Evaluation of failure probability of a oven by coupling MASD-MOSRA and Bayesian networks

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Abstract

Risk analysis of an industrial plant is a complex process because it is itself a complex structure consisting of machinery, storage, interacting between them, the operators and with the environment.
To give the maximum opportunity to demonstrate most of the risks of an installation, two methods are presented: Method of Analysis of Systems Dysfunctions MASD and Method Organized Systemic of Risk Analysis or MOSRA.
The causal relationships between different event types (cause and effect) that can put the malfunctioning oven are taken into account, while incorporating the conditional probabilities, relying on experts in the field and return experience.

Keywords
Risk Assessment, Bayesian networks, danger, oven, MASD-MOSRA

1. Introduction

The complexity increasingly growing industrial systems, coupled with the constraints of competitiveness and existing legislation in terms of compliance with environmental regulations for security and sustainable development, have pushed industrial and scientific researchers to look for new solutions that can make them more efficient and more secure systems.
An important part of this upgrade involves improving the RAMS (Reliability, Maintainability, Availability and Security).
We first interested in the risk analysis of the studied system and the evaluation of the probability of default in based on the feedback, and a method of decision support.
Among the methods of using the existing decision, our choice fell on a graphic probabilistic method: Bayesian networks. Indeed, in the case of complex mechanical systems where expert knowledge is available, it can use a graphical tool well suited: Bayesian networks.
This method allows to assess the likelihood of system failure, but it allows especially ask dreaded scenarios, making analysis and diagnostics.

2. Description of the installation

The furnace is used to heat the slabs for the production of sheets up to a temperature of 1500 ° C, said rolling. To avoid thermal shock, reheating is gradual. For this, there are two zones:
- The preheating zone for the gradual adaptation of the slabs, high temperature in this zone, the temperature may reach up to 1100C °.
- The soaking zone for the homogenization of slabs at a temperature of 1250C °.

The slabs are pressed into the furnace by means of pusher and slide on skis (runners) cooled water to the coke pushing area.

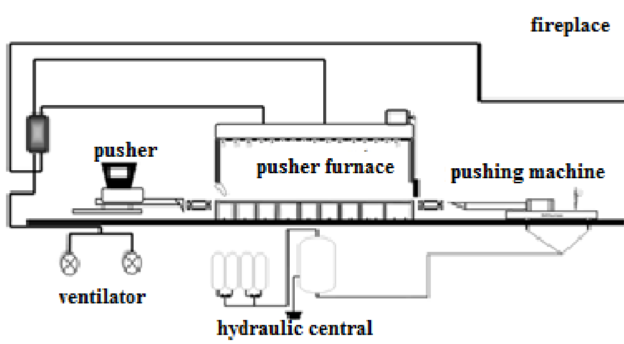

Figure 1.Synoptic installation

3. Application of the MASD-MOSRA method : Approach macroscopic

The MASD model (Figure 2), introduces the concepts of systemic and defines the overall model of the danger process while MOSAR method is a generic approach for analyzing the risks of installation and identify the means of prevention, protection and mitigation necessary to neutralize them.[1]
This method allows us to identify sources of danger to discern unwanted scenarios events then prioritize and propose safety barriers.
Unwanted events (UE) are malfunctioning likely to cause undesirable effects on the individual, population, ecosystem and installation. Unwanted events can be of two kinds: they may come from the source system and also act on the target system. [2]
One cans this represent a reference model danger process :

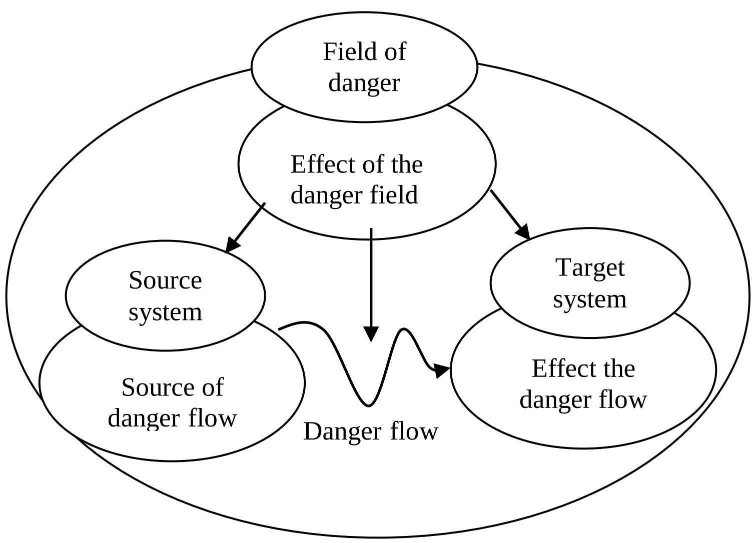

Figure 2. Model of the danger process [1]

4. Approach of method MOSRA

This method comprises two main modules (A and B), the first being a macroscopic analysis of the system, the second being a microscopic analysis. This is to realize the module A in MOSRA approach to the furnace area.

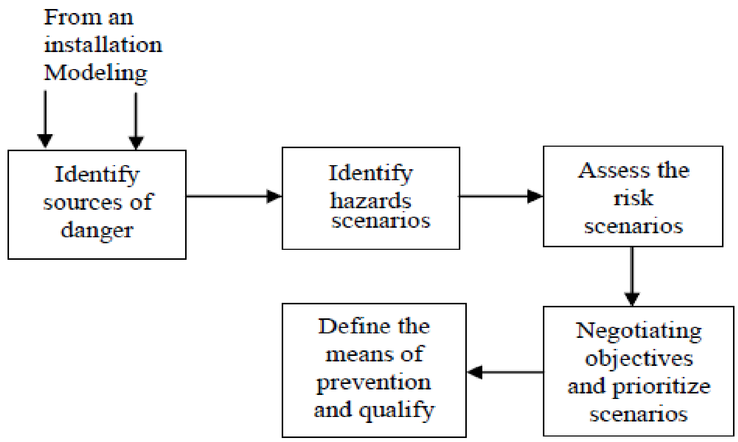

Figure 3. Macroscopic view of the installation, described by module A. [1]

4.1. System decomposition for each subsystem

The first step of the MASD-MOSRA method is to model the system by functional decomposition into subsystems of the furnace zone to identify for each subsystem (Ssi), the type of source of danger and establish safe process (long and short scenarios).

Our decomposition led us to discern six following subsystems:

Ss_1 : Pusher : It is a system that pushes the slabs in the oven.
Ss_2 : Ventilator: its role is the provision of furnace combustion air.
Ss_3 : Pusher furnace : The pusher furnace used to heat the slabs.
Ss_4 : hydraulic Central : Its role is to raise the pushing machine.
Ss_5 : Pushing machine: the role of pushing machine is to remove the slabs.
Ss_6 : operator.

4.2. Identification of sources of danger

This is to identify how each subsystem can be dangerous.

Table 1. Process of establishment of danger of subsystem pusher

Types de système **« pusher":** Application Grid	**Initiating events**		**initial events**		**Principal events**
	External (active environment)	***Internal***	***Related to the contai-ner***	***Related content***	
electric motor (C1)	Overload Overvoltage	short-circuit	Blocage		stopping the pusher
Transmission system coupling (A3)	Clumsiness Lack of lubrication	fissuring	Breaking	Crushing pinion	Blocking system Breaking teeth
Traction system rack and pinion (A3)	Overvoltage ill lubrication	fissuring	Fissuring	Deformation rupture the pinions	Deviation

Table 2. Process of establishment of danger of subsystem ventilator

Types of system « ventilator »	**Initiating events**		**initial events**		**Principal events**
	External (active environment)	***Internal***	***Related to the containner***	***Related content***	
control rod (flowrate) (A3)	ill lubrication Clumsiness Lack of maintenance	fissuring		Blocking the rod Deformation	no command
Lobe clapette (A1)	bad command Lack of maintenance	fissuring	Deformation		no command
Bolt fixing (A3)	vibration shock	corrosion fissuring	fissuring deformation		Ventilator bursting
Recuperator (A7)	thermal flux Lack of maintenance		Burns carbon tube		ill warming up
Compressor (A9)	vibration			dolt	Misalignent
electric motor (C1)	vibration overvoltage	Lack of lubrication			Dysfunction

Table 3. Process of establishment of danger of subsystem pusher furnace

Types de système « Pusher furnace»	**Initiating events**		**initial events**		**Principal events**
	External (active environ-ment)	***Internal***	***Related to the containner***	***Related content***	
Chain de la porte (A3)	corrosion thermal flux	shear counterwei-ght	Fissure Rupture	Deformation	Blocking the door
Skid (A1)	Shock overvolt-age	erosion		water leak	oven collapse

square Fer (A2)	Shock vibration thermal flux	lack penetration of weld	rubbing		Blocking slabs
Cooling system (A5)		obstruction corrosion		leak	Poor cooling
Burner (D5)	Clumsin-ess lack of combust-ion air overpre-ssure	deformation fissure	Fissure	poor burni-ng	Backfire bursting
refractor (B1)	Shock vibration overvolt-age	poor preparation	Fissure		erosion of skid

Table 4. Process of establishment of danger of subsystem hydraulic central

Types de système « hydraulic central »	**Initiating events**		**initial events**		**Principal events**
	External (active environ-ment)	***Internal***	***Related to the contai--ner***	***Related content***	
Oil Heating Resistance (C1)	overvoltage			poor warming up	Dysfunction of the central
Motor of pump (C1)	overvoltage vibration	short-circuit			The pumping stop
Pump (A1)		depression			Cavitation
Flexible (A1)	Calamine wrong position thermal flux		Rupture	Fissure	the cylinder stop

Gasket (A1)	thermal flux misplacing	usury	Hole	Deformation	Oil leak
Conduits (A2)	overpre- ssure thermal flux vibration	Corrosion fissure		Oil leak	Desynchronizing cylinders

Table 5. Process of establishment of danger of subsystem pushing machine

Types de système **« Pushing machine»**	**Initiating events**		**initial events**		**Principal events**
	External (active environment)	***Internal***	***Related to the container***	***Related content***	
the fingers (A3)	Shock rubbing thermal flux	Corrosion fissuring		Defor- mation	breakage of the fingers
electric motor (C1)	overvoltage overload		blocking		stop strain of pushing machine
Transmissio n system (A3)	thermal flux vibration	lack of lubrication		Rupture	Blocking System
Hydraulic cylinder (A1)	overload	quality oil High pressure	Deformation blocking	leak	Desynchronizing Oil leak

4.3. Identification of danger scenarios

By taking each subsystem in the preceding tables, it is the form of black boxes with inputs initiating events internally or externally and outputs are the main events.

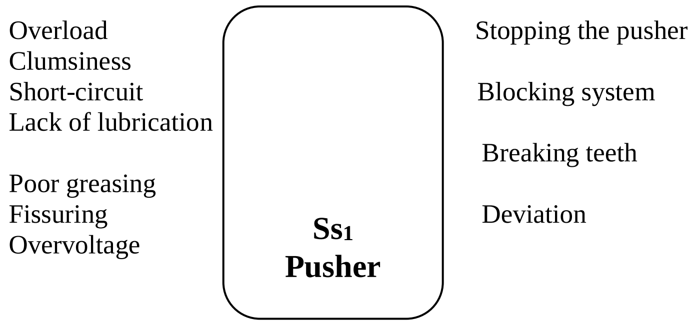

Figure 4. pusher black box.

4.4. Generation of short scenarios

The challenge now is to look after the generation of short scenarios. Indeed, we have in generating the previous tables process that brings up direct connections between the input and output events of the black boxes. We must now combine these events, output events between them and identify loop back and output events and input events.

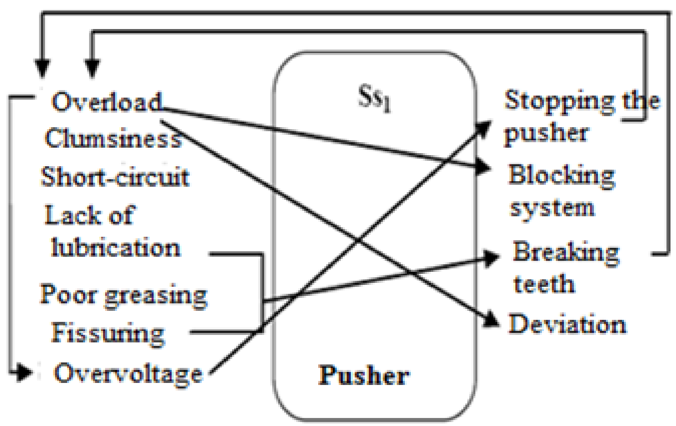

Figure. 5. Short scenarios of pusher.

4.5. Assessment the risk scenarios

This step helps to assess risk quantitatively by the use of software in particular, using the ELVIRA software to determine the probability of apparition of the feared event or adverse event.
For the construction of the fault tree, we have considered the scenario leading to an oven collapse.
Each elementary event was assigned a probability of occurrence that seemed to correspond better to reality.

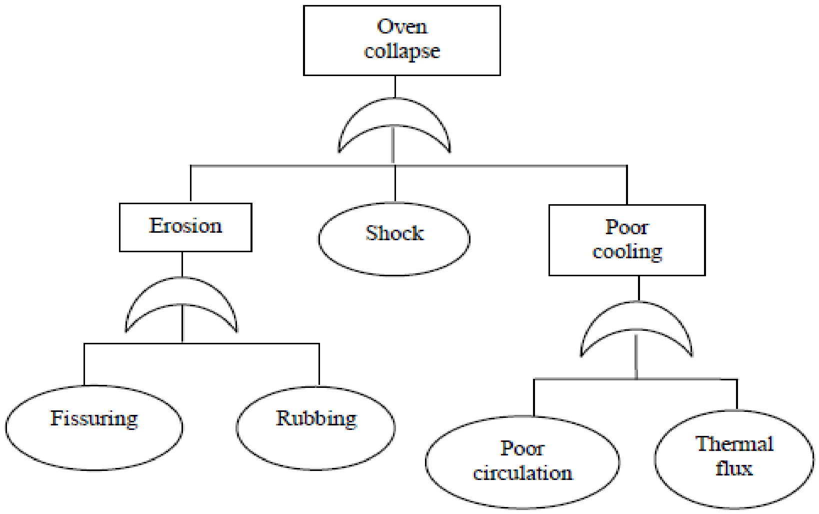

Figure.6 logic tree Collapse of oven.

Knowing the probabilities of occurrence of each intermediate event we can determine the probability of occurrence of the adverse event.

TABLE 6. Data of feedback

Cause	**Effect**	**frequency of appearance (year) (239 days)**	**Probability of failure**
Fissuring	Erosion	30 times	0.125
Rubbing	Erosion	22 times	0.092
Poor circulation	poor cooling	25 times	0.104
Thermal flux	poor cooling	33 times	0.138
Erosion	Oven collapse	16 times	0.066
Shock	Oven collapse	71 times	0.297
Poor cooling	Oven collapse	18 times	0.075

5. Overview of Bayesian networks

A Bayesian network is a directed acyclic graph (DAG) in which the nodes represent the system variables and the arcs symbolize the dependencies or the cause effect relationships among the variables. The DAG represents the structure of causal dependence between nodes and gives the qualitative part of causal reasoning.

thus the relations between variables and the corresponding states give the quantitative part, consisting of a Conditional Probabilistic Table (CPT) attached to each node with parents [3].
From the fault tree, it then builds the corresponding Bayesian network :

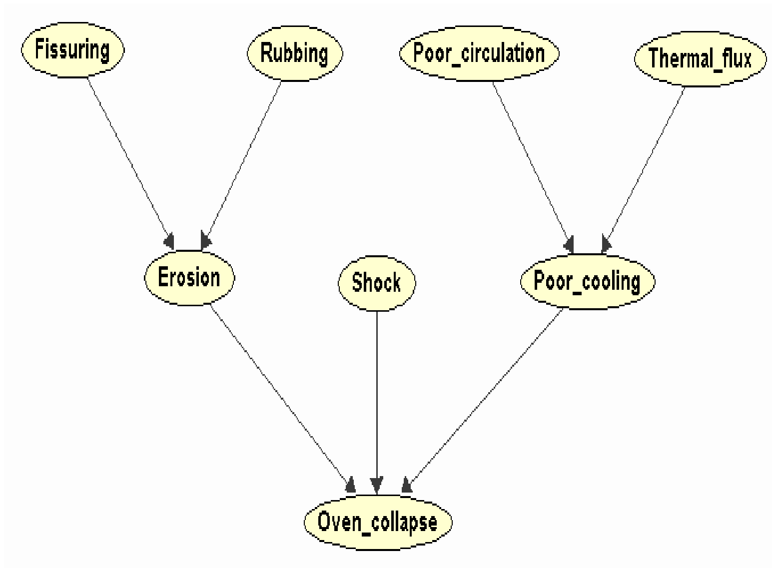

Figure 7. Bayesian network with Elvira.

6. Bayesian inference

Inference with Elvira allows propagation any a priori probability on the belief of the other nodes, a new table of probabilities is obtained on each node. So we just completed a probabilistic model of behavior by Bayesian networks the oven collapse. [4]

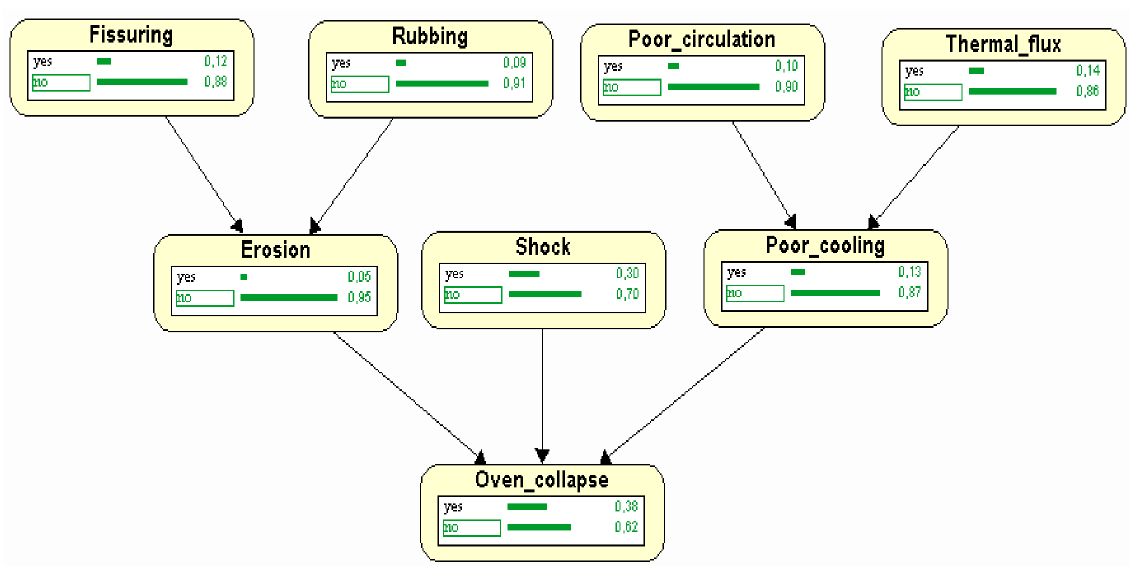

Figure 8. Inference with Elvira, for oven collapse

6.1. Discussions

The failure probability in the probability of occurrence of the adverse event (oven collapse) is average of around 38%, so can be seen on the inference that most affect this state event shock skid (fault 30%).
So one can use the model to diagnose the system failure.

6.2. Inference after improvement

According to the previous inference notice the shock skid is the most important event, it then puts the probability of shock failure to 5%, and by inference see how spreads this data on the system.

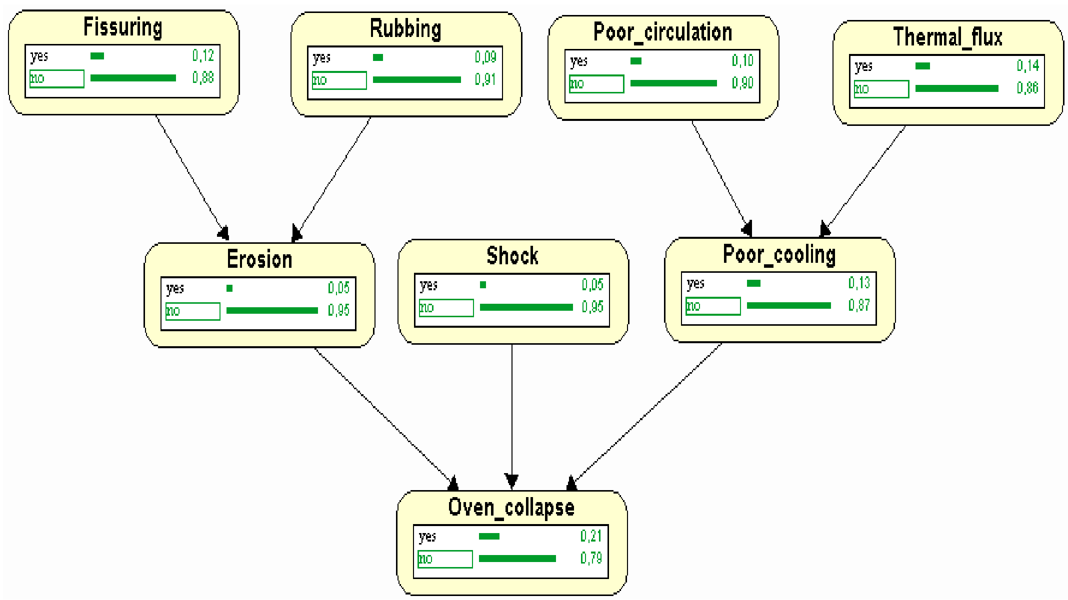

Figure 9. Inference with P (shock = 5%)

Analysis

With an failure probability for shock is 5%, the probability of collapse of the oven decreased to 21%.

Conclusion

Bayesian networks that draw their graph theory's profile, and in particular the integration of probabilities Bayes formula have the ability to update data by combining observation and feedback.
The major advantage of Bayesian networks is the a posteriori probability calculation variables, being based on expert knowledge and observation (the obvious) and the feedback.

In fact This allows for capitalize knowledge and enrich the database that will be used later as a priori data for the system.
Thus, As we receive the system status information, we will have the ability to update the probabilities of the target variables.
Also we can predict the probability of parents giving variables assumptions on the state of the descending variables.

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