2021). Results of the application of autonomous maintenance in the mitigation of waste generation: Case study in a footwear company in Jaú/SP. *Gestão & Produção*, 28(2), e5519. <https://doi.org/10.1590/1806-9649-2020v28e5519>

Abstract: Finding alternatives to what is generally used in companies allows a different strategic vision to be built, which can lead to different results. In this context, the present study applied the Autonomous Maintenance pillar (AM) of the Total Productive Maintenance tool (TPM) in an unusual context. The AM is used to involve the various actors of the company in the conservation of equipment with the aim of improving their performance concerning a reduction of failures and an availability and reliability increase. In the present study, the AM had the objective of mitigating the generation of waste in the production of a women's shoes industry, installed in a Local Productive Agglomeration (LPA). This APL is composed mostly of micro and small enterprises (MPE) that do not have the culture to using maintenance tools, but in its process generate hazardous waste. It is important to highlight that this kind of company does not typically use the concepts of industrial maintenance. In conclusion, with the implementation of the AM pillar, it was possible to reduce the volume of waste generated in the cutting sector, contrary to the fact that the company does not use the concepts of industrial maintenance in its strategic decisions, thus opening up new strategic possibilities for discussing the use of widely disseminated tools in some areas for other purposes.

Keywords: Women's shoes; Autonomous maintenance; Total productive maintenance; Local productive agglomeration.

Resumo: Buscar alternativas ao que usualmente é utilizado nas empresas, permite construir uma visão estratégica diferenciada, o que pode levar à obtenção de resultados diferentes. Neste contexto encontra-se este trabalho que aplicou o pilar de Manutenção Autônoma (MA) da ferramenta de Manutenção Produtiva Total (TPM) em um contexto diferente do usual. O MA é utilizado para envolver os diversos atores da empresa na conservação dos equipamentos com o objetivo de melhorar seu desempenho no tocante a redução de falhas, aumento da disponibilidade e confiabilidade. Neste trabalho o MA teve como objetivo a de mitigação da geração de resíduos na produção de calçados femininos, instalada em um Arranjo Produtivo

Received May 16, 2019 - Accepted Aug. 19, 2019

Financial support: None.



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Local (APL), composto majoritariamente por micro e pequenas empresas (MPE) que não tem a cultura de utilização de ferramentas de manutenção, mas que em seu processo geram resíduos perigosos. Deve-se salientar que se trata de um ambiente que não utiliza rotineiramente os conceitos de manutenção industrial. Ao final, com a implantação do pilar de MA, foi possível reduzir o volume de resíduos gerados no setor de corte, contrariando o fato de a empresa não utilizar nas suas decisões estratégicas os conceitos de manutenção industrial, abrindo assim novas possibilidades estratégicas para a discussão da aplicação de ferramentas largamente difundidas em algumas áreas com outros propósitos.

Palavras-chave: Calçados femininos; Manutenção autônoma; Manutenção produtiva total; Arranjo produtivo local.

1 Introduction

The Total Productive Maintenance (TPM) tool has been used by companies of different segments and sizes to improve the management of the equipment presented in the production processes.

This tool is structured in eight pillars, one of which is called Autonomous Maintenance (AM), which proposes a group of actions aimed at involving actors others than the maintainers in the context of equipment maintenance. Chand & Shirvani (2000) argue that TPM can be used as a component of the company's strategic plan to ensure that manufacturing is considered world-class, involving everyone, giving support to guarantee the proper functioning of the equipment. Those requirements are imposed when the company chooses to work with Just in Time (JIT).

Autonomous Maintenance prioritizes the operators. Ireland & Dale (2001) reinforce this idea, showing that in an environment in which the company is observing inadequate skill levels and low employee participation, as well as lack of application of appropriate methods of continuous improvement, TPM implementation can help solve these problems.

The justification for this is due to the fact that, according to Biehl & Sellitto (2015), the operators are closer to the assets and by expanding their horizon of action into conservation in their day by day, the regular and standardized inspection, cleaning, lubrication and even, in some situations, adjustments and minor repairs, increase prevention of failure.

Ireland & Dale (2001) also state that one of the actions foreseen in the AM implementation process should be to stimulate the involvement of all sectors, including production, development and administration; involving all employees from top management to operators, including administrative staff. For this purpose, AM seeks the awakening in the operators and others the feeling of belonging to a complex productive system, which depends on them to succeed, and not seem themselves as isolated members that perform only a production function.

Such new perception was explored in this case study, which aimed to introduce the idea of responsibility and belonging into the operators. This was meant not only for the purpose of equipment conservation, but adding a new objective: the relationship of this involvement with the reduction of waste generation in the sector, offering managers a new strategic option with the use of tools that have shown results in other areas for different purposes.

Thus, the general objective of this study was to verify the possibility of using the TPM tool, specifically its AM pillar (originally directed to the conservation of assets), for a new purpose: the mitigation of waste generation classified as "Class I - Hazardous"

by ABNT-NBR 10004 (ABNT, 2004) in the manufacturing process of cutting shoes in a local productive agglomeration (LPA) from Jaú/SP.

The main challenge regards the use of a maintenance tool in an environment that does not have this strategic direction. Notwithstanding, the characteristics of this environment indicate that the same results observed in asset conservation can be reproduced in the mitigation of waste generation.

With good results, it is possible to offer new strategic possibilities to increase the focus of the companies that comprise the LPA, considering the reduction of waste generation and the improvement of installed assets. Therefore, new possibilities can arise even for similar companies installed in other footwear retailers throughout Brazil.

To describe the development of this research, the following sections were structured: theoretical foundation (TPM, AM pillar, LPA-Jaú), methodological procedures (adapted and synthetic model, unit of analysis), results and discussion, conclusion with results and contributions.

2 Theoretical foundation

This section will present the main characteristics and concepts of TPM, the steps of implantation of the AM pillar, and details of LPA-Jaú, relating with maintenance.

2.1 Total Productive Maintenance (TPM)

According to ABNT-NBR 5462 (ABNT, 1994), industrial maintenance can be defined as the combination of technical, administrative, and supervisory actions, with the objective of maintaining or relocating an item in a state in which it can perform a function. In other words, it means doing all the necessary to ensure that an equipment or machine operates under minimum conditions of requirements and specifications.

To perform these tasks, maintenance is used through numerous techniques and tools that support asset conservation actions, one of them being TPM. According to Ribeiro (2014), TPM intends to achieve zero machine failure, which would result in zero defects in the final products and zero losses in the course of the production process.

Also according to Ribeiro (2014), TPM is the result of Japanese efforts aimed at improving the preventive maintenance technique idealized in the United States of America.

Palmeira & Tenório (2002) stated that these Japanese efforts had as motivation the difficulties faced in the postwar period. Moreover, Freitas (2007) considers that these actions were directly related to the efforts to eliminate losses in the process, in addition to the maximization of asset utilization, actions that would become the direct agents of TPM tool implementation in Japan.

For Takahashi & Osada (2000), TPM is one of the most effective methods to create an operation that focuses on the equipment, mainly, by the involvement of all employees in the process. This reasoning is corroborated by Mirshawka & Olmedo (1994), that emphasize the importance of the employee integration of the organization, from the top management to the workers of the production lines, and also, of course, the maintenance, in the search for the best results.

In Suzuki's view (1994), TPM arises due to the need to follow the technological evolution of the equipment installed in the production lines, which presented high level of automation and consequent reduction of labor for its operation.

Thus, the origin of the Japanese TPM model would grow with the proposal of involving all employees in the management of assets, minimizing the demand for interventions of the maintenance team in tasks that could be easily performed by the operators, for example.

However, the TPM tool underwent several evolutionary processes to reach its current format of application. We divided this evolution into four phases, as presented in Chart 1 (Palmeira & Tenório, 2002; Imai, 2000).

Chart 1. Historical evolution of the TPM.

	1970	1980	1990	2000
	1st Generation	2nd Generation	3rd Generation	4th Generation
Strategy → .	Maximum efficiency of the equipment	Production and TPM		Management and TPM
Focus → .	Equipment	Production System		General System of the Company
Losses → .	By fault.	Six major equipment losses	16 losts	20 losts
			Divided into: Equipment, Human Factors and Production Resources	Divided into: Processes, Inventory, Distribution and Purchases.

Source: Palmeira & Tenório (2002); Imai (2000) (adapted).

Figure 1 shows the TPM tool structured for the involvement of all employees in the pursuit of gains, expressed in: P-Productivity; Q-Quality; C-Costs; D-Delivery/Attendance; S-Safety; M-Moral. In achieving these goals or gains, the tool offers the support for eight pillars, as shown below.

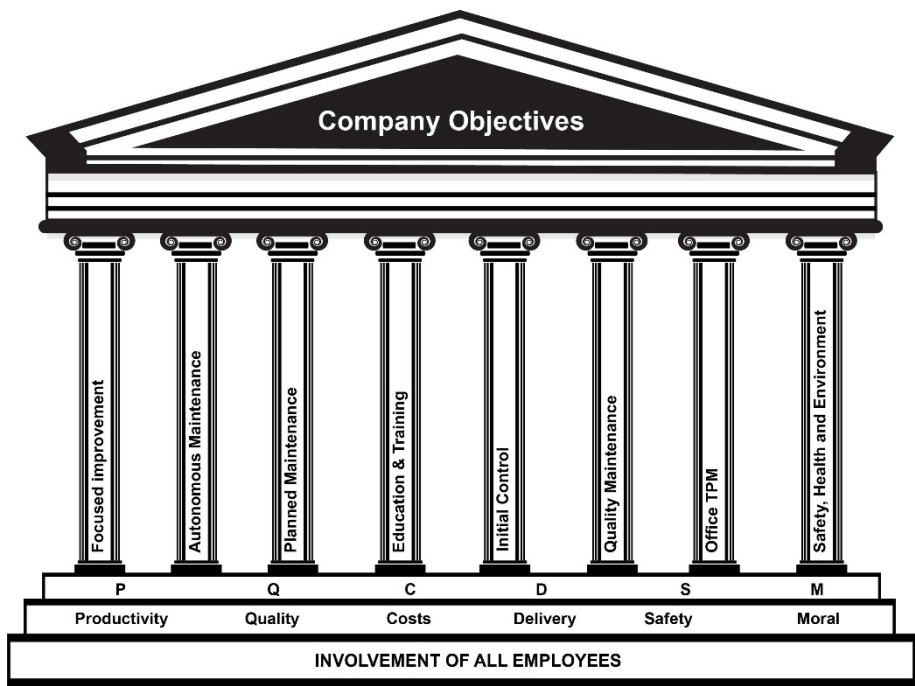


Figure 1. TPM Pillars. Adapted from Freitas (2007).

Authors Nakajima (1989) and Freitas (2007) suggest TPM implementation from the execution of twelve successive phases, emphasizing that considerations or adaptations should be proposed to suit the peculiarities of each company, also contemplating the regionalities involved.

A report of TPM implantation can be found in Reis (2018), who proposed a script adapted for a production cell, dividing the model into three stages, namely: Step 1: definition of the work cell where TPM would be applied, training and equipment inventory; Step 2: identification of the types of failures and definition of the degree of priority and risk of failure modes; Step 3: Creation and implementation of preventive and autonomous maintenance plans.

Gupta et al. (2006) warn that TPM implementation is not an easy task, requiring an adequate infrastructure and the commitment of all employees, regardless of their hierarchical level.

Sturion et al. (2017) pointed out that after three years of TPM deployment in a flexible packaging production process, reducing losses resulted in a 10.6% increase in the Overall Equipment Effectiveness (OEE) indicator, highlighting an improved efficiency, with the reduction of approximately 1,000 hours of work with low speed line.

Pinho et al. (2018) mention the importance of working to break down possible barriers to the TPM implementation process. The authors emphasize that behavioral barriers relate to the actors involved, cultural barriers relate to managerial thinking, operational barriers relate to routines already established, while financial barriers deal with the necessary investments, and technological barriers relate to the resources available for TPM implementation and development.

2.2 Autonomous Maintenance Pillar (AM)

One of TPM's support pillars is AM, which proposes to develop in the operators, and others involved with the equipment, the feeling of ownership, zeal, or even belonging to the context of production (Ribeiro, 2010; 2014).

Narender & Gupta (2012) emphasize that the AM pillar is focused on the technical development of the operators so that they can handle small tasks in the equipment they operate, leaving those activities that require more complex technical and/or specific repairs for specialized maintainers.

In the view of Xenos (2004), in the past, when the equipment was less complex, that is, composed of few mechanical components and of easy maintenance, the operators already performed and were responsible for some maintenance.

For AM implantation, it is necessary to base the actions in the preparation or qualification of the operators in technical questions so that they are able to carry out some new actions in their day to day. Nonetheless, Xenos (2004) highlights that although many actions are carried out by the operators, there will still be demand for technical repairs performed by the specialized maintenance team.

Kardec & Ribeiro (2002) conclude that AM is able to recover the operator's sensitivity to the equipment he/she operates, enabling a feeling of "ownership".

This involvement brings about a break of paradigm, provoking a change of behavior by the integration between two areas (maintenance and production) that end up competing in the day to day of the productive processes.

The implementation process suggested by Ribeiro (2010, 2014), Freitas (2007) and Suzuki (1994) in 7 (seven) steps can be summarized in Figure 2.

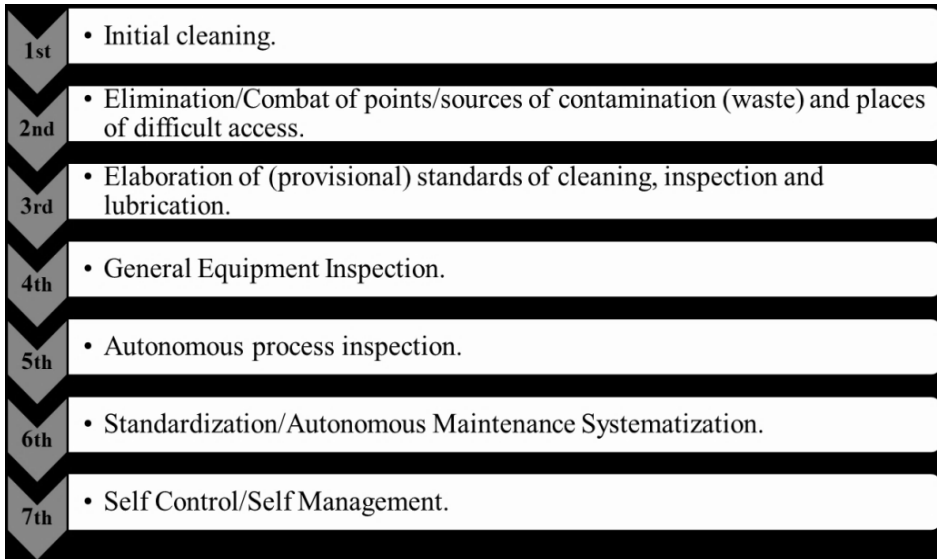


Figure 2. Steps for the implementation of the AM Pillar.

Once this pillar is implemented, the resulting actions will be contributing to the maintenance in the search for the best reliability of equipment and processes, leading to the reduction of losses as proposed by TPM.

Nevertheless, its main contribution is considered to be the enabling of the partnership between the production and maintenance sectors for the search of the best results, in addition to improved conservation of assets, and reduced losses with an increased productivity.

Some reports of AM pillar implementation can be found in Vital et al. (2018), who presented a multicriteria prioritization of the pillars, and in Soltovski et al. (2018), who demonstrated the application of this pillar in a food industry, highlighting its difficulties and benefits.

2.3 LPA of Women's Shoes of Jaú/SP and its relations with Maintenance

According to SINDICALÇADOS (2011), the LPA of Jaú/SP is composed of approximately 650 formal establishments, of which at least 150 are companies manufacturing women's shoes and the others distributed in the context of the production chain.

To understand the profile of these companies, data were collected through the application of a questionnaire in loco with 53 companies (about 35% of the total), selected for convenience, and all of them producers of women's shoes.

These data enabled to trace some profiles that showed the environment in which the study proposal was being made. Specifically in the general context of the companies, Figure 3 presents the main results.

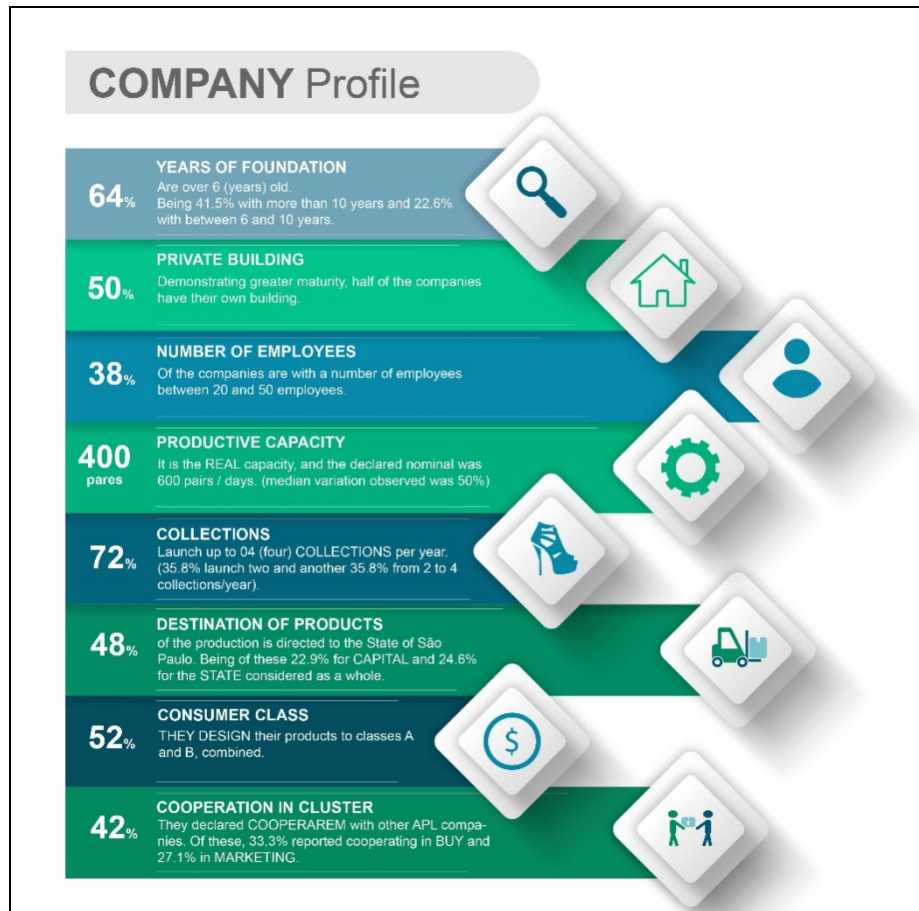


Figure 3. Profile of the companies that make up the Footwear LPA from Jaú/SP - Source: prepared by the authors.

From Figure 3, it can be noted that the companies present in the LPA are longevous, with most companies (64%) having more than 6 (six) years of operation, and with a high rate (50%) of companies having their own buildings.

Table 1 presents an analysis of the size of the companies in the LPA according to SEBRAE (2016), which classifies companies by the number of employees. From this table it can be noted that the LPA comprises basically micro and small companies.

Table 1. Grouping enterprises by the number of employees.

Number of employees	Size*	% of companies
up to 19	Micro	34%
from 20 to 99	Small	49%
from 100 to 499	Average	17%
more than 500	Big	

*Size according to SEBRAE reference for industry. **Source:** Prepared by the authors based on SEBRAE (2016).

Another highlight of the survey is the high rate of production idleness, reaching 50%, even with average production of only 400 pairs per day. Considering the new models,

in order to meet the high volatility of the fashion segment, LPA companies predominantly (72% of them) launch four collections (or group of new models) per year.

Regarding the use of industrial maintenance concepts (see Figure 4), it was possible to identify that 85% of the companies consider maintenance important or very important for their processes, and 93% state that the topic should be considered in the elaboration of global strategies. However, 76% of these companies do not have their own maintenance teams and, when it is the case, they have on average only one professional for this purpose. Notwithstanding, 67% of respondents consider that the contributions of resources for the purpose of maintenance should be considered as investment rather than expenses.

Even without their own teams, 83% declared to carry out preventive interventions. This is a relevant fact, even though this action is being carried out in 73% of the cases by outsourced companies, generally representing the suppliers of the equipment. It was not evident, but it is suggested that the activity be concentrated in newer equipment that depend on these actions so that the guarantees are respected.

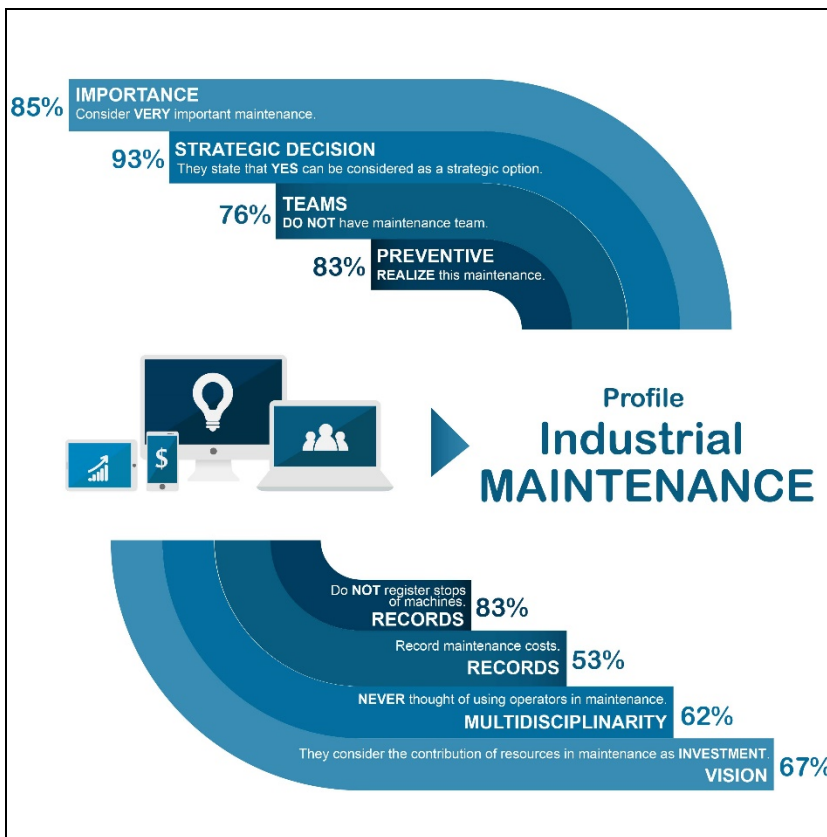


Figure 4. Profile of the companies that make up the Footwear LPA from Jaú/SP - Source: prepared by the authors.

Little has been observed of preventive actions carried out by “nontechnical” teams or by operators, or, in the case of simpler equipment, from the point of view of acquisition investment.

There is a certain lack of knowledge about the technical concepts of Preventive Maintenance, evidenced by the 18% who declare that “continuous improvement” would be

one of these techniques, or by the few (3%) who declare to know the TPM tool and that are failing to perform, for lack of knowledge of the tool, simple activities such as: cleaning, visual inspection, lubrication, among other actions that prevent failures or process stops, which could be carried out by the operators themselves on a day-to-day basis.

The possibility of operator use had already been considered by only 38% of the companies, action that is proposed by the AM pillar from TPM.

3 Methodological procedures

This case study was based on the construction of a synthetic and adapted model, aiming at the implantation of AM in a women's footwear company from the LPA of Jaú/SP.

The model was structured in 5 (five) steps, as presented in Figure 5, adapted from the authors Ribeiro (2014, 2010), Xenos (2004) and Kardec & Ribeiro (2002), who propose a deployment with more steps.

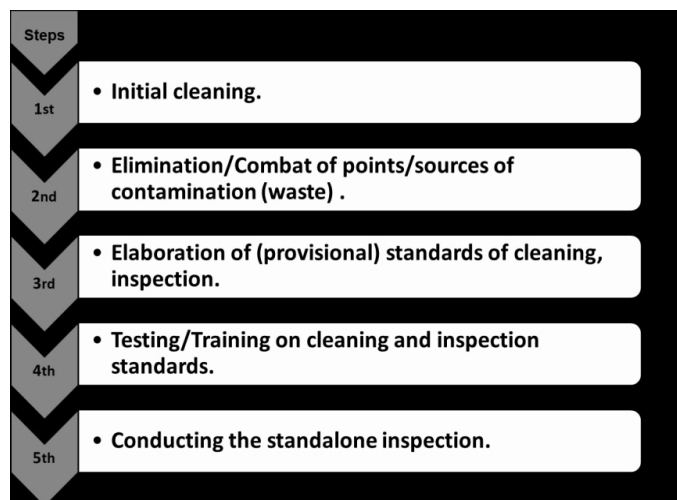


Figure 5. Model adapted for the implementation of the AM Pillar. **Source:** prepared by the authors.

The proposed model follows suggestions from the reference literature, which allows establishing standards to follow the evolution of activities and results.

The motivation to propose a more synthetic model was due to the characteristics of the LPA companies. Moreover, the company considered usually does not have maintenance teams, besides presenting low level of use of maintenance concepts according to the research done, which would make it impossible to adopt a model requiring greater involvement or technical support from maintainers.

As for the time needed to observe the full gains suggested, Ribeiro (2014, p.475) cites the Japan Institute of Plant Maintenance (JIPM) "TPM Awards" as a reference, drawing a parallel between the possible gains and the time needed to obtain them, noting that companies that adopt the TPM methodology will observe effective results "on average 2.5 to 3 years after its beginning".

Aiming at the implementation of the AM pillar, a series of actions were planned, as described in Chart 2. It is noteworthy that the steps proposed in the synthetic AM pillar implementation model (Figure 5) are included in the list of planned actions. The greater number of actions than steps proposed in the synthetic model refers to the need to carry out preparatory and complementary activities, providing the necessary basis for the study.

Chart 2. Actions to implement the synthetic model of AM.

Action	Activity
1	Presentation of the model and proposals to the owner (by the characteristic of the companies of the APL the owners are present in the day-to-day management of the companies);
2	Presentation of the model and proposals to the Main Plant Manager and Sector Leader;
3	Identification or appointment of sponsor (s) for the project, who are full (s) (leader or not) in the study sector;
4	Mapping of the current situation of the registries and the equipment installed in the sector - Done in conjunction with Manager and / or Leader of the sector;
5	Mapping of the indicators used in the day to day;
6	If there are no indicators or are not according to the need: → Propose the immediate implementation of indicators to record the current situation;
7	Make the formal opening of the program to those involved with the participation of the owner or principal manager DECLARING support for the project;
8	Operate the indicators before the implementation of the synthetic model;
9	Training on Maintenance; TPM; AM; Environmental Issues for Cutting Team, Maintainers (if any) and others indicated by the company; Training on the roadmap to be implemented, with objectives and proposals.
10	Plan in this training the accomplishment of the first step of the synthetic model, discussing proposals for the identification of possible contamination points of dirt and also possible improvements in equipment and in the sector; <u>(1st step of the syntetic model)</u>
11	Perform initial cleaning in the sector and equipment. If possible carry out the activity on an off-day; <u>(2nd step of the syntetic model)</u>
12	Identify the needs for adjustments of dirt contamination points in addition to the needs for improvements, mainly for access to the equipment in order to carry out cleaning and inspection activities; <u>(3rd step of the syntetic model)</u>
13	In the workplace – off-day if possible - close the cleaning and inspection standards, in addition to the execution control sheets, along with those involved; <u>(4th step of the syntetic model)</u> Conduct the first rounds of cleaning and inspection with supervision, aiming at a field training;
14	In this step, it is seek to identify the needs for adjustments of the standards in addition to technical deficiencies, proposing, if necessary, “one point” training, to adapt the technical skills of the operators; Observation: Start with the activities with greater interaction of the Operators with the equipment, hoping that as a result of the trainings and of this involvement, some variation in the generation of the residues can already be observed.
15	Make necessary adjustments to the standards of cleanliness and inspection, as well as in the records and application of “one-point” training if necessary; <u>(5^o passo do modelo sintético)</u> Period of autonomous activity accomplishments.
16	At this step the monitoring becomes remote, allowing everyone to become aware of their real importance to the success of the tool. The results, through the indicators, are presented in the Management of the View Framework (GAV) aiming to increase the involvement, increasing the awakening of the feeling of belonging to the work context;
17	Follow the results through the pre-established indicators, recognizing the achievements to each achieved goal; It is important that the collected data is presented, preferably in notice boards, in order for the following up of all those that are involved.

Source: Prepared by the Authors.

To measure the results, an indicator was established that will follow the volume of waste generated (Kg), normalized by the total pairs produced in the period, according to Equation 1:

$$\text{Indicator} = \frac{\sum \text{Kg waste}}{\sum \text{produced pairs}} \quad (1)$$

where:

\sum Kg waste: sum of waste generated per pair of shoe produced.

\sum produced pairs: total of pairs of shoes produced in a certain period.

From the comparison of this result before and after the implementation of the AM pillar, it can be verified whether or not the intervention contributed to the reduction of waste generation in the company's cutting sector.

3.1 Studied company

The study focused on a women's footwear manufacturer installed in the footwear industry in Jaú/SP, meeting the delimitation initially established for the study.

This company had its activities started in the year 1985, and its main characteristics are presented in Table 2.

Table 2. Main characteristics of the studied company

Years from Foundation	38
Number of employees	260
Hours of work per day	8:48
Installed capacity	6.500
Real capacity	~5.900
Main raw material	Sintetic material
Number of Collections per year	6 per year
Number of lines (average)	20 per collection
Number of models (average)	4 per line
Consumer Class	C-B
Quality	
5S - No	
Procedures (ISO) - No	
Quality sector - Yes with 5 (five) employees	
Promotes Training - Yes (Internal and External)	
Cutting sector	
Number of employees	34
	1 Leader
	2 Aux. Leader
	18 Cutters
	1 Cutter Repair
	7 Reviewers
	5 General Helpers
Experience (average) Cutters (years)	11,4 years
Kind of machines	Balancim (bridge – simple)
Number of machines (balancim)	13 – Bridge type + 1 – Simple

Source: Elaborated by the authors based on the data collected in the Company of the study.

The studied company is considered by LPA representatives as one of its exponents because of the way it handles production issues in the context of managerial processes, being considered a sustainable company in a scenario of decreasing number of companies in the LPA during the last years.

4. Presentation of results

The development of the study that allowed the analysis of results came from the accomplishment of the proposed actions, these being realized in four distinct steps in the course of the study:

1. Study setup: in this first step, actions 1, 2, and 3 were carried out, which proposed the presentation of the model for those responsible for the company's management, and included their designation of the sponsor who would follow the process.

The company appointed two representatives to be the interlocutors, the Cutting Sector Manager (focus of the study) and a Quality/CronoAnalyst, who would be following directly the study, both becoming future facilitators after the tool was implemented.

2. Initial data collection: at this point, actions 4, 5, and 6 were performed to map the current situation of the equipment and indicators already used. New indicators were proposed when necessary.

This collection was not limited to the data, expanding to the identification of the equipment and the general situation of the sector, thus creating the necessary references that could corroborate the efforts undertaken for the implementation of the new tool.

3. Organization of the work environment: comprising actions 7, 8, 9, and 10, being initiated by 8th action with the operationalization of the indicator to map the current situation, since there were no indicators being used in the sector that could follow up the generation of waste. The other actions followed with the formal opening of the project and the training completion.

The indicator was operationalized with the use of already available data of production in pairs and waste generation in kilograms, from January/2018.

During the training, the two standards were elaborated to be used in the inspection and cleaning routines, as shown in Figure 6. It was a collective construction, thus increasing participation and stimulating the desired awakening of the feeling of belonging to the context instead of just fulfilling orders to perform tasks.

The models were created using a single sheet for the cleaning and another for the inspection standards, with both a photo of the equipment and indicative captions with the activities to be performed, aiming to simplify the understanding and the use.

In addition to the standards, two spreadsheets were created, one for the registry of possible anomalies found and another for the tasks, allowing the registration of the execution (or not) and possible justifications.

For the operationalization of the activities, these forms were available in each of the workstations, on a drawing board, with the two standards (cleaning and inspection), inserted in a single plastic envelope for its preservation, in addition to the two supporting sheets.

LOGO Company		Cleaning Standards	
Balancim de Ponte Rapid 27 e 28		Cutting department	
Frequency	Weekly	Responsible	Operator
Comments			
<ul style="list-style-type: none"> - The inspection should be a DAILY rocker performance FOLLOWING; - The WEEKLY accomplishment of this inspection is to establish a ROUTINE, but any deviation must be communicated; - Perform this inspection AFTER performing weekly cleaning; - Use the appropriate personal protective equipment; - Always follow SAFETY RULES; - REPORT TO RESPONSIBLE ANY REMOVAL OBSERVED FOR REGISTRATION. 			

Figure 6. Example of the cleaning pattern used. Source: prepared by the authors.

4. Implementation of the synthetic model: this step took place with the accomplishment of actions from 10 to 16, which aimed at the implementation of the model itself.

The highlight of these activities was the initial cleaning and the organization of the sector. The company already had a routine to keep the workplaces clean, but there were still items unnecessary for the activities in the workplaces (Figure 7), which were destined to suitable places to perform the new routines. The result can be observed in Figure 8.



Figure 7. Sector before initial cleaning.



Figure 8. Sector after initial cleaning.

5 Observed results

Comprising the 17th and last of the actions, proposed to analyze the results for the implantation of the model, comparing them with the situation observed previously.

The listed actions and analyses were carried out between May and December 2018, with routine cleaning and inspection activities starting at the end of September, going through December 2018, with weekly frequency.

4.1 Results achieved

With the actions carried out and the data collected it was possible to verify whether the behavior of waste generation had changed or not.

The analysis of the results was performed based on Table 3, which shows the volume of production (in pairs) and the total waste generated (in Kg), the data being divided in two periods, from January to July 2018, before intervention, and from August to November 2018, during the model deployment period.

In addition, a graph (Figure 9) was used for the analysis, in which it is possible to observe the behavior of waste generation in the two periods, including their respective trends.

Table 3. Obtained results.

Month	Days	2018			Waste	
		Total of Pairs	Kilos	Value	Kg/Pair	R\$/Pair
Jan	18	70.864	2.186	R\$ 896,26	0,031	R\$ 0,013
Feb	20	92.265	6.176	R\$ 2.532,16	0,067	R\$ 0,027
Mar	21	106.653	6.936	R\$ 2.843,76	0,065	R\$ 0,027
Apr	24	130.844	6.889	R\$ 2.824,49	0,053	R\$ 0,022
May	23	121.708	4.034	R\$ 1.653,94	0,033	R\$ 0,014
Jun	15	48.666	3.364	R\$ 1.379,24	0,069	R\$ 0,028
Jul	21	101.051	6.253	R\$ 2.813,85	0,062	R\$ 0,028
Aug	22	135.880	6.728	R\$ 3.027,60	0,050	R\$ 0,022
Sep	19	124.896	6.323	R\$ 2.845,35	0,051	R\$ 0,023
Oct	22	155.623	7.223	R\$ 3.250,35	0,046	R\$ 0,021
Nov	19	138.658	6.237	R\$ 2.806,65	0,045	R\$ 0,020
Dec						

Source: Company of the study.

In the first period, there were more random behavior points in January and March 2018, showing a lack of standard in data collection. In the analysis of the available data, it was not possible to identify the real reasons that led to such disparate values in the months of January and May. Despite the oscillatory nature, it can be observed that there is a global trend of increase in waste generation.

In the second period (August-November 2018), as a result of the actions carried out, it was first possible to observe regularity in the values of waste generation, which tended to decrease, thus reversing the scenario before implementation.

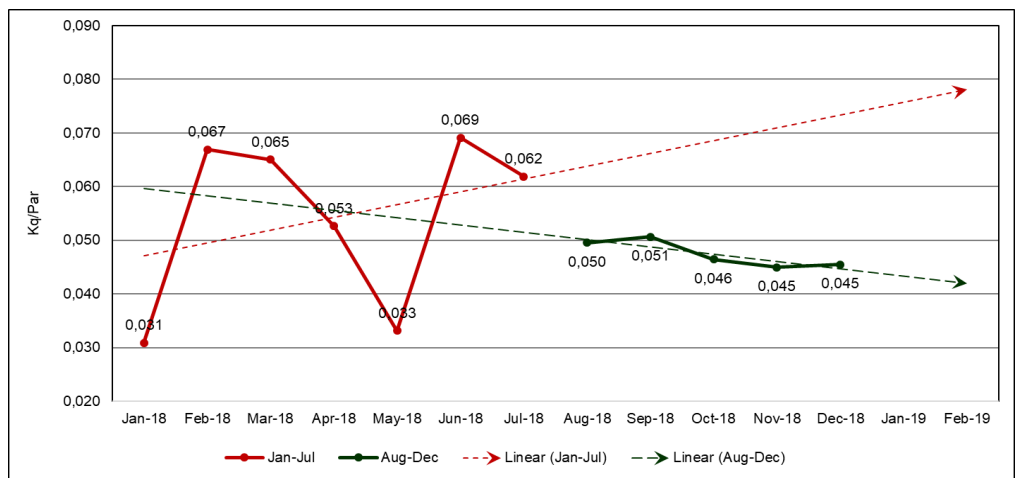


Figure 9. Evolution of waste generation per pair of footwear produced.

Analyzing the periods separately, as shown in Table 4, it is possible to observe favorable variations regarding the volume of discard per pair produced. This was the initial objective of the study, which registered a reduction of 11.6% of residue per pair of shoes produced when comparing the periods.

Table 4. Change in discard volume.

Month	Days	2018				Waste	
		Total of Pairs	Average Pairs/Day	Kilos	Average Kilos/Dia	Kg/Pair	R\$/Pair
Jan - Jul	142	672.051	4.633	35.838	249	0,053	R\$ 0,022
Aug- Dec	82	555.057	6.780	26.511	324	0,048	R\$ 0,021
						-11,6%	-3,5%

Source: Company of the study.

Furthermore, the values (R\$) involved with the destination of these wastes were verified, which also showed a decrease of 3.5% (Table 4). Although there was also a reduction, these results did not follow the reduction observed in the volume, due to a readjustment in the value of the collection and destination, from July.

5 Conclusions

Having as a proposal the search for strategic alternatives to reduce the generation of waste from the production of women's shoes in a LPA, this article uses the concepts of the industrial maintenance tool known as TPM, more specifically applying one of its eight pillars: Autonomous Maintenance (AM).

This was an innovative proposal, since the TPM tool in its AM pillar is known worldwide for its effectiveness in asset conservation and reduction of unforeseen process shutdowns, but had not yet been presented as a strategic option to enable waste reduction.

In the context of the production of women's shoes, raw materials classified as dangerous are used, which demand adequate collection and disposal, putting economic pressure into the companies and drawing attention to environmental issues.

Preliminarily, to clearly understand the scenario in which the study would be applied, a field survey was carried out with 53 companies that, based on primary data, outlined a series of profiles of the companies that compose the LPA. In one of these profiles, it was possible to identify a low level of use of maintenance concepts by LPA companies, which would represent a difficulty in consolidating the proposal. On the other hand, it could be unprecedentedly applied in unfavorable scenarios where industrial maintenance is not used on a day-to-day basis.

In order to complement the understanding of the context and clearly define a feasible proposal, a bibliographical review of the main related topics was carried out. Based on these understandings and definitions, it was possible to make an adaptation of the theoretical concepts for the implementation of the widely diffused AM, targeting the characteristics of the LPA companies and adding a new purpose: waste reduction in a given sector.

With a viable application in an unfavorable scenario, new possibilities would open up for the other companies that compose the LPA, not only for the reduction of waste

generation, but also arousing interest in the adoption of industrial maintenance practices.

Thus, with a structured model, the AM pillar was implemented in a company belonging to the LPA, whose results, in a first analysis, allowed a reduction of about 11.6% in the waste volume of the cutting sector. Moreover, the costs involved in the disposal of this waste in a controlled manner (in accordance with current legislation) decreased by 3.5%.

Although preliminary results were obtained, it was possible to verify that using the same concepts already diffused by the traditional tools, but with a new direction, new results can be obtained without the essence of the tool being lost, thus contributing with new strategic options for the companies.

References

- Associação Brasileira de Normas Técnicas – ABNT. (1994). *NBR 5462: Confiabilidade e Manutenibilidade*. Rio de Janeiro: ABNT.
- Associação Brasileira de Normas Técnicas – ABNT. (2004). *NBR 10004: Resíduos sólidos – Classificação*. Rio de Janeiro: ABNT.
- Biehl, N. C., & Sellitto, M. A. (2015). TPM e Manutenção Autônoma: estudo de caso em uma empresa metal-mecânica. *Revista Produção Online*, 15(4), 1123-1146. <http://dx.doi.org/10.14488/1676-1901.v15i4.1632>.
- Chand, G., & Shirvani, B. (2000). Implementation of TPM in cellular manufacture. *Journal of Materials Processing Technology*, 103(1), 149-154. [http://dx.doi.org/10.1016/S0924-0136\(00\)00407-6](http://dx.doi.org/10.1016/S0924-0136(00)00407-6).
- Freitas, A. J. N. (2007). *Curso TPM na Linha da Confiabilidade*. São Paulo: Loos Prevention/ABRAMAN.
- Gupta, S., Tewari, P. C., & Sharma, A. K. (2006). *TPM concept and implementation approach*. Retrieved in 2019, March 25, de <http://www.maintenanceworld.com/tpm-concept-and-implementation-approach/>
- Imai, Y. (2000). *TPM como estratégia empresarial*. São Paulo: IMC.
- Ireland, F., & Dale, B. G. (2001). A study of total productive maintenance implementation. *Journal of Quality in Maintenance Engineering*, 7(Issue: 3), 183-192. <http://dx.doi.org/10.1108/13552510110404495>.
- Kardec, A., & Ribeiro, H. (2002). *Gestão estratégica e manutenção autônoma*. Rio de Janeiro: Qualitmark: ABRAMAN.
- Mirshawka, V., & Olmedo, N. L. (1994). *TPM à moda brasileira*. São Paulo: Makron Books.
- Nakajima, S. (1989). *Introdução ao TPM Total Productive Maintenance*. São Paulo: IMC.
- Narender & Gupta A. K. (2012). A review of total productive maintenance system into an indian service sector. *International Journal of Mechanical and Production Engineering*. 1(1), 12-20.
- Palmeira, N. J., & Tenório, G. F. (2002). *Flexibilização Organizacional: Aplicação de um modelo de produtividade total*. Rio de Janeiro: FGV: Eletronorte.
- Pinho, B., Pereira, G. M., & Borchardt, M. (2018). Mitigando as Barreiras na Implantação do TPM: Estudo de Casos. In *Anais do XXXVIII Encontro Nacional de Engenharia de Produção (ENEGEP 2018)*. Maceió: ABEPRO. http://dx.doi.org/10.14488/ENEGEP2018_TN_STO_258_483_35141.
- Reis, Y. (2018). Criação de um Roteiro para Implementação de Manutenção Preventiva aos Moldes do TPM. In *Anais do XXXVIII Encontro Nacional de Engenharia de Produção*

- (*ENEGEP 2018*). Maceió: ABEPRO.
http://dx.doi.org/10.14488/ENEGEP2018_TN_STO_258_483_35594.
- Ribeiro, H. (2010). *Desmistificando o TPM*. São Caetano do Sul: PDCA.
- Ribeiro, H. (2014). *A bíblia do TPM: Como gerenciar a produtividade na empresa*. Santa Cruz do Rio Pardo: Viena.
- Serviço Brasileiro de Apoio às Micros e Pequenas Empresas - SEBRAE. (2016). *Critérios de classificação de empresas: MEI-ME-EPP*. Retrieved in 2016, April 23, from <http://www.sebrae-sc.com.br/leis/default.asp?vcdtexto=4154>.
- Sindicato das Indústrias de Calçados de Jaú - SINDICALÇADOS (2011). *A história do calçado*. Retrieved in 2016, August 11, from <http://sindicaljau.com.br/>.
- Soltovski, R., Pontes, J. Matos, C. & Oliveira, K. A. (2018). Proposta de aplicação do programa de manutenção autônoma na indústria alimentícia: um estudo de caso. In *Anais do XXXVIII Encontro Nacional de Engenharia de Produção (ENEGEP 2018)*. Maceió: ABEPRO.
- Sturion, L., Sturion, L. H. C., & Reis, M. C. (2017). Redução de Perdas em um Processo Produtivo Através da Implantação da Manutenção Produtiva Total - TPM. In *Anais do XXIV Simpósio de Engenharia de Produção (SIMPEP)*. Bauru: UNESP-FEB.
- Suzuki, T. (1994). *TPM for process industries*. Portland: Productivity Press.
- Takahashi, Y., & Osada, T. (2000). *TPM/MPT Manutenção produtiva total* (2a ed). São Paulo: Instituto IMAN.
- Vital, J. C. M., Ferreira, T. H. D., Lima, C. R. C. & Helleno, A. L. (2018). Utilização de Método Multicritérios para Priorização dos Pilares de Implementação do TPM. In *Anais do XXV Simpósio de Engenharia de Produção (SIMPEP)*. Bauru: UNESP-FEB.
- Xenos, H. G. (2004). *Gerenciando a Manutenção Produtiva: O caminho para eliminar falhas nos equipamentos e aumentar a produtividade*. Nova Lima: Falconi.