Application of Risk Analysis Method FMEA to the Phases of Reception, Storage, Pre-cleaning, Preparation of the Seed and Extraction at Iberol

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Abstract

A risk assessment was made at an industrial unit (Iberol SA.) of production of biodiesel using FMEA – Failure Mode and Efects. The analysis addressed the sections of reception, storage of seeds, pre-cleaning, preparation and extraction of the oil.

The parameters severity (referred to the process, environment and workers), occurrence and detection were rated from 1 to 10 and multiplied to get RPN – Risk Priority Number, which prioritizes situations of failure. To minimize the risk, specific actions are recommended in two situations: when RPN is above 125, and when the limits of acceptance of any individual parameter are exceeded.

According to the results of FMEA analysis the main actions proposed replacement of the dryers, regular cleaning of the sieve or installation of a pre-cleaning sieve, and the introduction of pumps in duplicate

Keywords

FMEA, risk assessment, process risk, RPN, risk mitigation

1 Introduction

Iberol. - Iberian Society of Biofuels and Oilseeds, SA, is a company working in the field of biofuel production, and its headquarters and manufacturing facilities are in Alhandra, in the municipality of Vila Franca de Xira, Lisbon district.

Iberol emerged in 1968, from the Portuguese, Spanish and American capitals, and has been dedicated to the agri-food sector with the soybean oil extraction and production of its pulp, with a processing capacity of 100 tons/day seed soybean continuous working 24 hours a day, 7 days a week.

Today, there´s a capability of processing 150 tons of seed per day and producing 450 tons per day of full-fat. The greater restructuring occurred in 2004 when biodiesel production was installed, which is mainly produced from the oil extracted but also from oils bought from outside companies, being the biodiesel incorporated 7% in the diesel sold in the market.

In order to respond to market pressures, Iberol felt the need to draw up a risk analysis at the level of its production process. The company of oilseeds extraction and biodiesel production has recently become majority-owned by a management company of venture capital funds and restructuring, ECS Capital. This fundamental change has led to a change of management policies based on risk analysis structured with a view to continuous improvement of all processes.

In order to perform risk analysis various methodologies are used in the chemical industry as, for example, HAZOP, brain storming, fault tree analysis or FMEA. The latter type was selected for this case study, allowing clear identification of process failures, their consequences, facilitating the prioritization of actions to be taken according to their severity, frequency and existing detection systems.

2 Method and Procedures

2.1 – General Concepts

AMFE methodology was created in 1949 by the US military, gaining particular notoriety in the 60s, when applied to the Apollo 11 mission, when man tread the lunar surface for the first time, successfully. At the end of the 70s, the Ford Motor Company introduced the FMEA for the first time in industry as the main way of risk analysis, and proved that the use of FMEA is extendable and applicable to various areas, due to its versatility in adapting to each individual case. The method has the motto "Do the best you can, with what you have" and can be used at any time but is usually applied in the following situations:

- When new systems, equipment, processes or services are made;
- When new systems, equipment, processes or services are about to change;
- When new applications are found for systems, equipment, processes or services;
- When improvements are considered for systems, equipment, processes or services;

Risk analysis by FMEA essentially has the following objectives:

- Identification and perception of all the potential faults, causes and its effects;
- Risk estimation associated with failures, causes and effects, prioritizing corrective actions;
- Identification and implementation of corrective actions in the most necessary cases, mitigating the risk;

Since it can be applied to basically any field, there are four primary types of FMEA´s applications: i)- to system, ii)- to equipment, iii)- to service and iv)- to process. Type iv) FMEA was implemented in Iberol, in order to assess risk and ensure safety optimizing the effectiveness of the production line, product quality and minimizing waste.

2.2 – Scope and range of the Failure Identification

This risk analysis is ranging from the reception of the seed till the extraction phase. In these sections hazards were identified and targeted for analysis, and the inherent failures and risk identified. Notice that faults consider the control methodologies that are already implemented, being admitted possible sensor failure, but not specific methodologies implemented for solving a given failure. Otherwise, the risk wouldn´t be minimized.
The faults considered are the ones in normal operation conditions, excluding the start and stop times of the process.

2.3 – Severity, Occurrence and Detection

After failure identification, it is necessary its parametrization in terms of severity, occurrence and detection.
Within the risk assessment made at Iberol, the methodology chosen covers several aspects of severity which reflects in the consequences of a given failure.

It is important not to restrict the evaluation just to damages that may occur in the process, but consider the damage to workers and the environment associated with the procedural conduct.
The global value considered in severity results in the higher value considering the three domains of analysis for severity.

Table 1 - Classification table of severity to the process

Severity		
Process	1	No effects
	2	Anomaly with no need of being solved
	3	Local anomaly that can be immediately solved and don´t disturb the following process/continuity of operation
	4	Anomalies in several spots that can be immediately solved and don´t disturb the following process/continuity of operation
	5	Local anomaly that disturbs the following process and/or involves product reprocessing
	6	Anomalies in several spots that disturb the following process and/or involves product reprocessing
	7	Local anomaly that puts in jeopardy the unit´s safety, leading to immediate stop
	8	Anomalies in several spots that put in jeopardy the unit´s safety, leading to immediate stop
	9	Equipments destroyed with process stop
	10	Total process fail/Major unit´s destruction

Table 2 - Classification table of severity to the workers

Severity		
Workers	1	No injuries
	2	Low severity injury (1 person)
	3	Low severity injury (several people)
	4	Medium severity injury (1 person), with time loss between 1 to 3 days
	5	Medium severity injury (several people) with time loss between 1 to 3 days
	6	Medium severity injury (1 person), with time loss between 4 to 30 days
	7	Medium severity injury (several people) with time loss between 4 to 30 days
	8	High severity injury (1 person), with time loss above 30 days
	9	High severity injury (several people), with time loss above 30 days
	10	Death

To clarify the types of injuries, it has been stipulated that low severity injuries are those involving superficial wounds, abrasion, irritation and 1st degree burns; medium severity injuries consist in joint dislocations, sprains, strains, traumatic hematoma, 2nd degree burns and low back pain; finally, high severity injuries are considered amputations, 3rd and 4th degree burns, internal traumatic injury, ingestion or skin contact with toxic substances in harmful quantities.

Table 1 - Classification table of severity to environment

Severity		
Environment	1	No environmental impact
	3	Small impact, confined and easy to solve
	5	Medium impact, confined and difficult to solve
	7	Big impact, reaching the exterior of the unit and with short time resolution
	10	Big impact, reaching the exterior of the unit and with difficult/impossible resolution

The occurrence parameter aims to quantify how often a given failure occurs. It is something relevant for risk analysis because a failure may not even provide significant impacts, but if constantly occurs with high frequency, should be identified and has the proper attention. The data is provided by the maintenance data base – DIMO - and complemented with workers judgments.

Table 4 – Classification table of occurrence

Occurrence	
1	Remote possibility to occur
2	It may occur rarely but there is history of it (>3 years)
3	From 3 to 3 years
4	From 2 to 2 years
5	Annually
6	Several times per year
7	Mensally
8	Weakly
9	Daily
10	New technologies with no data available

Finally, detection parameter corresponds to the capability degree of identification of a potential failure occurrence. Generally it´s related to sensors or procedures attributed to operators that allow detection of specific failures.

Table 5 – Classification table of detection

Detection	
1	Systematic control over a certain failure
3	Very likely to be detected
5	50% chance of being detected
7	Unlikely to be detected
10	Impossible to detect

For each parameter there´s an individual limit that means the risk it´s not acceptable, and above that limit actions need to be taken. For severity and detection, the acceptance limit it´s the value 6, and for occurrence the risk is tolerable until the value 7.

2.4 – RPN

Beyond the individual limits, there is another key factor that determines the acceptability of the risk of a given fault – the RPN – which stands for Risk Priority Number, that results from multiplying the above three parameters. As the name suggests, this value represents the degree of risk associated with a given failure, and, as the FMEA risk analysis is performed based on the same methods and principles for all situations, these values are likely to be ordered. From the RPM, failures can be prioritize, which sets out the actions order to minimize the risk in the process under study. The higher the RPN value, the greater is the need to take action in order to minimize, at least one of three parameters: gravity, occurrence or detection. It may, however, be established, as to the individual limits, a limit of acceptability to RPN, from which the actions are established. The limit should not be too inclusive or exclusive, and must adapt to the reality of existing RPNs in the analysis, therefore is usually established by senior management and conductive parts of the FMEA.

For this particular case, the chosen limit resulted from the product of the three medium values of the parameters (5 x 5 x 5), culminating in a RPN of 125.

3 Recommended Actions

Once the risk assessment is made, there follows the step of establishing measures in order to minimize the risk, in cases where the failure has an RPN that exceeds the value 125, or in cases where failures exceeds one of the three values of individual limit parameters. Recommended actions are displayed in Table 6.

Table 6 – Inacceptable failures and recomended actions

Failure	Values that exceed RPN 125	Exceeds individual parameter	Recommended actions
Dryers metal trays break/loosen up	378	Severity and detection	Dryers replacement
Clogging of sieve screens	175	-	Regular cleaning / Installation of a pre-cleaning sieve
Carriers stop	147	-	Alternative circuits
Inoperational blower	126	Detection	Operator´s verification of outlet pipeline / Pressure sensors in the outlet pipeline
Failure of single pumps (P1, P19, P8 and P60)	126	-	Duplication of pumps in parallel
Sensors/Actuators failure	Various numbers above 125	-	Duplication of sensors
Dusting zone in the discharge	-	Occurrence	Ventilation system / New graintank
Ignition in the carriers	-	Severity	Suppression system / Relocate the carriers and venting panels
Rupture of bag filter screen	-	Detection	Pressure display in the control room /

			Verify the local pressure display
Centrifuges of degumming the oil dirty	-	Occurrence	Oil filtration system at the outlet of the extractor
Interface between water and hexane in the 32A/B | 34 decanter	-	Severity	Repair of the condenser tubes
Failure of 136 compressor	-	Severity	Regular preventive maintenance

4 Conclusions

In the outcome, here are some critical comments on the methodology adopted for the risk analysis and its mode of implementation. Starting by mentioning some of its limitations, the FMEA assumes the independent evaluation of failures, not considering their potential overlap in a given situation or equipment, not covering all real situations that may arise. A fault tree analysis, should be considered. Moreover, the method is suitable for the degree of risk compared in different failure situations through RPN; however, it is not adequate as an absolute classification of risk related to a product/process. Finally, in this present study, the method was primarily applied by an element, accompanied by two experts in Industrial Safety, resulting in a more limited perspective on the risk analysis. On the other hand, the chosen methodology and how has been developed also shows clear advantages and positive aspects. This is a preventive method that allows to foresee failure situations and allow minimization of risk, even if they have never succeeded. Therefore, avoids larger extent of damage and do not always greatest economic expenses are required for the prevention, compared with the remediation of the effects after failures. And being provided recommended actions for the two situations of unacceptability, the risk can be minimized in the best way than if it were only given special importance to RPN more than 125.

In particular way to the FMEA approach in this work, it must be pointed out the transversal character has been achieved in severity, and analyzed in the first instance, gravity related to the production process, but also there is the panorama environmental severity and workers. Although analyzed these two gravities only in the sense of procedural line and activities associated with it, already has an advantage, highlighting potential failure situations affecting these two areas, such as the possible ignition sources in carriers. More specific analysis should be made in terms of workers safety and environment.

The percentage of failure above RPN 125 is roughly 15.5%, which shows that a first risk analysis to the unit and first approach to risk management methodologies, it was not too demanding nor tolerable, being a perfectly reasonable percentage of failures whose risk should be reduced. It´s strongly recommended that that the cases with higher RPN value are met promptly, in order to optimize production and avoid downtime. Essentially it is recommended to replace the dryers, regular cleaning or installation of a pre-cleaning sieve, and introduce pumps in duplicate. Other recommended actions would be to create alternative circuit carriers and duplication of sensors / actuators in the most appropriate locations. Due due to the highest value of gravity, explosion suppression systems should be installed in the carriers, at least in those near to other equipments.

So far, Iberol hasn´t implemented a risk management system, and this FMEA analysis may be a starting point in that way, being recommended the continuity of this evaluation, narrowing gradually the risk acceptance in order to reduce it as much as possible.

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