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Yu. S. Radchenko, PhD (Engineering), assistant professor (BSTU)

RISK ANALYSIS OF OIL-PROCESSING OBJECTS

Consistency of carrying out of risk analysis of oil-refining enterprises has been given in the article. The article deals with the possibilities of using existing methods for assessing the aftermath of emergency conditions at the installations of the oil-refining enterprises and methods for estimating the probability occurrence and development of emergency. Some arrangements are aimed at ensuring the required level of safety refining facilities.

Introduction. Technological installations and refining facilities are complex technological systems designed to implement the hydrocarbon processing into commercial or semi-finished products for further reprocessing. The elements of this technological system include not only the main process equipment (column equipment, reactors, process piping, tanks, pump-compressing equipment, etc.), but also equipment designed for the regulated functioning of technological equipment (power supply equipment, instrumentation systems, water supply and sewerage, etc.). The number of elements of technological installation PRI is capable, to some extent, affect the emergence and development of an emergency, depending on the complexity of the installation can reach from a few hundreds to thousands. In this regard, such risk analysis of similar technological systems is quite complex problem, requiring knowledge of technology, the peculiarity of elements of the system and the interrelation between them. At present, risk analysis methodology is developed and tested extensively for complex technical systems of aerospace industry and nuclear energy. Actual problem nowadays is the adaptation of these methods to the conditions of PRI and the possibility of their use in risk analysis of the installations and facilities of oil refining.

Main part. Risk of industrial enterprises exploitation is usually associated with uncontrolled release of energy or leakage of highly explosive or toxic substances. Though the real danger to the public does not come from the whole enterprise, but from some of its structural units (installation, workshops, productions, storehouses, etc.). Obviously that some of the units of the enterprise are more dangerous than others, and for the effective analysis they should be divided into subsystems to identify areas and divisions being sources of danger; and further assess their risk [1]. Technological installations and refineries have a number of specific characteristics that require a special approach to risk analysis and using of known methods and techniques for assessing the consequences of possible emergency situations, as well as estimating the probability of the occurrence and development of emergency. Specificity of refining installations is determined by highly explosive properties of technological media in equipment, high temperature and high pressure in realization of the technological process. The analysis of plant equipment PRI, as elements of a complex technological system, taking into account the content of explosive inflammable substances, the quantity of each type of equipment in installations, frequency and nature of failures and malfunctions allowed conditionally divide it into the following types: column equipment, tanks and containers, heat exchangers, heating furnace, pump and compressor equipment, industrial pipe-lines.

The following main stages of risk analysis for refineries are proposed taking into consideration the specifics of refining facilities and modern methods of risk analysis of hazard production facilities used to solve similar problems in other industries.

At the first stage, the hazard identification of the object is defined i.e. the process of its identifying, taking into account the features of the industrial object (technology, design parameters of the equipment used, the physical-chemical properties of substances reversing, their number, etc.) and characterization, resulting in compiled a list of adverse events leading to the accident.

During hazard identification it is necessary to determine the amount of each substance that is in capacitive equipment (column apparatuses, containers, tanks) and in heating furnaces as devices with fire heating, and highlight the items with the highest content of hazardous substances. Identifying the amount of substance in each kind of equipment it is necessary to take into account their physical state, to establish and clarify the technological parameters of the equipment operation (temperature and pressure of the system, the ratio of the individual components), physical chemical properties of substances (explosive limits, spontaneous ignition temperature, flashpoint etc.). In addition, the analysis of the most typical defects is needed with regard to the number of failures for each type of equipment (columns, tanks, vessels, pipes, heating furnaces, pumps and compressors).

The most “energy-intensive” equipment, that in this case refers to the equipment containing the greatest amount of hydrocarbon material is exposed on the basis of the analysis of distribution substances for certain types of equipment, materials and aggregate state of substances, process dependent parameters. According to the analysis of some failures and problems the most “problematic” equipment is revealed, i.e. equipment having the greatest number of failures that could lead to an emergency situation. On the basis of the distribution of substances in each piece of equipment and with regard to their physical and chemical properties it is necessary to conduct a rapid assessment of the parameters of a possible explosion, fire, toxic exposures characteristic with the definition of the affected areas and the number of possible victims. Express-evaluation can be made by known techniques [1–3], which allow for a short period of time with adequate accuracy for this stage to determine the possible effects of an emergency on the oil refineries. Then on the basis of this it is possible to make decision regarding further more detailed risk analysis.

Organizational arrangements are developed to maintain the existing level of the facility safety (regular training and personnel certification, timely and qualitative maintenance of equipment, adherence to the operating practices within the regulated parameters, etc.) in case of making a decision about the relative safety of the facility and inexpediency of further analysis of risk.

When the need for further risk analysis appears, its evaluation is made, which consists of the analysis of the frequency of emergency occurrence and consequences of it (the second stage). Frequency analysis consists in determining the probability of occurrence of a particular hazard, while the qualitative (logical methods, expert judgment) and quantitative (using statistics on accidents and reliability of the technological system, the type of object or activity) evaluation methods are used.

On the basis of the list of the most “energy-intensive” and the “problem” equipment, the analysis of faults and failures of equipment as well as the analysis of emergencies previously occurred on this same or similar facility. The result of the analysis of problems and emergencies is to identify the causes of emergencies and their consequences. Cause-and-effect relations of incidences resulting in the emergencies as well as assumptions of possible emergencies are revealed on this basis. Quantitative characteristics of failures and malfunctions of equipment (the probability of failure, the flow rate of failures, mean time between failure) are determined by known mathematical relations for the theory of reliability taking into account each type of failure or malfunction.

Logical graphic schemes of the development of emergencies for the most “energy-intensive” and the “problem” equipment revealed before are built according to assumptions of possible emergencies taking into account technological relations of separate elements of the technological scheme and the quantitative characteristics of the failures and problems. The result of this phase of risk analysis i.e. risk assessment of the probability of an emergency is quantitative indicators obtained using logical graphic schemes.

The third stage of risk analysis of equipment operation is the analysis of consequences which includes impact assessment of an explosion, fire on people, property and the environment. To forecast the consequences it is necessary to evaluate the physical effects of adverse events (fire, explosion, toxic waste). Analysis of the emergency consequences is based on the preliminary distribution of substances for technological units and for certain types of equipment, taking into account technological processes and physical chemical properties of the process fluid. The amount of gas and liquid phases in the equipment is determined at the initial stage. Gas phase at depressurization of the equipment is fully involved in the formation of explosive cloud. While assessing the behavior of liquid hydrocarbons resulting from depressurization of equipment, one should be considered options with the complete destruction of equipment and participation in the formation of evaporation area and explosive cloud in total volume of the liquid phase. In addition, it is necessary to take into account equipment depressurization resulting from the defects in the equipment (such as cracks, depressurization of isolation valves, corrosion effect). For this it is necessary to determine the amount of ejected material and spillage area of liquid hydrocarbons. The amount of ejected material is evaluated in shape and size of holes considering the physical properties of liquid products according to known hydraulic relations. The mass of vapor-gas cloud formed by evaporation from the surface of the liquid phase of the spill is determined according to physical properties, operating parameters and spillage area. Options of explosive impact on surrounding objects, thermal effects of fire, spillage, fire ball are determined on the basis of the total weight of the vapor-gas cloud formed as a result of the sum of the amount of gas and vapor. Based on the results obtained, the impact on buildings and structures, as well as the number of possible victims are determined. To determine whether the destruction of the most “energy-intensive” equipment (column apparatus, tanks, heating furnaces) and the further development of accidents on a “domino effect” is possible, it is necessary to assess the impact of the blast wave on this equipment.

Conclusion. The result of the risk analysis is the development of measures aimed at improving the reliability of equipment, equipment systems, emergency protection (EP), improving process control and reducing the potential danger of the object.

Reliability improvement implies a set of measures aimed at reducing the probability of an accident as a result of failure or malfunction of certain types of equipment. This unit can also include measures for replacing obsolete equipment by modern and more reliable; improving machine maintenance, more effective corrosion protection, the use of sealed pumps for liquefied gases and flammable liquids.

Oil refinery facilities with EP systems are designed to achieve the control values of the process parameters to critical; timely adaptation of the system into trouble-free state is now a prerequisite while designing, constructing and renovating of facilities.

Improving process control implies the activities aimed at early detection of changes in the technological parameters and the prevention of an emergency due to the introduction of expert systems and improvement of personnel training. The reduction of potentially dangerous objects implies technological measures aimed at reducing the potential danger of the object, namely the reduction of the process parameters (temperature, pressure), the replacement of individual components of the technological system possessing high fire explosive properties to substances with lower fire explosive characteristics, reducing the number of highly explosive and toxic substances being on the object at a time.

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