Lean Maintenance Management Model, Based on TPM and 5S to Increase the Availability of Machines in the Plastics Industry

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Abstract. In a production system in the plastics industry, the implementation of the Lean Manufacturing tool is carried out with a view to reducing machine downtime, because there is a relatively low availability rate, which is generated by breakdowns constant and prolonged time in its restoration. With the application of the Total Productive Maintenance technique focused on the criticality analysis of modes, effects and failures. It seeks to reduce the six major losses of equipment, through the timely identification of the main causes of unforeseen breakdowns, which affects the availability of machines and their productivity and increases production costs. The Solution model will be implemented in three of these: First, the preparation stage. Then, the implementation stage that consists of the development of two methodology that is Total Productive Maintenance and 5S. Finally, the monitoring stage that allows the indicators to be compared with the improved line.

Keywords: Lean manufacturing · Total productive maintenance (TPM) · 5S · Availability

1 Introduction

Today, a need arises to improve the productive processes of the industries due to the presence of globalization, since competition is increasing every day due to the fact that many new companies arise, which is why it is important to keep production costs low. Industries concentrate efforts on maintaining a more efficient and productive production system, to avoid losing profits and becoming more profitable, in order to stay in competition [1]. Industries in their quest to increase their productivity and obtain higher income, seek to eliminate their problems that generate waste. Industries that treat plastics are generally characterized by pinching machines. In these machines, the operating methods can be very complex. Therefore, a machine failure would greatly affect the performance caused by the time required to know the factors that explain the downtime. Machine

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downtime refers to downtime periods when machines are not productive Industries need to be aware that machine downtime already whether planned or not, it is very expensive.

From the costs of production downtime, labor, and reserve value, the cost of downtime extends to other resources within the facility, as well as to the organization as a whole [2]. Also, reducing downtime increases machine availability, reduces order delivery times, and increases customer satisfaction. Causes of machine downtime can include problems with real machines such as breakdowns or jams, no materials, no planned maintenance. Thanks to the collection of research on the tools implemented in some companies, the great value of the Total Productive Maintenance methodology can be seen. Factors to consider when evaluating a manufacturing industry are the quality of the products and the efficiency of the machines and the efficiency of the machines. Maintenance management has a noticeable influence on these two factors. Likewise, the participation of the human factor in maintenance practices is essential in the plastics industry [3]. Approximately 30% of the total cost of production corresponds to the development of maintenance activities. [4] The maintenance area plays a fundamental role in providing continuous production of the equipment in its normal operating condition.

Many industries strive to implement these tools in their production processes in order to make them more efficient and more productive. Factors to consider when evaluating a manufacturing industry are the quality of the products and the efficiency of the machines and the efficiency of the machines. Maintenance management has a noticeable influence on these two factors.

2 Estate of the Art

2.1 Maintenance Management Models in Plastics Industries

The industries dedicated to the processing of the plastic item day by day fight against the problems that arise in their production processes, for which they are forced to resort to tools that solve their problems, of which many opt for the implementation of models. of maintenance management that involve various tools [1, 2, 5, 6]. Machine maintenance is a key resource in the plastics industries [2] due to its high importance since more than 90% of the processes are carried out by machines, which are essential for production. The impact of unplanned machine shutdowns during production is significant [1, 2] and this generates large losses, therefore authors [1–3] and [5] opt for the implementation of maintenance models in which they focus on the preservation of the machines. Among the most widely implemented tools is the TPM and its 8 pillars [3, 5] due to their great contributions in productivity, efficiency, effectiveness by increasing the availability of the machines.

2.2 Planned Maintenance for the Plastics Industry

The proposed solution model for the present work is shown in the figure. The solution model consists of three stages of preparation, implementation, and follow-up. Next, the proposed model will be developed.

In the preparation stage, it aims to sensitize those involved about the problem that the company is afflicting; as well as, it is important to have the support of senior management during implementation to achieve effective results [7, 8]. For this, at this stage it consists of different activities such as: The creation of teams that will be part of the TPM committee, the promotional campaign of the project, among others. The activities carried out in the preparation stage are shown below in the figure.

3 Input

3.1 Maintenance Management

During the review of the research literature, different scientific articles have been compiled on the Total Productive Maintenance (TPM) and 5s tools. According to various authors, the use of a Lean methodology technique has the ability to solve any type of problem. The contribution of this research work consists of the combination of two representative tools in order to obtain the results immediately, based on seeking to transform the mentality of the workers in the development of continuous improvement. The proposal model is based according to the authors Kotter and AIDKAR.

3.2 Implementation of Maintenance Management in the Industry

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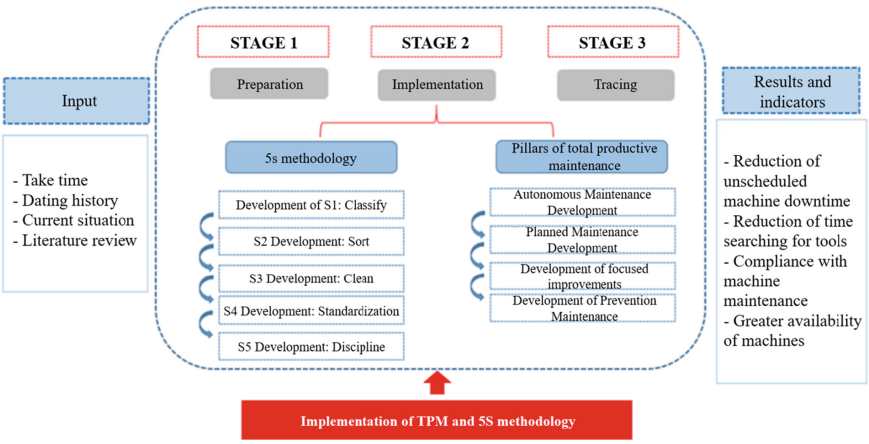


Fig. 1. Proposed model

STAGE 1. In the preparation stage, it aims to sensitize those involved about the problem that the company is afflicting; as well as, it is important to have the support of senior

management during implementation to achieve effective results [5] For this, at this stage it consists of different activities such as: The creation of teams that will be part of the TPM committee, the project's promotional campaign, among others. The activities carried out in the preparation stage are shown below in the figure.

STAGE 2: In the implementation stage, it consists of the development of the 5S methodology as well as the TPM (Total Productive Maintenance). It should be noted that, according to the root causes of the low availability problem, the pillars of autonomous maintenance, planned maintenance and focused improvements will be developed.

In the implementation stage, the 5S methodology will be developed as the basis for the pillars of the TPM. The steps to be carried out in the implementation of the 5s are shown in the figure (Fig. 2).

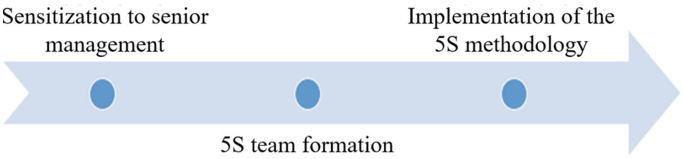


Fig. 2. Implementation of the 5S methodology

In the first step of awareness, it aims to sensitize those involved. Then, the 5S work teams will be formed where each work team has specific functions. Finally, the implementation of the 5S methodology will be developed, the implementation of which will be explained in the figure (Fig. 3).

Fig. 3. Implementation development

For the development of the 5S it consists of the steps of: Classify, order, clean, standardize and discipline.

First, in **CLASSIFY** the necessary elements will be identified by means of a format that will allow them to classify the necessary tools according to their use to place it in a list tools officer. The necessary tools and spare parts are separated according to their need. Finally, there is the process of labeling the items, which will be used by the colored cards.

In **ORDER**, you have the purpose of properly tracking tools and spare parts. For this, a specific place must be established for each element. In this stage, a signaling of tools

that reduce tool search time. As well as, the design of a shelf will be made to separate the necessary elements according to the frequency of use.

In **LIMPIAR**, cleaning schedules are established in the three work shifts, where workers will have the responsibility of keeping their work area orderly and clean. For this, a weekly schedule has been made for each work area.

In **STANDARDIZING**, the purpose is that the first S become habits; For this, it is necessary to create a constant evaluation and training procedure.

Finally, the last step, which is **DISCIPLINE**, will be hanging posters that promote cleanliness and order. As well as, audits will be carried out in order to propose improvement actions, among others.

Likewise, in the implementation stage, the implementation of the TPM methodology will be developed. According to the causes, the autonomous maintenance pillars, planned and focused improvements were implemented.

Autonomous Maintenance. Aims to get operators to commit and take responsibility for their work area through training.

For the development of autonomous maintenance, the following steps have been developed:

- As a first step, it is the training plan for the operators that lasts for one month.
- A cleaning is carried out where it is necessary to record the anomalies presented during the process.
- Then, the key parts of the machines are identified in order to keep them clean.
- Establish a cleaning and lubrication schedule for the machines, where the operators are responsible for cleaning.
- In the general inspection, it is intended that each operator has the ability to detect any anomaly. To do this, he will record it in the monitoring format in order to reduce repair time.
- In the autonomous inspection, the operator supervises the proper functioning of the machines.

Preventive Maintenance. Unscheduled machine shutdowns are caused by lack of planned maintenance in order to reduce operating costs. Currently, the company has a preventive maintenance plan. Planned maintenance in pelletizing machines is important, to avoid constant jams, thus reducing the number of unscheduled machine stops.

Focused Improvement. This pillar is important to solve problems that are not visible in order to make decisions that reduce the number of hours of machine downtime.

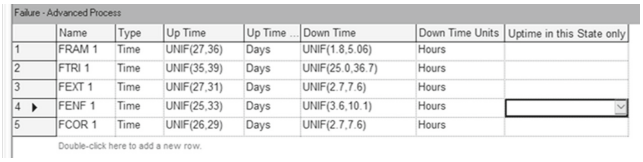
Diagnosis of the problem. To diagnose the problem, the 5 Why? Tool will be used to identify the root cause and be able to solve it.

STAGE 3: Finally, in the follow-up stage, the indicators of the improved production line will be compared.

4 Validation

For the validation of the solution model of the TPM and 5S implementation, a simulation was performed using the Arena Rockwell software. The simulation was carried out with the collection of related data from 4 pelletizing machines. The company under study conforms its production processes as follows. In the first place there is the ramp machine which is in charge of lifting the plastic to the next process, in second place is the shredding machine, which is in charge of transforming the PVC tapes into smaller pieces, in the 3rd place is the extruder already that by means of a screw at high temperatures this melts the material, in fourth place is the cooler which uses the water to solidify the newly melted PVC filaments, Finally there is the cutting machine which is in charge of chopping the solid filaments to transform them into plastic pellets. The simulation was carried out for one year.

To calculate the availability of the machines, a maintenance record has been taken into account, which is related to the MTBF and MTTR (Fig. 4).


Failure - Advanced Process

	Name	Type	Up Time	Up Time ...	Down Time	Down Time Units	Uptime in this State only
1	FRAM 1	Time	UNIF(27,36)	Days	UNIF(1.8,5.06)	Hours	
2	FTRI 1	Time	UNIF(35,39)	Days	UNIF(25.0,36.7)	Hours	
3	FEXT 1	Time	UNIF(27,31)	Days	UNIF(2.7,7.6)	Hours	
4	FENF 1	Time	UNIF(25,33)	Days	UNIF(3.6,10.1)	Hours	
5	FCOR 1	Time	UNIF(26,29)	Days	UNIF(2.7,7.6)	Hours	

Double-click here to add a new row.

Fig. 4. Maintenance record

Likewise, the same procedure was carried out for the different production lines. As a result, we obtained the following table in which we can see the significant improvement in terms of the reduction of hours lost, in the first year a reduction of 39.6% was obtained and for the second year a reduction of 57.4% was obtained % (Table 1).

Table 1. Results

	Line 1	Line 2	Line 3	Line 4	Lost in soles by stops	%Var
Current scenario 1	101	99	123	400	S/. 578,877.17	100.0%
1st year scenario 2	61	63	76	238	S/. 349,508.22	39.6%
2st year scenario 3	38	46	57	168	S/. 246,447.00	57.4%

5 Conclusions

To improve the availability of the machines in the pelletizing area, the implementation of the TPM and 5S should be adopted. When implementing, it was possible to improve the availability of the machines, another parameter that was improved is the performance and the quality rate.

- It can be seen that in 2018 there was an availability of 71% and after implementing the TPM and 5S it increased by 13%.
- It can be seen that the time between failures in 2018 was 28 days and with the implementation an MTBF of 47 days was obtained, which was an increase of 40.43%.
- Another indicator that was improved with the implementation is that of OEE, where it improved by 14.20%.
- With the implementation of the TPM and 5S, the MTTR indicator was improved by 58.51% and the space of the area increased by 176 m.

In conclusion, with this the effectiveness of the TPM can be validated when obtaining the improvement results, the availability of the machine is the most significant.

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