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A NEW APPROACH TO FIRE SAFETY SYSTEM IN THE PROCESS OF ATMOSPHERIC RECTIFICATION OF OIL

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Review article

Abstract: This paper presents the methods of detection and diagnosis of failures, that is, detecting the existence and causes of failure that can be applied in systems that operate in real time. The proposed system allows automatic and semi-automatic security management, and provides general average or minimizes the consequences of disasters. In addition, it defines the conditions, i.e. the intervals of parameter values, under which causes of failure are created. Based on these parameters, optimal design of protection is possible and it enables the efficient management of the system.

Suggested fire safety system in the process of atmospheric rectification of oil offers the possibility to choose an optimal diagnostic algorithm and its practical and economic usage.

A new approach should be applied in order to reduce fire hazards in the process of atmospheric rectification of oil. Fire safety system should be inseparable from the technological process, and vise versa.

The procedure recommended for fault detection and diagnosis consists of two phases. The first phase involves the assessment of the process state, while the second involves the identification of the values of processing parameters and their correlation with the process model parameters.

Keywords: Fire safety system, atmospheric rectification of oil, failures detection, diagnosis of failures, security management.

Introduction

Administration of any technological system requires current information about the parameter values that are important for a system of fire protection. Thus, measurement of process parameters and their immediate availability is essential for the system to run a technological process. The development and improvement of the methods of the evaluation of the technological process is a continuous interest of science and technological experts. With the degree of complexity of the technological process arise the need to implement systems able to detect failures in the process of diagnosing their causes.

For optimization and design of the protection system, methods to detect and diagnose failures are of special interest. That is, detecting the existence and causes of failure that can be applied in systems that operate in real time. There are cases when the cause of failure cannot be removed until the termination of operation, or the impact of failures on safety is insignificant but the early warning system can at least provide the information for better decision making about the management of care.

By using proposed fire protection system the likelihood of sudden accidents will be reduced, as well as achieving more efficient management, and operating under such conditions will be adequate.

The procedure recommended for the detection and diagnosis of failures consists of two phases. The first assesses the state of the process, and the second identifies the values of process parameters and compares them with the parameters of the model process.

Materials and methods

Process of Atmospheric Oil Rectification

Before the rectification of crude oil is prepared, water and impurities that could hinder the process must be separated. Water evaporates and the steam would be too discouraged and kept, increasing pressure rectification, and salt and ingredients will be caught on the walls of the furnace, thus the heating will be less efficient, and the amount of ash in the distillation residue will increase. The simplest way is that the oil is left to stand, possibly a slight heating (40 - 60 °C), at the same time the water shrug at the bottom with solid impurities (salt, sand, silt) but it takes a long time. Water and impurities can be removed in various ways: centrifugation, using

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a variety of chemical agents to break the emulsion, by using dismulgators or by electricity (15,000 to 30,000 V) with the strong electric field of charged droplets gather in larger drops and shrug. Methods of water separation could be combined. Maximum remaining of water in oil should be 0.2 % with 0.02 % salt. Oil is often cleaned with the springs that would save money in transportation. Oil , free of mineral impurities, is heated to 350 to 400 °C and under pressure introduced into the atmospheric distillation column. In this refraction column, free of pressure, lighter fractions evaporate immediately, and harder fractions that do not evaporate move to the bottom of the column. The evaporated gas phase is going to the top of the column in contact with the liquid phase, leaving on each floor heavier fractions that it still carries. The temperature in the column decreases from bottom to top, making the separation easier. To improve the flow and reduce the partial pressure of hydrocarbon in the column for rectification, heated vaporous water is introduced, which mostly comes out of top of the column with a gasoline vapor, condenses with them, and then separates into a water separator.

From distillation columns with different floors, at least four products are collected - gasoline from the top of the column, jet fuel, easy gas oil and heavy gas oil. Any faction that leaves the main column is still a mixture of larger number of hydrocarbons. That is why some fractions are further processed in additional columns. As the end products of atmospheric distillation, fuel gas, liquefied petroleum gas, gasoline (light, primary and feeder stream for platforming), jet fuel and kerosene, light and heavy gas oil are obtained.

The waste streams from atmospheric distillation are gases from the furnace for heating crude oil (CO, SOx, NOx, unburned hydrocarbons and solid particles), volatile emissions of hydrocarbons, the emissions from the ejector and oily acidic water, which is separated by condensation in the separators of gasoline, and refinery sour gas containing hydrogen sulfide, ammonia, chlorides, mercaptans, phenol and hydrocarbons from petroleum. There is usually no or very little solid waste in this process. Gas oil is the heaviest fraction, which is obtained from atmospheric distillation. Heavier fractions do not stand out in this process, but they stay in the atmosphere or as a slight residual, which is isolated at the bottom of the column and which makes up 35 to 50 % of the quantity of crude oil that has entered the column. Atmospheric residue is usually processed in the second stage of primary production in the vacuum distillation.

Fig. 1 shows the simplified technological scheme of the crude distillation unit, indicating the wastewater flows.

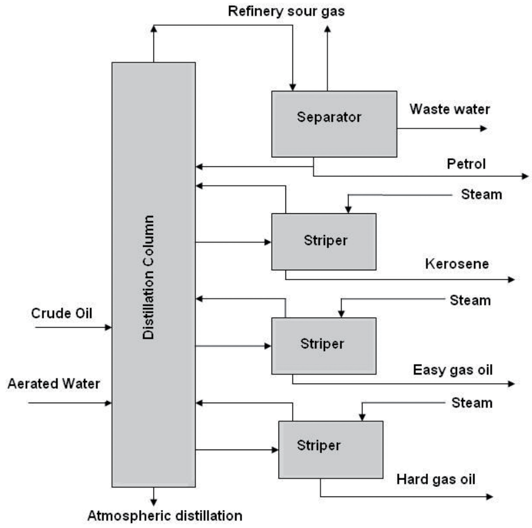

Fig. 1 Simplified technological scheme of the atmospheric distillation

Part of the condensate can be returned into the column as reflux (to push fractions down). Fractions are obtained as condensates in some column floors. By combining the condensate with a number of floors, fractions with the desired composition can be obtained.

Each of the factions is still a mix of high number of hydrocarbons. Fractions can be rectified in additional columns that are close to the main column.

If a sharper rectification is needed, two or more rectification columns may be used.

Distillation can be done in two phases: crude oil is first heated to a slightly lower temperature to 300 - 340 °C, where it receives only lower fraction, and the rest from the bottom of the column is heated in a furnace to a higher temperature 360 - 420 °C, and then rectified in the second column, possibly in a vacuum.

The rest of the plant consists of the extra column (stripper), heat exchangers, condensers and storage tanks, associated with pipe lines.

Results

Definition and Classification of Failures

From the standpoint of security analysis system, canceling is the change outside certain limits of at least one of the characteristics of the system that cause injury to people or damage material or natural resources.

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To facilitate the analysis of security system, failures are classified based on different criteria, making it possible to access the following classification (Tab. 1).

Tab. 1 Classification system failure

The criterion for classification	**Types of failure**	
1. Kind of changes of the state	unexpected failure	
	gradual failure	
2. Links to other dismissals	independent failure	
	dependent failure	
3. The usability of the system after failure	complete cancellation	
	partial cancellation	
4. Natural elimination	permanent cancellation	
	cancellation that eliminates automaticly	transient cancellation
		return failure
5. External events	obvious failure	
	covert failure	
6. Cause of failure	structural failure	constructor error, imperfect method of construction
	technological failure	error in production, imperfect technology
	exploitation failure	errors in exploatation
7. Nature of failure	natural termination	
	artificial termination	
8. Time of failure	failure during testing	
	failure in the period of preparation	
	failure at the end of service	
9. Failure intensity	random failure	
	systematic failure	
10. According to the impact on safety	safe failure	
	dangerous failure	

Unexpected (sudden) failures are caused by sudden changes of at least one element of the system parameters. Such changes are caused by hidden defects in materials and system components, or by incorrect use.

Gradual failures are caused by gradual changes of at least one element of the system parameters. Changes often occur due to the disturbance of input system characteristics.

Independent failures occur without the influence of another failure and are usually caused by only one element of the system.

Complete failures are failures when the system can be repaired. Partial failures will result in deterioration of some characteristics of the system.

Transient failures are failures that repair on their own intervention. Return failures are failures due to various disturbances to the side and follow quickly one after another.

Systematic failures are failures where the failure intensity is constant, and are caused by many influences that come independently on each other. They may be early and cancellations due to aging. Early failures are characterized by a high decrease in the intensity of the process parameters over time and are caused by the lack of rough elements of the system. Failures due to aging have increasing intensity with time, due to the wear of elements of the system.

Random failures are those whose failure intensity is changing in time.

Harmless failures do not affect the reduction in the level of system security.

Dangerous failures will result in endangering the security and may cause injury or damage to material or natural resources.

Methods of Assessment, Identification and Diagnosis Failure

Simultaneous identification of three elements in the process model includes: (1) state variables, (2) the output state, and (3) parameters. One of the most common approach for the determination of these three elements is to seek optimal solutions for the nonlinear model of the direct minimization (or maximization) of functions. Solving procedure requires a long calculation, shows the numerical uncertainty and can produce locally optimal solutions for any or all three elements.

Another approach to the simultaneous assessment of these three elements is the use of hierarchical identification strategy, a method which in principle is nothing but an alternative approach to nonlinear optimization, and it can also produce local optimal estimates and long-term calculations.

Among the commonly used criteria are the minimum error square function or the minimum probability function. Selecting the least square function leads to a simple and fast calculation algorithms than when using the probability function. However, the likelihood function involves higher-order nonlinearities of quadratic functions that require more computing to reach a satisfactory solution as well as in the case of choosing the minimum of the quadratic function. Kalman filter (Watanabe and Himmelblau, 1984; Giles and Schuler, 1982) also presents a method for solving nonlinear problems of identification. Kalman filter is a nonlinear filter

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suitable for the evaluation of the category approach and the maximum likelihood function. Goldmann and Sargent (1971) applied the Kalman filter for cosmic spacecraft, Himmelblau used it to identify the parameters in nonlinear chemical processes, and Wels (1971) and Seinfeld (1970) and others apply it to the linear discrete model with abrupt or trendy changes in the parameters. All these researchers have achieved satisfactory results through simulation.

To detect and diagnose errors, it is important to know the constant value of process conditions and parameters as compared to the same values that are achieved under normal operating conditions. Otherwise, there is a confusion in determining the actual cause of error.

Strategy that Watanabe and Himmelblau (Watanabe and Himmelblau, 1984) suggested in their paper avoids expensive implementation due to: measuring the minimum number of conditions, reconstruction of the remaining inaccessible state variables using the reduced linear, considering the nonlinear process (module is known, but has unknown parameters and inputs).

On the basis of interest, the examiner can use the estimated state variables to make decisions in relation to the failure, if the lower and upper limits for each stage are pre-arranged.

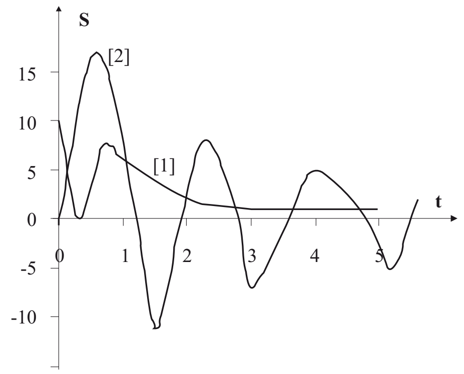
Watanabe and Himmelblau take the view that the failure causes the changes of different process parameters. By the measurement of process parameters it is possible to determine the moment when it begins to take unwanted shares. Watanabe and Himmelblau state that better results than estimates of unknown parameters can be achieved by a combination of identifiers and filters.

Assessment of Rectification Columns

In the area of chemical process control, regulation and optimal management of the rectification column is rather treated (Koehne et al., 1977; Retzbach, 1972). The reason is the enormous energy savings opportunity. Given the fact that very often large processing units are analyzed and the savings are large, it could be easy to convince decision makers about the non-academic importance of the relatively complex algorithms. The following sequence of procedures for optimization has been developed: (1) mathematical modeling of processes, (2) validate the pilot column or computer simulations, (3) design a column with given performance and (4) algorithm of regulation that ensures consistency of all sizes that could cause the removal of pre-specified conditions (e.g. feeder control flow, pressure drop, flow and temperature etc.).

As measured parameters are taken the temperature changes in the floors where the separation of easily volatile components are conducted.

Simulation analysis showed that the approach proposed by Watanabe and Himmelblau is optimal. Fig. 2 shows the comparison of performance when the process is regulated by PID controller and by using optimally managing the evaluation of the condition. Disorder caused by fluctuations on the floor when the control exercised with PID temperature regulator, regulation and assessment of state is hardly noticeable. The authors do not specify the details, but it is obvious that the oscillation in the first case is likely to seek termination of the column and was undoubtedly the performance of the above approaches.



Legend:

[1] - PID controller

[2] - Optimal regulation control for evaluation of the identifier

S - Deviation of places matter changes in rectification column from the steady-state

Fig. 2 Oscillation parameters of rectification columns

Conclusion

Based on preliminary examination and consideration we can conclude:

Because of present danger, protective systems should prevent the failing or to minimize the consequences of possibly disaster. Installation of the protection system provides the option of automatic and semi-automatic protection, which has a direct impact on reducing fire hazards.

Reduce the risk of fire in the atmospheric rectification of oil should be handled well with new approach to the protection system that should be inseparable part of the technological process.

Thereafter we should strive to implement the methods of evaluation and identification for the detection and diagnosis of failures, which may provide before-failure assessment of the technological process of atmospheric rectification of oil.

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The proposed system of fire protection in the process of atmospheric rectification of oil enables the selection of optimal diagnostic algorithms, as well as its economical application.

Also, the system defines the conditions under which failure causes may be involved in the process model.

Optimal design of fire protection in the process of atmospheric rectification, its management and diagnosis of failure allows only the specified parameters.

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