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Improved maintenance by the FMECA: Case Study

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Abstract: **Nowadays, maintenance has become a strategic function in its own right since it must ensure maximum uptime at lower cost. Thus, and to ensure the availability of equipment, knowledge and rigorous and optimal management of maintenance is needed, and also a continuous improvement of the reliability and maintainability. In this context, our work takes stock of the FMECA study as a tool to improve the maintenance and the availability of equipment. Therefore, it is necessary to know the failure mode to which the system is subjected, and also of their criticality in order to the development of an adequate maintenance schedule while following the specifications of the element, and by securing a security and optimum availability.**

Keywords: Maintenance, FMECA, improvement, maintenance plan

I. Introduction

The maintenance function plays a major role in the current context of organization and business management. Therefore, the maintenance strategy has a direct impact on the operation of equipment. At each moment of the operation of the system, the maintenance manager must make a choice as to possible interventions on the system to determine the action to be implemented. This choice will allow optimization of the exploitation of the system, according to the objectives previously set. However, these so-called objectives may be multiple, such as maximizing the availability and / or security, or to improve the quality of products and services and minimize losses. In addition, economic concerns are certainly one of the major motivations for carrying out of maintenance optimization studies. The objectives related to operations of a system are very varied and may lead to conflicting situations. That is why it is necessary to define maintenance policies and selection criteria that will identify the dates and the type of intervention to be implemented without affecting the production rate.

In this article, and in order to point out the importance of FMECA in improving maintenance, we will develop a maintenance plan of a clarifier with a FMECA study. Indeed, analysis of failure modes and their effects (FMECA) is an inductive and quantitative approach which will help the decision makers of the maintenance department to have a deep knowledge of the workings of the system, its components and its functions while reducing breakdowns and mastering the risks of critical failures.

II. Failure mode, effects and criticality analysis (FMECA)

A. Definitions and typology

Failure mode, effects and criticality analysis (FMECA) is a "technical analysis used by a product design team as a way to identify, define, and eliminate, to wherever possible, failures potential of a system (...) known». [1,2]. It is a well understood method in engineering and it is described by many authors in the literature such as LINDEMANN 2006, OTTO & Wood, 2001, PAHL& BEITZ, 2006, STAMATIS 2003. The possibilities of application of FMECA are many because various systems can be analyzed while taking into account the concepts, designs, processes or services [3,5].

The analysis is a logical result of the action in risk reduction. It is an inductive analysis research of the effects of component failures on the subsystems and the system.

In principle, the criticality or failure occurrence probability is not calculated when the analysis is performed at a functional level.

Initially, failures can be characterized by their component of severity, which called FMEA, Failure mode, effects analysis. A FMECA study further comprises the criticality assessment. There are three types of FMECA [4]:

- FMECA product (finished product, sub-assembly, component), it has the goal of zero defects
- Process FMECA product (production operation) also known as Process FMEA, it has the goal of zero non-conformities
- Average production FMECA (machine), it has the goal of zero failures

B. FMECA methodology

It is practiced like a value analysis, a working group led by a trained animator to the method. The method comprises different steps: [4, 5]

- A detailed review as possible, from the APR, the possibilities of system failures studied for each function of the equipment and its interfaces
- Identification of components or equipment requiring analysis using FMECA
- For each identified failures, determining the causes effects on other subsystems

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- The criticality assessment C = Detectability(or non-detectability) x Severity x Occurrence(frequency) = D x S x O
- Determining fault detection tools
- Proposals for action to remove the failure

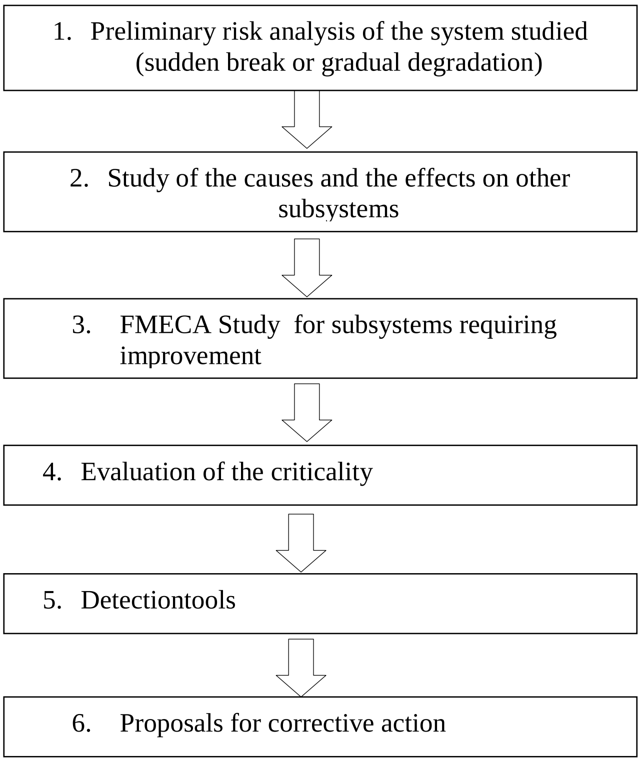


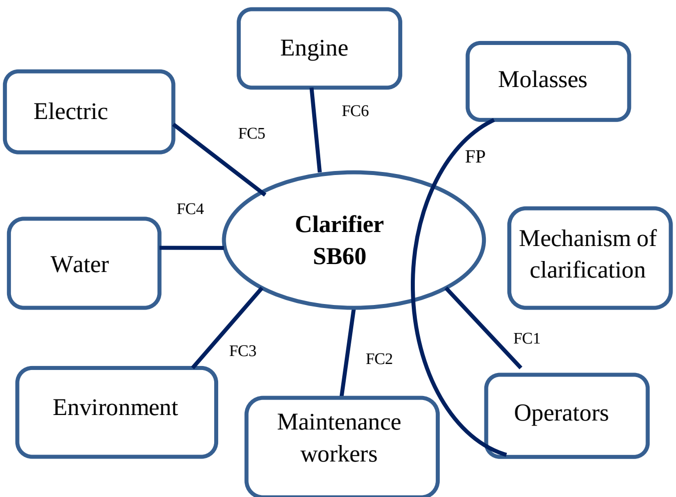
Figure 1: FMECA approach

The FMECA is defined as a systematic method for identifying modes of potential failures. This is to treat failures before they occur, with the intention to eliminate or minimize the associated risks; it is therefore a preventive method.

III. DEVELOPING A MAINTENANCEPLAN FOR THE CLARIFIER WESTFALIA OF TYPE: SB 60-36-177

A. Study context

This work was carried out for the interest of a global player in the domain of yeasts and fermentation in Morocco. The study focuses on the Westfalia clarifier with bowl self-sludge trap and self-thinker system whose type: SB 60-36-177,it is a machine of plates with bowl self-sludge trap used in clarification and to separating solids suspended in a liquid .



Therefore, and in order to anticipate potential failures and optimize maintainability and availability of the system, we have developed a maintenance plan using the FMECA tool.

B. Functional and decomposition analysis

We performed a functional analysis (Fig.2) in order to determine the functions of the system and the detailed functional decomposition (Fig.3).

With:

- FP1: clarifying Molasses's impurities through the clarification process
- FC1: be driven by the operators
- FC2: be accessible by maintenance workers
- FC3: resist aggression from the environment
- FC4: controllable and / or rinsed with water
- FC5: to be supplied with electric power
- FC6: rotating shaft clarifier

Figure 2: Pieuvre diagram of Clarifier SB60

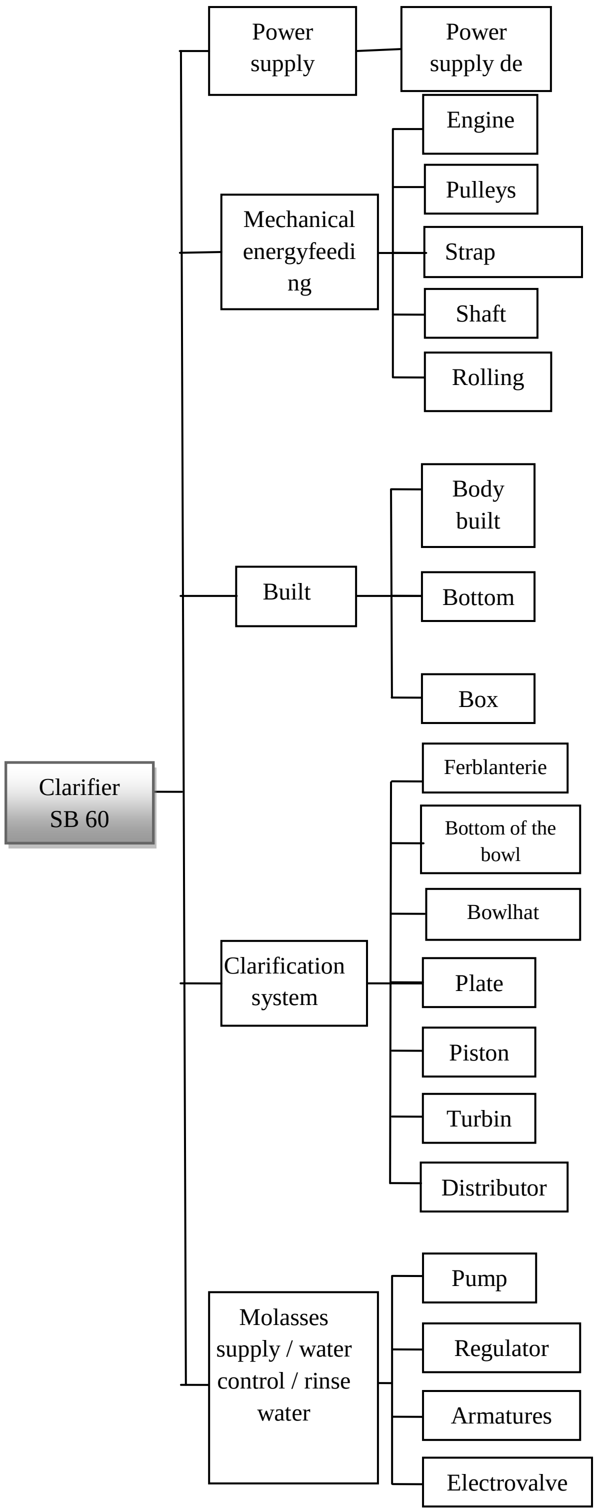


Figure 3: The functionaldecomposition of the clarifier SB60

C. Failure's analysis

From the functional decomposition, the demarche involves researching:

- Failure modes (function loss, degradation of a function …etc.)
- Effects and causes (choice can be guided by the severity of the consequences)
- Criticality. It is a rating and not quantization failures

In order to identify possible causes of failures, we have developed a cause-effect diagram (Ishikawa). The possible causes are classified into 5 categories:

- The raw materials
- Equipment used
- The middle (providing premises for example)
- Methods
- The labor force

D. FMECA study for the clarifier SB60

The criticality assessment for each combination cause and mode and effect, is used by means of the scoring criteria:

- The frequency of occurrence of the failure
- The severity of the failure
- The probability of non-detection of the failure

To perform this evaluation, we used grids (or scale) of quotation most frequently defined according to four levels.

Our choice was based on:

- Knowledge of group members on dysfunctions
- The databases of the reliability and the Returns of experience

We developed the grills of quotations in collaboration with maintenance managers as follows:

Tableau 1: the grille of frequency

Level	Value	Definition
Veryweak	1	Rare failure: <1 time per year
Weak	2	Possible failure : 2 time per year
Medium	3	Occasional failure: 1 time per month
High	4	Frequent failure:> 2 time per month

Tableau 2: The grille of gravity

Level	Value	Definition	
Minor	1	- production shutdown - Little or no spare part needed	<=1h
Medium	2	- Production shutdown - pieces in stock	1<panne<=2h
Most	3	- Production shutdown - Pieces in stock orultra-quick delivery	2<panne<=4
Grave	4	- Production shutdown - Long delivery	>4

Tableau 3: The grille of probability of non-detection

Niveau	Valeur	Définition
Evident	1	- Certain Detection - Alarm (5mm/s) - Automatic way (triggering of the judgment to 7 mm / s) - Apparent signs:leakage of molasses and / or water
Possible	2	- Detectable by the operator, by roads inspections, by vibration
Improbable	3	- Hardly detectable, complex means (dismantling, appliances)
Impossible	4	- Undetectable, no sign

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IV. RESULTS AND DISCUSSION

A. FMECA study for critical components

We conducted a Pareto study to determine the critical elements of the clarifier, the result is as follows:

Tableau 4: Table of Pareto diagram on clarifier components

	S	F	ND	C	RANK	Accrued	%
Completeshaft	4	2	3	24	1	24	15%
Hat	4	2	2	16	2	40	25%
Bottom of the bowl	3	2	2	12	3	52	33%
Plates	3	1	3	9	4	61	39%
Pad	3	1	3	9	5	70	44%
complete piston	3	1	3	9	6	79	50%
distributor	3	1	3	9	7	88	56%
ring	3	1	3	9	8	97	61%
Turbine	3	1	3	9	9	106	67%
Engine	4	1	2	8	10	114	72%
Strap	2	2	2	8	11	122	77%
Oil pan	2	2	2	8	12	130	82%
Armature	1	3	2	6	13	136	86%
Pulleys	2	1	2	4	14	140	89%
Body frame	4	1	1	4	15	144	91%
foot	3	1	1	3	16	147	93%
Ferblanterie	1	2	1	2	17	149	94%
Brake	1	2	1	2	18	151	96%
Electrovalves	1	1	2	2	19	153	97%
Regulator	1	1	2	2	20	155	98%
Pump	1	1	2	2	21	157	99%
Clamping claw	1	1	1	1	22	158	100%

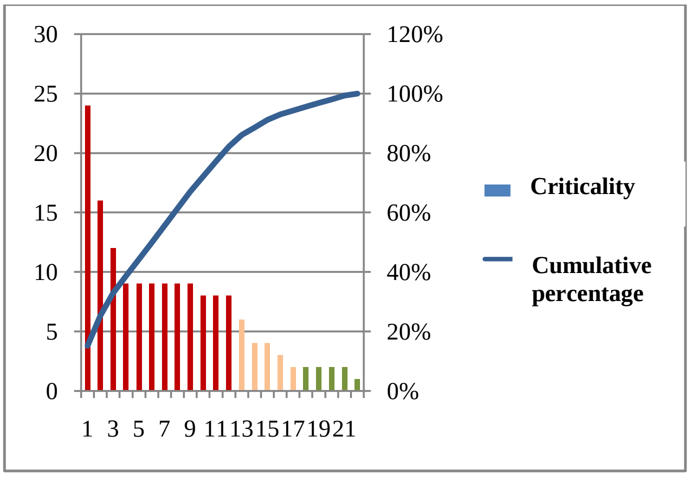

Figure 4: Pareto chart related to the clarifier parts

We observe from the Table 4 and the Figure 4 that the components whosehad the criticality exceeds 9 constitute the Class A of critical elements.

We present below the FMEA table of these critical elements, and then Table 6 represents the maintenance plan for the improvement of critical components

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The company	**FMECA machine**

Tableau 5: Tableau AMDEC pour le clarificateur SB60

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	System : Clarifier with bowl self-sludge trap and self-thinker system ***Type : SB 60-36-177***				***Operating phase***		***Analysis date***				
Equipment	**sub-equipment**	**Function**	**Modes of failures**	**causes**	**Effects**	**Modes of detection**	**T_i(h)**	**Criticality**			
								S	**F**	**ND**	**C**
Engine		Generates the rotation of the shaft	No movement	• electrical failure (overload, short circuit ...) • Deterioration of the Rolling	• The machine does not work • Loss of production	Other	8	4	1	2	**8**
Control system	strap	Transform the rotation-translation movement	Poor transmission of the movement	• Wear • Manufacturingdefect (Dimension) • Matériaux • OilyStrap • Too extensive Strap • Incorrect alignment	• Absence of the shaft movementLoss of performance	Vibration	2	2	2	2	**8**
	Completeshaft	Allowrotationalmovement	Blocking the shaft	• Wear • Lack of lubrication • Rolling wear	• Deterioration of bearings • The bowl does not rotate correctly • Vibration of the separator	Noise	6	4	2	3	**24**
	Pad	Rotating guide	badguiding	• Wear • Lack of lubrification	it cause wear of the shaft	Echauffement	4	3	1	3	**9**
Bowl	Hat	Cover the bottom of bowl	Will not closed	• Worngaskets	• The bowl closes / not opens perfectly • Leaking of fluid	• Noise • Vibration	6	4	2	2	**16**
	Bottom of the bowl	Contains molasses	Malfunction	• Wear of gaskets • Lack of lubrification	• Deterioration of the shaft • Poor clarification	• Noise • Vibration	4	3	2	2	**12**
	plates	Separatingliquid	• poor separation of the liquid • Vibration	Failure to respect mounting	Poor clarification of the liquid	Vibration	4	3	1	3	**9**
	complete piston	• Allows to removesludge • Opening and closing of the bowl	Blocking	• Lack of lubrication • Lack of water's pressure • Damage of the joints • Deposit of dry sludge or	• Débourbage incomplet • Le bol ne se referme /s'ouvre pas parfaitement	Other	4	3	1	3	**9**

				fragments of worn seals							
	Distributor	Distributing the liquid	Blocking	• Lack of lubrification • Deposit of sludge	• Mauvaise distribution du liquide • Le bol ne se referme pas • Débordement du bol	Noise	4	3	1	3	**9**
	Retaining ring	Tighten the bowl	• Break • Not correctlytightened	• Corrosion • Deposit of sludge • vibration	• Fuite du liquide • Détérioration du bol suite du dépôt des boues	Visual	4	3	1	3	**9**
Turbine	Turbine	Discharge the liquid under pressure	Not discharging the liquid	• Exceeding the maximum pressure • LiquidViscosity	Décharge incomplète	Noise	4	3	1	3	**9**
Oil pan		Lubrication	Absence of Lubrication	• lubricantInsufficient • Lubricant has expired • Wearof pipping	• Dysfonctionnement /Blockingof themechanism • Wearof pieces	Visual	2	2	2	2	**8**

B. Maintenance plan for the improvement of components whose failure is critical

Equipment	Failures	Action	Type of maintenance	Fait par qui
Completeshaft	Blocking of the shaft	• Clean the suctionhosessystematically • Change or cleaning in case of breakdown of the hoses • Change the bearings after 5000 hours of operation • SystematicLubrication	• Preventive • Corrective • Preventive • preventive	Technician
Hat	Not closing	• Systematic Change of the joints	• Preventive	Technician
Bottom of the bowl	Malfunction	• Changement systématique de joints • Change of the protective sheet metal in case of wear • Total revision of the bowl after 2500h of Service	• Preventive • Corrective • preventive	• Technician • Maintenance Team
Plates	• Poor separation of the liquid • Vibration	• Control of the number / mounting plate • Systematiccleaning of the plates • Add a reserve plate (if necessary)	• Preventive • Preventive • Corrective	• Technician • Cleaning Team
Pad	Bad guiding	• Control of the spring and buffers after 1500 hours and / or 6 months of service • Replace the spring after 5000 h of service	• Preventive • Preventive	Technician
Complete piston		• State Checking of the joints after 1500 h of service	• Preventive	• Technician

	Blocking	• Systematic Changing the seals / ring after 5000 hours of service • Cleaning the bore • Lubricationeverydisassembly	• Preventive • Corrective • Preventive	• Cleaning Team
Distributor	Blocking	• Systematic Changing the seals • Lubricationgrooveseachdisassembly • Cleaning the machine column for overflow bowl	• Preventive • Preventive • Corrective	• Technician • Cleaning Team
Withheld ring	• Break • Not properlytightened	• Lubricationeverydisassembly • Change of the ring	• Preventive • Corrective	Technician
Turbine	Do not discharge the liquid	• SystematicChanging the seals • Systematic controlof the state of the turbine	• Preventive • Preventive	Technician
Engine	Malfunction / no start	• Checkconnectioneverycommissioning • Greasing the rolling after 1500 hours of service	• Preventive • Preventive	• Operator • Technician
strap	Poor transmission of the movement	• Check the state and the tension of the strap after 1500h of Service • Change strap in case of wear • Tighten the new straps after the first day of service	• Preventive • Corrective • Preventive	• Operator • Technician
oil pan	lack of lubrication	• Verification of Level and circulation of oil every day • Emptying and cleaning the housing after 2500 hours and / or 6 months of service • controller sometimes if the lubricant contains water	• Preventive • Preventive • Preventive	• Operator • Technician

V. Conclusion

The development of a maintenance program is not made overnight. We must put energy and resourcesthere. However, we can save much time and effort if plans and responsibilities are clarified at an early stage.

In terms of system reliability, our work helps to identify the components on which special attention should be paid while also determining the critical failures and the improvements that need to be implemented.

We must note that the FMECA analysis is a logical and structured approach to better control the system studied while identifying the weak links and to know the types of maintenance applied to each subsystem and component. It is a real process of optimizing maintenance costs and ensures maximum availability for production tools.

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