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Application of the FMECA method to define preventive maintenance strategies in a vacuum system of a PET extruder.

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Abstract. This work aims to demonstrate the application of the FMECA method in the identification and characterization of failure modes and their effects in an extruder machine, used in the manufacture of wires. The equipment's vacuum system was evaluated, and different failure modes were characterized in the piping, air pump and valve components. For each failure mode, its priority risk number (NPR) was determined, through the combined analysis of the occurrence, severity and failure detection factors. From the analysis of the NPR, the strategy for maintaining the equipment was developed, in which actions were proposed aimed at increasing the ability to detect failures, reducing the frequency and severity of failures, and consequently reducing the NPR values. From the analysis of the NPR, the strategy for maintaining the equipment was developed, in which actions were proposed aimed at increasing the ability to detect failures, reducing the frequency and severity of failures, and consequently reducing the NPR values.

Key words: Preventive maintenance, FMECA method, Critical failures and effects.

1 Detailing the work development

With the increasingly fierce market competitiveness, the demand for manufacturing quality products has been a fundamental factor for the survival of organizations [1, 3, 4]. Companies continually strive to develop reliable production systems. Establishing an adequate maintenance strategy, aiming to increase the availability of the productive resource through identifying and assertively treating failures in its critical components can be an appealing competitive advantage for the organization [1,3,4,5]. Failure Mode, Effect and Criticality Analysis (FMECA) is a systematic tool used to assess and reduce processes failures, by identifying, defining, prioritizing and reducing the potential of this failures [1, 2,3].

In this work, the objective is to demonstrate the application of FMECA to analyze PET extruder vacuum system, used in the manufacture of wires (Fig. 1). The method allowed to identify failure modes of the components of the vacuum system and, therefore, to determine the priority risk number (PRN), being defined as the product of severity factors, frequency of occurrence and level of failure detection (tab. 1). Then, from the data obtained with the application of FMECA, a proposal for a strategy for maintaining the vacuum system was developed, consisting of actions directed by the PRN values of each failure mode identified. The vacuum system was used as an object of study, as it is a fundamental component of the extruder. The vacuum system removes polymer particles, dirt and moisture from the equipment, favoring the manufacture of wires that respect technical requirements, contributing to the final product meeting the level of quality required by the market, and to the sustainability of the business.

To carry out the work, the vacuum system was divided into three components: pype system, vacuum system and air pump. The survey of component failure modes was carried out with the participation of workers from the company's maintenance and production sectors. Thanks to the ease and simplicity of FMECA, the degree of acceptance of the method was high with those involved. The absence of a control of historical maintenance data showed to be a factor of difficulty in obtaining failure data.

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The results obtained (Tab. 2) shows that three failure modes were identified, one in the pipe system (PRN = 36), one in the air pump (PRN = 36) and one in the vacuum system valve (PRN = 75). The frequency of occurrence of faults (O) in the pipe system and in the air pump proved to be low (O = 3), and moderate (O = 5) for the failure observed in the valve. The severity of the failures (S) is considered low for the pipe system (S = 2) and for the valve (S = 3), and moderate for the air pump (S = 4). The degree of detection (D) presented the index 6 for the failure mode observed in the pipe system, 3 for the air pump and 5 for the valve. From the analysis of this results, improvement actions were developed with focus on the indicators O, S and D, aiming at reducing the PRN of the failure modes analyzed (Table 3).

The FMECA method was found to be adequate as a basis for the development of the maintenance strategy, allowing to characterize the failure mode of the vacuum system components. The analysis of the factors that determined the PRN led to the development of assertive actions, focused on improving the detection capacity and reducing the severity of failures. It is estimated that the proposed actions lead to the reduction of the PRN, doing so at low cost and with easy implementation. Improvement actions are being implemented and monitored. Based on the monitoring, it will be possible to evaluate the effectiveness of the actions.

A) B) C)

Fig. 1: PET extruder vacuum system. a) Air pump, b) Vacuum system, c) Pipe system.

Table 1: Graph of severity, frequency of occurrence and degree of detection of failures.

Severity (S)	Occurrence (O)	Detection (D)	Rating
Hazardous without warning	Very high failure is almost inevitable	Absolute uncertainty	10
Hazardous with warning	Very high failure is almost inevitable	Very remote	9
Very high	High repeated failures	Remote	8
High	High repeated failures	Very low	7
Moderate	Moderate occasional failures	Low	6
Low	Moderate occasional failures	Moderate	5
Very low	Moderate occasional failures	Moderately high	4
Minor	Low relatively few failures	High	3
Very minor	Low relatively few failures	Very high	2
None	Remote failure is unlikely	Almost certain	1

Table 2: Results obtained from the three failure modes identified.

Component	Possible Failures			Current Control	Indexes			PRN
	Mode	Effects	Causes		O	S	D	
Pipe system	No passage of waste through vacuum	Clogging, no removal of waste and moisture	Variation in machine operation and yarn quality	Cleaning once a year	3	2	6	36
Air pump	Pump malfunction or breakage	For heating, unusual noises and worn internal parts	Lack of vacuum in the system, oscillation in the operation of the machine and quality problem in the wire.	Protection relay, water flow regulation register	3	4	3	36
Valve	Prevent water and dirt from passing through the valve	Passage of water into the pump and into the reservoir due to lack of cleaning	Damage to the pump, which may stop its operation, loss of reservoir filter life, loss of vacuum, oscillations in the machine and loss of quality in production	None	5	3	5	75

Table 3: Improvement actions and PRN reduction forecast.

Preventive actions		Improvement projection			PRN
Recommended	Action to be taken	O	S	D	
Follow up to ensure that the time is ideal.	Check every 4 months	2	2	3	12
Verification of vibrations, frequent noise, monitoring on the vacuum meter.	Analysis of periodic vibrations, verification of the functioning of the protection relay and recording of the water flow.	1	2	2	4
Clean the valve.	Clean and monitor periodically to obtain the necessary time for each cleaning	2	2	5	20

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