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Statistical / Dynamic approach to assess the effects of industrial fire

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Abstract—In this paper, we will combine a statistical analysis of accident cases concerning the Algerian Oil and Gas Industry occurred during the period of 2003 to 2013 to a dynamic analysis based on the use of a numerical dispersion model. This combination lies in the use of the information obtained from the statistical analysis as input data in the Numerical Dispersion Model (NDM). This study may be useful to illustrate what the industry should learn from these accidents and in such a way be more alert to prevent future major accidents

Index Terms— Statistics, accidents, fire, Numerical Dispersion Model, combined statistical/dynamic approach.

I. INTRODUCTION

Fires are a detriment factor in many type of industries and constitutes a potential source of human loss, equipment damage and environmental impact and as the oil refining industry is by its nature subject to the most hazardous industrial conditions, it is important to take into consideration that in a number of cases, the resulting fatalities and serious injuries cost millions of dollars. The risk of those accidents is associated with the presence of dangerous substances at large quantities and under such conditions that an uncontrolled accident [1]. The consequences of these latter are at various levels and may affect not only the industrial sites, but also people, environment and economy [2].

Every year, industrial accident causes a number of deaths, injuries and property losses due to petroleum refining operations. Industrial accident has become a threat to human safety such as the accidents of Skikda refinery in January 2004 and October 2005 and the accident of the Arzew refinery 2007. Besides that, Oil pollution accidents are nowadays become a common phenomenon and have caused ecological and social catastrophes. Petroleum refining unavoidably generates considerable volumes of oily sludge during oil of production and processing activities [3].

Thus, accident statistics are important measures for the success of safety programs and determining if the impacts of those accidents are primarily perceived as a major environmental problem [4], but associated socio-economic effects also play an important role [5]. In order to assess how life safety is being affected year after year, this paper presents an overview of 11 years of accidents related to petroleum refining in Algeria during the period 2003-2013. To complete

this study, it was considered appropriate to model fire in order to understand more clearly the fire effects and the steps that can be taken to avoid them [6].

In this paper, we will use numerical dispersion model (NDM), the input data of this NDM are retired from the statistical analysis (e.g. substance involved and generated by the accident, weather conditions, etc.), the obtained results can be used to investigate the fire plume evolution and the smoke impacts (e.g. concentration, temperature) [7]. In this study, we are interested in a tank fire that took place in the refinery of Skikda (Algeria), October 5, 2005.

The principal objective of the present work is the combined statistical / dynamic approach; a proposed approach that combines two tools: statistical analysis of industrial accidents and Numerical Dispersion Model (NDM). One important purpose of such tools is to provide relevant and structured information in decision-making processes.

II. COMBINED STATISTICAL / DYNAMIC APPROACH

This paper proposes a framework of the coupled statistical and numerical analysis, shown in Fig. 1. Complete overview of the accident starting with the date and place of occurrence, its immediate causes, the substances involved and the effects that this accident had generated.

Thereafter, one part of this data such as the nature of substances involved and generated by accidents, weather conditions and the accident location will be injected in the numerical analysis as input data for the Numerical Dispersion Model, to provide information on the concentration of pollutants generated by the accident, and the propagation velocity of the thermal effect of the pollutant plume.

The other part such as the accidents causes, consequences, and human behavior will be used directly in the combined statistical/dynamic approach for proposing solutions.

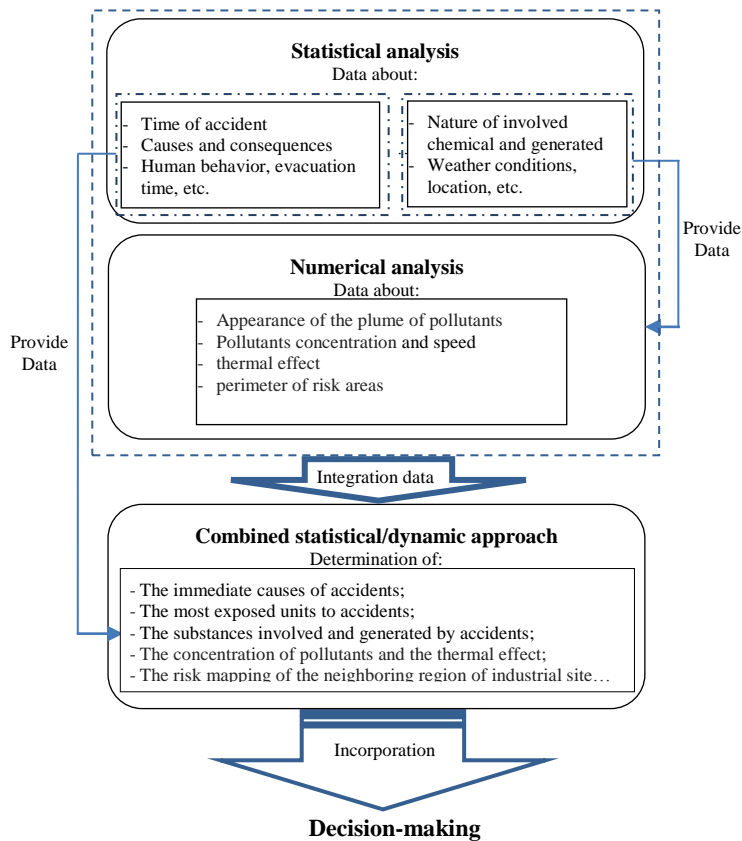


Fig.1 Combined statistical/dynamic approach framework

A. Statistical analysis of past accidents

A series of major accidents on refinery sites across Algeria in the late 2000s and early 2010s led to growing concern over the safe operation of industrial sites, particularly those which could present major hazard effects to local populations. Considering the economic importance of the Skikda and Arzew refineries and the absence of data on accidents in refineries of Algiers and Hassi Messaoud, our study will focus on statistical analysis of accidents related to Skikda and Arzew refineries.

The information collected about each accident has been summarized in the table 1, who presents data on accidents in the oil refining industry during 2003 to 2013.

In Table 1, an overview is provided of a numbers of 53 accident / incident that have occurred over the last 11 years. For each accident, the year of occurrence, Ignition source, the number of fatalities and injuries is provided as indication of the severity.

1) Refining accidents frequency

The distribution of accidents in the refining sector per year in the period of 2003-2013 is presented in figure 2.

This section recapitulates the statistics of oil refining accidents in Algeria. Refining accidents are considered to be high in Algeria; the overall number of accidents is 53 declared accidents/incidents over the period 2003–2013. The annual average of accidents which occurred between 2003-2008s1 and 2008s2–2013 were 24 and 29, respectively.

This demonstrates that the accident frequency is increasing over the period 2008s2–2013, noticing that in 2009, the frequency increases 3times more than the previous year's figure, and the largest number of accidents was recorded in 2013.

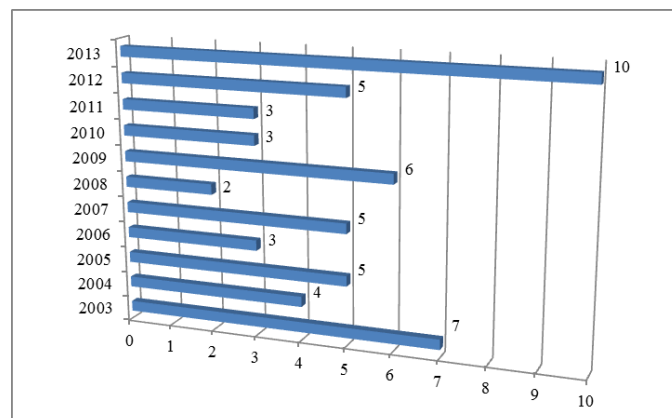


Fig. 2. Number of oil refining accident in Skikda and Arzew, per year of occurrence (2003-2013).

2) Causes of accidents

The identification of the accident initiators is obviously a key aspect of the overall risk assessment and great care must be put into its completeness since those accident events not included at this stage are very unlikely to enter in the analysis at a later stage [8].

Fig.3 presents the causes oil refining accident in Skikda and Arzew (2003-2013). It shows that the material failure was the most frequent cause of accident with 33% and the leak or product release was the second most frequent cause with 21%.

The rest were spark with 13%, open flame for 10%, environmental causes like floods or thunderstorms and environmental conditions like hot temperature present 4%. While the human error, played a minor role 2%. Accidents for which the relevant information was not available or where the cause was not one of those given are listed under "Unknown" and present 17%.

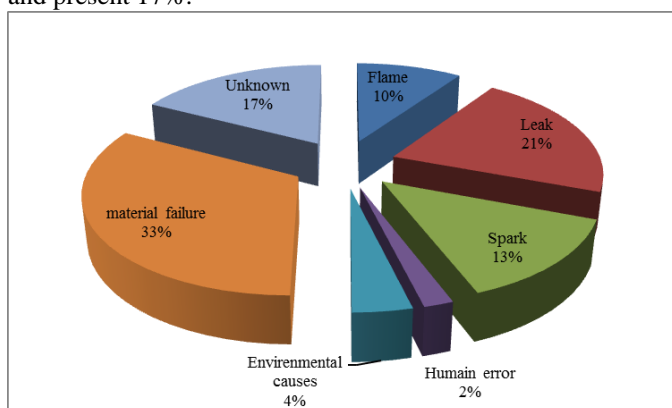


Fig. 3. Causes of accidents oil refining accident in Skikda and Arzew (2003-2013).

TABLE I. THE HISTORY OF REFINING ACCIDENTS IN THE PERIOD OF 2003-2013

| Date and site | Unit type | Equipment | Substance | Ignition source | Primary accident | Damage |
|---------------------|--------------------------|-----------------------|---------------------|--------------------------------------|--------------------------|--|
| 10/06/03 Skikda | Unit 100 | Heater | Gas | Flame | Fire | 3 injuries |
| ---/06/03 Arzew | Ammoniac Unit 2 | | Gasoil | Bursting of a beam of heating diesel | Explosion | 2 fatalities + material damage |
| ---/06/03 Arzew | Ammoniac Unit 2 | Storage tank | | Gas release | Asphyxia | 1 fatality |
| 16/07/03 Arzew | Unit 22 | Turbo-compressor | GPL | Propane release | Fire | No injuries or damage |
| ---/10/03 Arzew | Ammoniac unit | | Gasoil | Bursting of a beam of heating diesel | Explosion | 1 fatality + material damage |
| 19/10/03 Arzew | Train 300 | | | Gas release | Fire | No injuries or damage |
| 15/11/03 Arzew | | Oven | Gasoil | | Fire | 5 injuries + material damage |
| 19/01/04 Skikda | Unit 40 | | LNG | Gas leak | Explosion | 27 fatalities +74 injuries + 3 units are destroyed + 800 million of damage |
| 21/04/04 Skikda | CTE | Basin 1-cell A | Gas | Spark | Fire | No injuries or damage |
| 03/10/04 Skikda | Unit 100 | Top reactor 100-R3 | H ₂ | Auto inflammation of H ₂ | Fire | No injuries or damage |
| 20/11/04 Skikda | Central laboratory | Room Bitumen | Bitumen | Flame | Fire | Destruction of the conduct of gases and extractor |
| 08/01/05 Arzew | Ammoniac unit | Oil tank | | | Explosion | Material damage |
| 17/03/05 Skikda | Unit 1020, section A | First cell cool tower | Hydrocarbon and gas | Spark | Fire | Destruction of engine, chimneys and wiring. |
| 15/08/05 Arzew | | Pipeline 30 | Condensate | Condensate leak | Fire | No injuries or damage |
| 24/09/05 Skikda | Natural area | Pipe 22 inches | Crude reduced | Gas leak | Product release | Soil contamination + Cracking of pipe section +Pollution. |
| 05/10/05 Skikda | tanks 105, 106 | | | Accumulation of gas | Explosion | 2 fatalities + 7 injuries + 6 million \$ of damage |
| 21/01/06 Skikda | At weight scales passage | Brak of tank of truck | Bitumen | Gas leak | Product release | Soil contamination. |
| 06/06/06 Skikda | Industrial area | Pipe | Crude reduced | Flame | Fire | Calcination of pipe |
| 09/08/06 Skikda | Plat form SH/ENG | | Brushwood | Spark | Fire | An area de100 m ² brush is burn |
| 25/02/07 Skikda | | Truck | | | Falling | 1 fatality |
| 13/06/07 Skikda | | Recovery tank | | Driver inattention | Skidding of vehicle tank | Failure of line of fire network system |
| 16/07/07 Arzew | | Pipe | Condensate | Leak | Fire | Material damage |
| 24/10/07 Skikda | Unit 100 | Pneumatic transmitter | Naphta B | Spark | Fire | 1 fatality + Damage of: electrical and instrument cables |
| 09/11/07 Arzew | | Methanol enip | Methanol | defecting of a gas mixer | Explosion | 7 injuries + material damage |
| 11/06/08 Skikda | Naturel area | Sludge pit | Hydrocarbon waste | Hot point (fiery debris) | Fire | Shutdown of process pumps, coolers, pollution |
| 07/07/08 Skikda | Unit 62 | Vessel | HCl | | Explosion | Distraction of vessel, automatic valves, remote control and loss of HCl |
| -- /02/09 Skikda | Air conditioning | | | Short-circuit caused by flooding | Fire | No injuries or damage to materials |
| 03/04/09 Skikda | Topping 10 | Valve flange | Gas-oil | Braking of flange, fuel release | Fire | 3 Injuries +damage of : pipe, instrument cables |
| 30/07/09 Arzew | Training center | | | | Fire | 3 fatalities |
| 13/09/09 Skikda | Topping 10 | | Condensate | Spark | Fire | No injuries or damage |
| 24/09/09 Skikda | Air conditioning | | Hydrocarbon and gas | Hot point | Fire | Distraction of electrical equipment |
| 10/11/09 Skikda | Unit 10 | Transformer | | Infiltration of rain water | Explosion | Shearing of the terminal box of the transformer |
| ---/02/10 Skikda | Reforming unit | | petrol | Hydrogen release | Fire | No injuries or damage |

| | | | | | | |
|--------------------|------------------|------------------------|-----------------------------|-----------------------------------|--------------------|--|
| 12/03/10 Skikda | Storage area | water output of tanks | Gas-oil | Contact of the steam pipe MS | Auto inflammation | Contamination water and soil |
| 19/12/10 Arzew | | Control valve | | hydrocarbon Leak | Explosion | 1 fatality + 7 injurie + Material damage |
| 05/02/11 Skikda | Reforming Unit | electric transformer | electric current | Increase of the current intensity | Electrical failure | Destruction of electrical cables and transformers |
| 06/02/11 Skikda | Unit 100 | Exchanger E1 | | Compressor voltage down | Hydrogen leak | Destruction of: exchanger, compressor |
| 11/03/11 Skikda | Unité 100 | Pipe | Naphtha | Leak in the pipe | Leak | Deterioration of the pipe line Pip way |
| 05/03/12 Skikda | Reforming unit | Charge pump | Essence | | Explosion | Material damage |
| 21/06/12 Skikda | All site | | | | Electrical failure | No injuries or damage |
| 22/11/12 Skikda | Unit 200 | Pipe | Gas | Pipe burst | Leak | Temporary shutdown of the unit |
| 17/12/12 Skikda | Unit 11 | | | Gas release | Explosion | 6 Injuries + material damage |
| 23/12/12 Skikda | Unit 200 | | | | Gas release | No injuries or damage |
| 03/01/13 Skikda | Unit 100 | Heater 100-F-1 | Naphta B and H ₂ | Burner flames | Explosion | 2 Injuries + Deterioration of heater and electrical cables |
| 03/02/13 Skikda | | Pipe | fuel | Leak | oil spill | Pollution |
| 13/02/13 Skikda | Unit 11 | Electrical substation. | | Short-circuit | Fire | No injuries or damage |
| 26/02/13 Skikda | | | Condensate | Spark | Leak | Material damage |
| 06/03/13 Skikda | Deposits | | | Spark | Fire | Material damage |
| 09/07/13 Skikda | | | | Landslide | landslide | 1 fatality + 1 injury |
| 06/08/13 Skikda | Unit 100 | | | Pump failure | Fire | No injuries or damage |
| 10/08/13 Skikda | Unit 100 | | | flame rejected by the torch | Fire | No injuries or damage |
| 17/12/13 Skikda | Electric central | | | | Fire | No injuries or damage |
| 20/12/13 Skikda | | | | | Explosion | Material damage |

3) Types of primary accidents

In Fig. 4, the distribution of notified accidents per type of accidents is showed.

The events recorded in this study indicate that the fire is the most frequent in the total number of occurrence with 25 accidents from total of 53, followed by the explosion by 13 accidents.

With 53 cases as indicated in Table 1. Fire and explosion together accounted for 76% of total cases. Toxic gas release and electric failure were the third and the fourth most frequent, respectively.

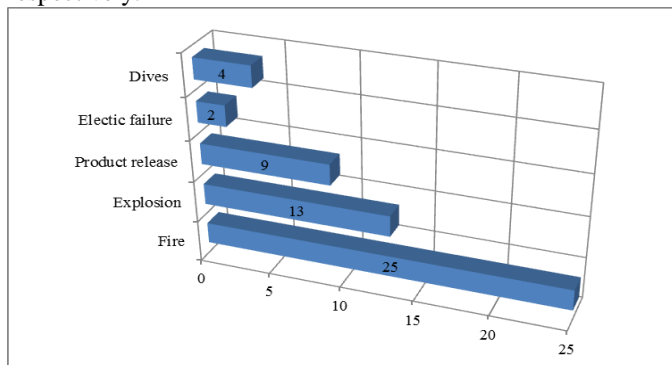


Fig. 4. Types of primary accidents of oil refining Skikda and Arzew (2003-2013)

The following figure (Fig.5) shows the number of accidents by the type of primary accident.

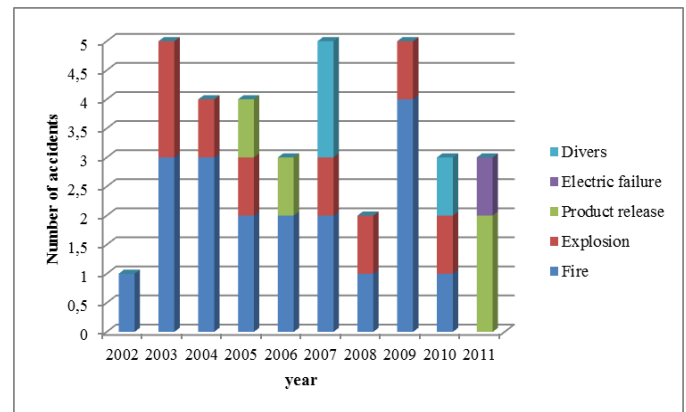


Fig. 5. Types of primary accidents of oil refining Skikda and Arzew per year (2003-2013).

Incidents involving explosion, product release and electric failure have been much more prevalent in refining operations. For incidents involving fire, overall numbers have trended downward since the early-mid 2008s. There are two major causes of refining fires, the first one is the spark and the second is the flame, the third is the secondary effects such as short-circuit or equipment failure, etc.

4) *Substances involving in accidents of Algerian oil refining industry*

Fig.6 shows the substances that were more involved in reported accidents of the Algerian Oil Refining Industry for the period 2003-2013, field directly or indirectly.

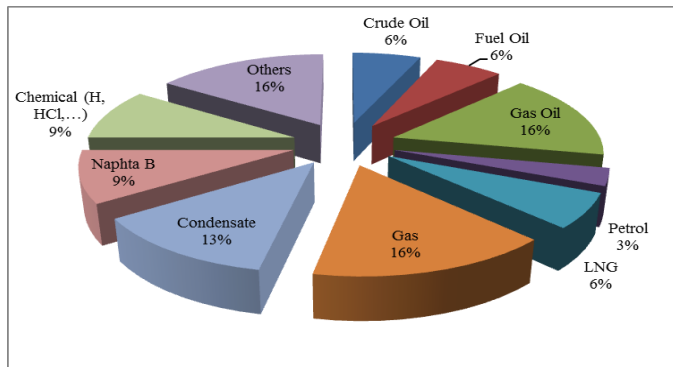


Fig.6. Percentage of substances involved in oil refining Skikda and Arzew (2003-2013)

In most cases, Gas and Gas oil are the most usual substances involved in accidents by 16% for each. While, Condensate was reported in 13% of reported accidents. Chemical and Naphtha B present 9% for each, Other substances or products like Hydrocarbon waste, Brushwood were involved in 16% of the accidents. While, Natural gas (LNG, Methane, ethane), Fuel oil and Crude Oil was notified in 6% of cases for each and finely, Petrol presents only 3% of accidents cases.

5) *Refining accidents and the related consequences*

Fig.7 presents the consequences of the accidents notified in the Algerian Oil Refining Industry. As for the accident type categories, there is significant overlap among the consequence categories. It is evident that in most accidents with fatalities and/or injuries, there is also material loss involved, while in cases with bigger number of fatalities [9].

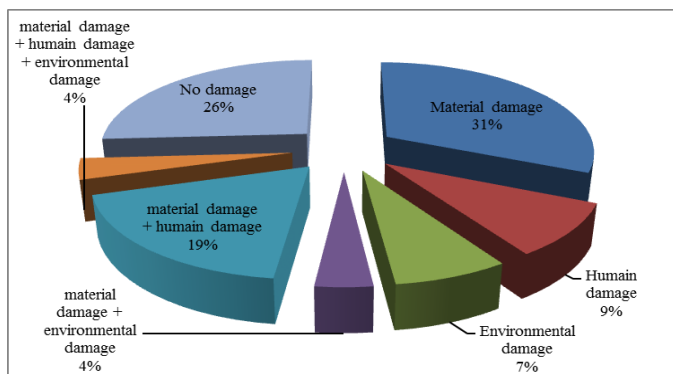


Fig.7. Categories of consequences of accidents in Skikda and Arzew refineries (2003-2013)

A main observation in the present analysis is that 32% of the accidents (16 accidents), led to human injuries and fatalities who can be associated to material and environmental

damage, this reflects that workers in this sector are exposed to higher accidental risks [9]. While in 31% of the accidents (17 accidents), only the material damage were registered. Furthermore in 15% of the accidents (8 accidents), environmental consequences were registered. Again, no information is given on the magnitude or the severity of the consequences in the ecosystem. For 53 reported accidents, 14 accidents had no injuries and material damage.

6) *Refining accidents and the related injuries and fatalities*

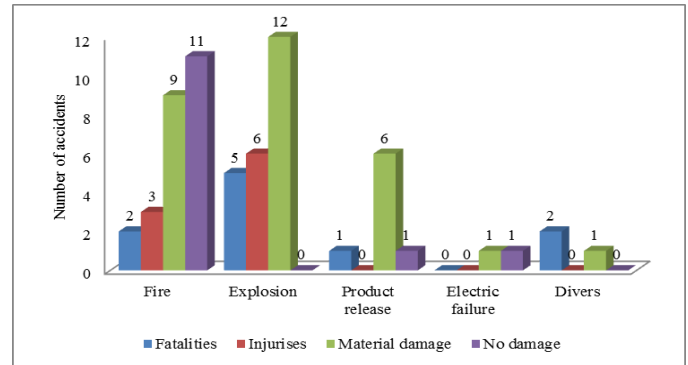


Fig.8. Refining accidents in Skikda refinery (2003-2013) and the related effects

Fig.8 presents the related injuries and fatalities to the refining accidents. The review reports 156 injuries (including 40 fatalities) in 2003-2013 which resulted from fire and explosion related incidents. Product release and electric failure presented as the event causing the least of death or injury. The information has been broken down into five categories: fire, explosion, product release, electric failure and others.

However, explosion was identified as the principal cause of fatalities and injuries. Fire was the most frequent type of material loss with 9 of 29 cases. Knowing that, in case of an accident starting with an explosion (24.5%), fire follows preferentially. If fire occurs first (47%) a following explosion is expected. However, the most probable global sequence is an explosion followed by fire.

The population affected by the accidents is divided into two classes according to the entity of the consequences suffered: number of deaths, number of injuries.

B. *Fire effects simulation*

Due to the complex nature of fire, the use of numerical modeling in the field of industrial fire accidentology has become common nowadays. Many years of research have made it possible to model a wide range of fire phenomena with fire and smoke transport models. This tendency is expected to increase with the development and performance simulation tools.

1) *Numerical Dispersion Model*

Smoke dispersion prediction systems are becoming increasingly valuable tools in smoke management. There are a variety of potential applications that can help current

management issues [10]. These include screening, where methods and models are used to develop “worst-case” scenarios that help determine if alternative burn plans are warranted or if more in-depth modelling is required. Such tools also help in planning, where dispersion predictions aid in visualizing what fuel and weather conditions are best suited for burning or when supporting data are needed to report potential environmental impacts [10].

We are interested in this study, not to the combustion modeling, but that thermal effects and pollutants emitted by the fire [11]. The theory of our model based on the interaction FIRE- Environment; the coupling between the modes of heat transfer and mass. It is considered that the plume is subjected to a two-dimensional stationary turbulent, compressible flow, with a constant wind speed. Numerical dispersion model is a computer program that uses a mathematical algorithm to simulate how pollutants disperse in the atmosphere, their concentrations and the thermal effect supply to the environment.

The plume is described in terms of unsteady state convective transport by a uniform ambient wind of heated gas and particulates matter introduced into a stably stratified atmosphere by a continuously burning fire. The mathematical model of a smoke plume consists of the conservation equations of mass, momentum and energy which govern the temperature T, pressure P, density ρ and velocity (u,v) in the direction (x,y), in connection with the k- ϵ turbulence model [11]. The induced flow, mass fraction and temperature field can be described by a set of equations derived from the conservation laws for mean flow quantities; the model we have developed and used in this paper is briefly described below [12]:

Transport equation:

$$\frac{\partial \Phi}{\partial t} + \frac{\partial U \Phi}{\partial x} + \frac{\partial V \Phi}{\partial y} = \Gamma \left(\frac{\partial^2 \Phi}{\partial x^2} + \frac{\partial^2 \Phi}{\partial y^2} \right) + S \quad 1$$

Numerical Dispersion Model (NDM)

- Continuity equation:

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

- Movement equation:

$$\frac{\partial U}{\partial t} + \frac{\partial U.U}{\partial x} + \frac{\partial V.U}{\partial y} = \frac{1}{\text{Re}} \left(\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} \right) - \frac{\partial P}{\partial x}$$

$$\frac{\partial V}{\partial t} + \frac{\partial U.V}{\partial x} + \frac{\partial V.V}{\partial y} = \frac{1}{\text{Re}} \left(\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} \right) - \frac{\partial P}{\partial y} + (G r_m . C + G r_T . T) / \text{Re}^2$$

- Equation of energy:

$$\frac{\partial T}{\partial t} + \frac{\partial U.T}{\partial x} + \frac{\partial V.T}{\partial y} = \frac{1}{\text{Re} . \text{Pr}} \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right)$$

- Equation of conservation of mass:

$$\frac{\partial C}{\partial t} + \frac{\partial U.C}{\partial x} + \frac{\partial V.C}{\partial y} = \frac{1}{\text{Re} . \text{Sc}} \left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} \right)$$

Adimensional number

| | | |
|---|---|--|
| Reynolds Number $\text{Re} = \frac{U_{\text{jet}} . L}{\nu}$ | Schmidt Number $\text{Sc} = \frac{\nu}{D_m}$ | Prandtl Number $\text{Pr} = \frac{\nu}{D_T}$ |
| Grashof thermique Number $G r_T = \frac{\beta_T . g . \Delta T_{\text{max}} . L^3}{\nu^2}$ | | Grashof massique Number $G r_m = \frac{\beta_m . g . \Delta C_{\text{max}} . L^3}{\nu^2}$ |

With:

- U_{jet} : Rate of pollutant;
- P : Pressure ;
- C : Pollutant concentration
- U : Horizontal viscosity
- g : Gravity
- β_T : Coefficient of thermal expansion;
- β_m : Coefficient of mass expansion;
- D_T : Coefficient of thermal diffusion;
- D_m : Coefficient of mass diffusion;
- ΔT_{max} : Maximum thermal gradient;
- ΔC_{max} : Maximum concentration gradient;
- V : Vertical viscosity
- T : Temperature
- ν : Kinematic viscosity;
- Φ : Random variable T, C, U, V
- L : Length of the area

The Numerical Dispersion Model allows the follow-up of the plume by determining the quantities of the pollutants at each position and at every moment along the life cycle of the plume, which will make it to determine the residence time of the pollutant. That shows the importance of modelling as tool for decision making aid, especially to the experience feedback.

2) Incorporation of statistical data in the Numerical Dispersion Model

Concerning the determination of the pollutant concentration and the thermal effect emitted from the accident, we could use the Numerical Dispersion Model. The data of this part could be acquired from the overview of fires (accidents) occurred in Skikda refinery from 2003 to 2013 where it is possible to obtain full or almost full information about the fire size, location, causes, consequences, the nature and the quantity of involved chemical, weather conditions, etc. For this, we could reference to a fire which took place in the refinery of Skikda (city in Algeria). The fire occurred in the refinery of Skikda (October 5th, 2005), represent serious accident that involved two tanks and have a considerable human and material damage (27 dead and completely destroyed two tanks).

3) Analysis results and discussion

Our case study is a tank fire which took place in the refinery of Skikda (Algeria), October 5th, 2005. Referring to the statistical analysis, the fire started on a first crude oil tank (S106) and it was extended to an adjacent tank (S105). The source (S106) was in filling at 70 %; the specification of maximum RVP (Reid vapor pressure) is 0.75 kg/cm² for a floating roof tank. The estimate of the contents in LPG (Liquefied petroleum gas) is 3 % mole with 0.75 kg/cm² and 5

% mole with 0.95 kg/cm^2 [13, 14]. The investigation, carried out by a team of experts, showed also that smoke contains gaseous pollutants in particular NO_x (Oxides of Nitrogen) and VOCs (Volatile Organic Compounds). All the results have been obtained from the solution of the partial differential equation described by the general Eq (1) using the finite volumes method, we have implemented on a FORTRAN environment (FORTRAN 6.6).

In the simulation of the fire, the numerical model allows us to track the spatiotemporal evolution of smokes released during the accident to determine the environmental impacts on the neighboring population which is very close to the terminal. The results of the simulation allow us to infer the residence time of pollutants in the urban area.

This work includes two parts: the first part concerns only the thermal effects of the fire which are represented by the contours of temperature a function time (Fig. 8) while the second part (Fig. 9 and 10) for the results of the coupling of transport, and chemical kinetics of thermal effects in the overall model that has been applied to nitrogen oxides

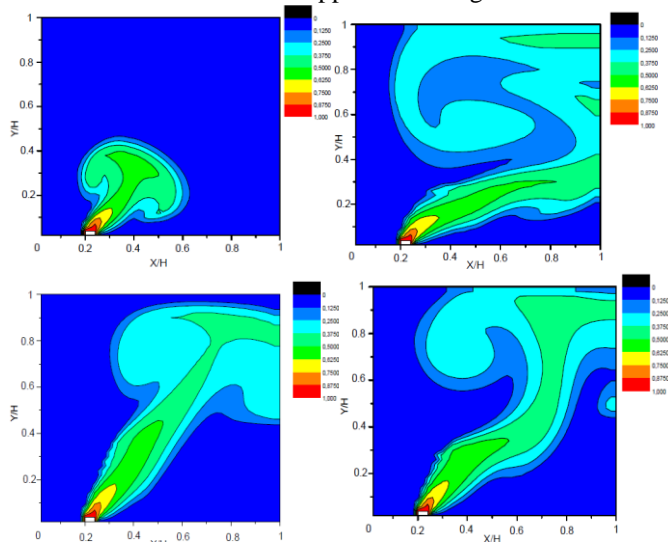


Fig.8. Outline of temperature for different time

Indeed, the presence of atmospheric turbulence and wind speed will influence on the temperature and on the propagation of smoke in the volume control.

The Fig. 8 shows the two-dimensional variation of the temperature (in the horizontal direction of the wind and elevation $0x \ 0y$) function of time. The figures show that in the vicinity of the fire source there was a rapid and remarkable temperature and gradually as one moves away, with the effect of ambient air (open fire), the gas plume gravitating at an altitude of neutral floatability, and then they gradually spread throughout the study area. Fig. 9 represents the evolution of NO_x concentration profiles function of time. Referring to Fig. 9.a (without kinetic effect), the trend is due only to the transport, which shows slow variations compared to those of Fig. 9.b (presence of kinetic effect). The concentration changes are faster in this case, which is due to the interference effect and the kinetics of the turbulence effect.

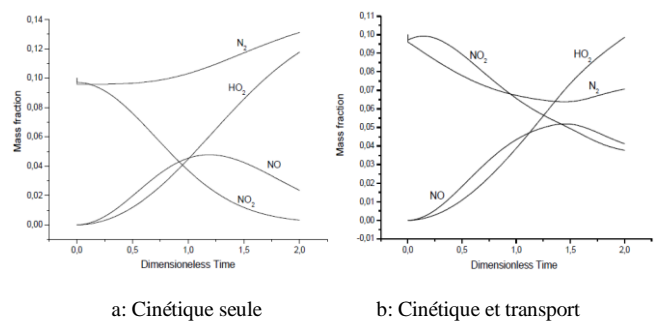


Fig.9. Evolution of the of NO_x concentration

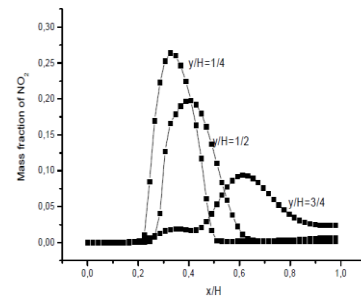


Fig.10. Concentration profiles in different positions

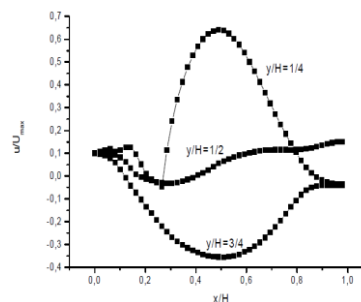


Fig.11. Velocity profiles in different positions

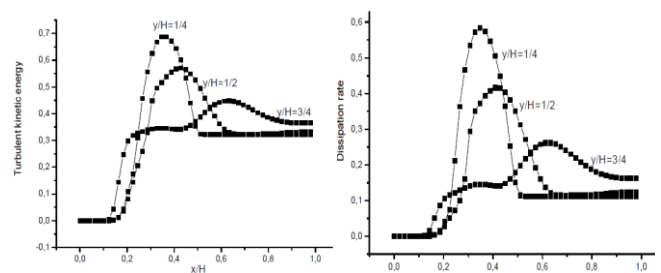


Fig.12. Profiles of the turbulent kinetic energy and the rate dissipation in different positions

Fig.11 represents the velocity vectors of the flow. Three characteristics of the flow zones are distinguished: area close to the source of the fire, the above and the recirculation. In the area close to and on top of the fire, the speed of the flow takes values which exceed the wind speed upstream allowing the

propagation of hot gases; in the recirculation zone, the speed is low and negative, this area is characterized by counter-rotating turbulent structures.

III. CONCLUSION

This paper presents a combined statistical/dynamic approach; this methodology is principally based on two analyzes. The first one is a statistical analysis of all reported accidents in Skikda refinery from 2003 to 2013. An overview was developed to include industrial accidents (fires, explosions and substance releases), the immediate causes of those accidents and their consequences and more others information. This information will be subsequently used in a dynamic analysis as input in the numerical dispersion model to study the industrial fire effects to obtain the pollutants concentration and thermal effect generated by the fire.

The combined statistical/dynamic approach is applied to a case study for petroleum production process.

The obtained results will allow us to:

a) Determine the immediate causes of these accidents and subsequently the choice of prevention and the most appropriate protection. In the case of material causes accident prevention is based on the renovation of the refinery installations and the commitment to preventive maintenance policy to avoid critical failures. In the cases where the causes are due to the human factor, corrective measures must be based on the following factors:

- Strengthening of awareness especially regarding occupational risks associated with worksite;
- Increase the frequency of audits and inspections;
- Staff training on risk identification methods and the methods of investigation of accidents and incidents (Hazard Recognition);
- Staff training on RCA (Root Cause Analysis);
- Review of HSE procedures;
- Awareness about process of managing the road transport of dangerous substances.

b) Identify the most exposed place (Unit) to accidents and take them into consideration during the implementation of safety systems (fire detection, fire extinguishing systems, etc.;

c) Know the substances involved to avoid the lack of knowledge about chemical reactions and poor handling of these substances that are toxic, flammable and explosive and can lead to fires and explosions.

d) Determine the concentration of pollutants and the thermal effect generated by accidents and check if they are conforming to the values of exposure threshold.

e) Implement a risk mapping of the area via the level of the pollutant concentration and their thermal effect.

The limits that can be found during the application of this approach are:

- The problem of lack of information on industrial accidents, for this purpose the statistical study may give erroneous conclusions;

- Like any numerical model, the Numerical Dispersion Model presents a significant level of uncertainty, which affect the performance of the model;

For this, it is proposed in future work, the use of multifactorial analysis methods to characterize particular coupling between statistical analysis and numerical modeling. Perform an uncertainty analysis and sensitivity analysis in order to have results more certain and thereby they can be used in the field of industrial safety.

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