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THE ANALYSIS OF TECHNOGENIC RISK MAIN FACTORS

Main factors of technogenic risks are considered. Methods of risks estimation and expense optimization at decision making procedures in technogenic risk management are proposed.

technogenic risk, failure frequency, fault probability, fault tree, event tree, acceptable risk

Introduction

The analysis and determination of overall risk main factors are the most rational approach to the problem of improving safety and preventing accidents at chemical-engineering systems and extra-hazardous objects. The failure frequency and the fault probability are the basic data to quantitative evaluation of main risk factors. The failure frequency supposed (normalized to specified time limit, e.g. a year) is calculated by cause-effect schemes processing. As a basis for calculations the logical-and-probabilistic schemes in the forms of a fault tree and an event tree are used [1, 2].

The effectiveness of controlling tools and safety means at chemical-engineering systems can be estimated by analyzing an event tree [1]. We check out these events one by one, beginning from the top, and moving toward the bottom until we exclude a failure possibility; then we retrace our steps and try again. For example, suppose the trouble is that the technological points are out of adjustment. We are sure not to know this fact originally, so we start from the very top, putting a question to each possibility to verify whether it is true. Almost everyone finds this process hard for risk estimating and decision making. The complexities of fault tree analysis are really much more the concern of a knowledge engineer than of a domain expert.

Formulation of the problem. Finite nodes of the event tree contain the quantitative indicators (indexes) which define the danger value and the probability of loss or damage. For example, the major index of the danger value because of atmospheric emission of steam-flue fuel gas mixture is the substance mass per the explosion area. The quantity of such substance depends on accidental depressurization conditions, valving reliability, safety means, ignition probability, etc.

In its turn the fuel amount in atmospheric emission defines the velocity and quantity of energy release and fire class - cluster of flame, deflagration, detonating. As a result of event tree constructing we have two-dimensional array on possible damages and their probabilities.

That is why risks-analyzing problem and evaluation of eventual economic losses are actual.

Problem solving

For every extra-hazardous object the main technogenic risk factors are analyzed in the following sequence:

1. Logical-probabilistic analysis of a technological process, failure-tree constructing, intermediate events and top state probability determining. We have a set of events with high failure probability (exceeding ultimate probability) as a result.

2. Fail-safe analyzing, safe means and equipment performance evaluating.

3. Modeling dangerous physical process for every situation from a set of events with exceeding ultimate probability. Calculating danger and injure indexes, evaluating the probability of people injuring and suffering, estimating damage level and material loss.

4. Economic analysis and calculating quantitative indexes of environmental damage for selected situations. Constructing bar graph grounded on the *Damage/Probability* data array.

5. Determining environmentally acceptable risks, absolutely unacceptable risks, choosing the boundary of unacceptable risks, picking out damage ranges which exceed the Farmer lines.

6. Selecting the emergency situation and comparing it with damage range. When having comparable estimations (rates) we can organize safety-oriented decision making process and come to the conclusion concerning sufficiency, redundancy of the technological process, efficiency and reliability its safety means.

7. Analyzing safety means and developing technical and organization plans to decrease damage ranges; economic analysis of proposed plans.

8. Additional analyzing and modifying the failure-tree and the event-tree according to the proposed safety-oriented activities.

The sequence of the main factors of the technogenic risk analyzing process is shown in fig. 1.

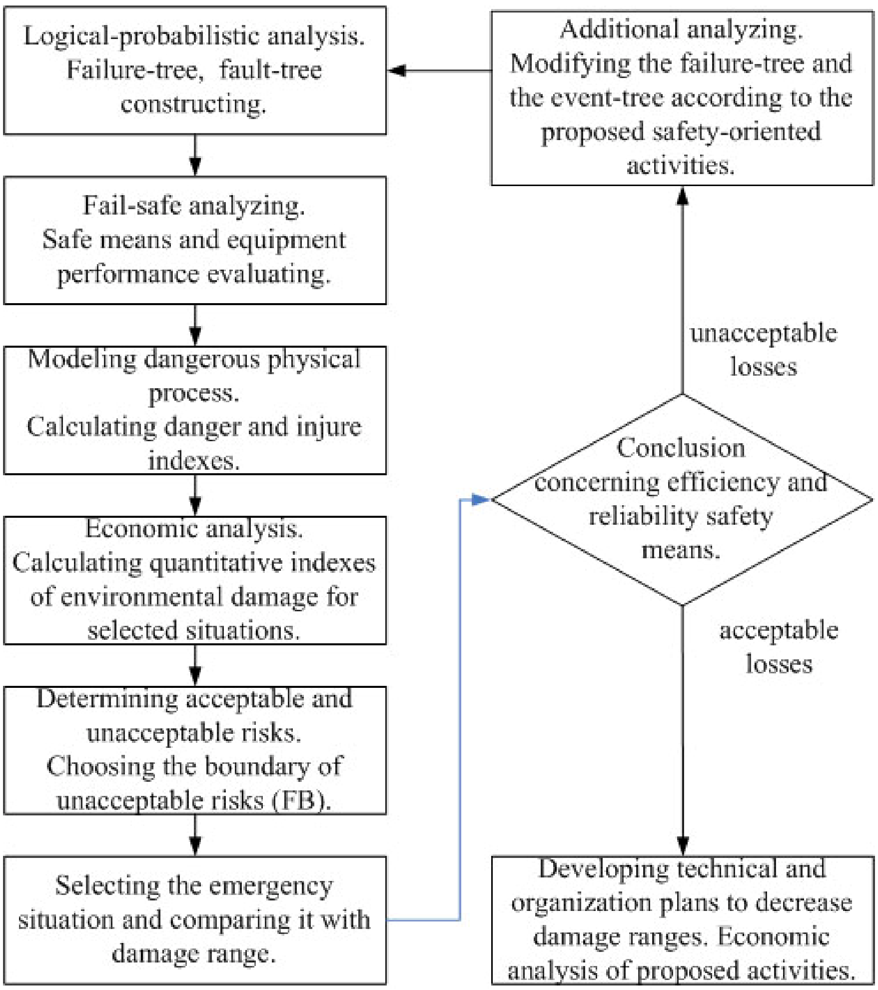

Fig. 1. The process of the analyzing of technogenic risks main factors

Economic loss evaluating

While economic loss evaluating one of the main parameters to determine technogenic risk foreseeable losses during and after emergency situation. There are different kinds of economic losses for chemical plants.

In fig. 2 an example of the chemical plant losses expected is given.

Bar graph is constructed by using different levels of failure probability. Economic losses are calculated in thousands of grivnas and probabilities of losses are normalized for a year period.

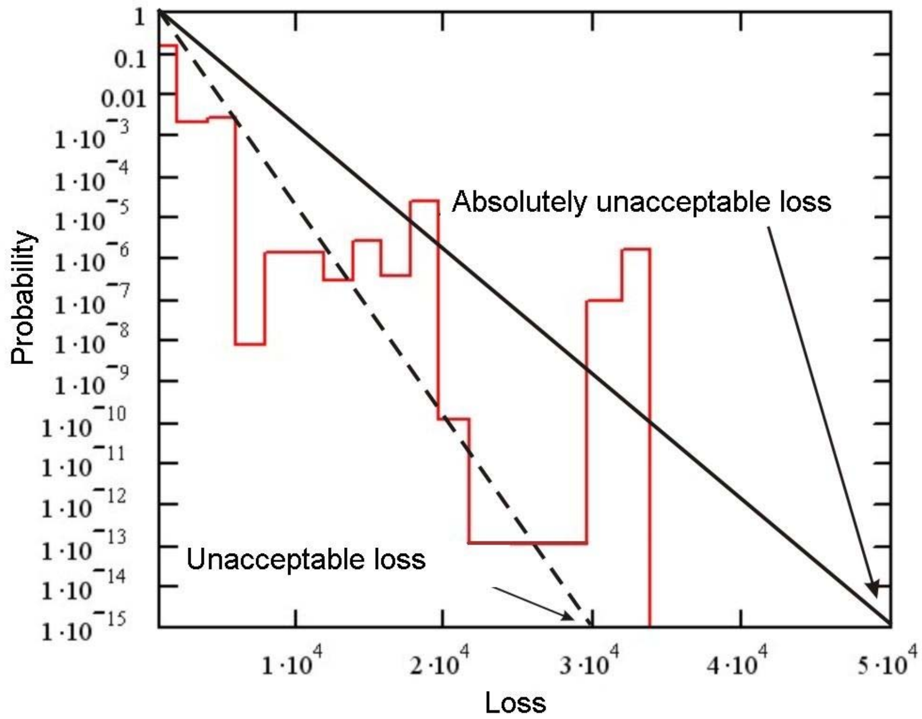

Fig. 2. Probabilities of losses during and after emergency situations

In [3] the method of evaluating possible and expected losses in producing uranium feed and transuranic elements is given. In this paper the usage of Farmer line for analyzing safety measures sufficiency is proposed. The measures suggested are oriented on safety from uranium elements pollution and refer to providing radiation safety. Farmer line runs from the zero to the point of a chosen expected loss, as in the method mentioned. Unacceptable risk is considered to be the value of economic losses when the process is not profitable.

In fig. 3 an example of a risk level selection with a reasonable damage is given.

In this example the probability of 30 millions grivnas economic loss is less than 10^{-8}. The parts of the bar graph above Farmer line belong to a set of absolutely unacceptable risks. The ones below F-line belong to a set of risks with little possibility. For the ranges with high level of expected damage the additional analysis of proposed safety-oriented activities is required. The safety means, technical and organization plans for ranges belonging to a set of risks with little possibility are environmentally acceptable or superfluous. For such ranges safety simplification is justified.

For selected ranges the definition of the failure-tree top nodes is required. Quantitative index of loss risk of a definite top event is calculated by the following formula:

$$P_d = P_r \sum P_j P_{m/j},$$

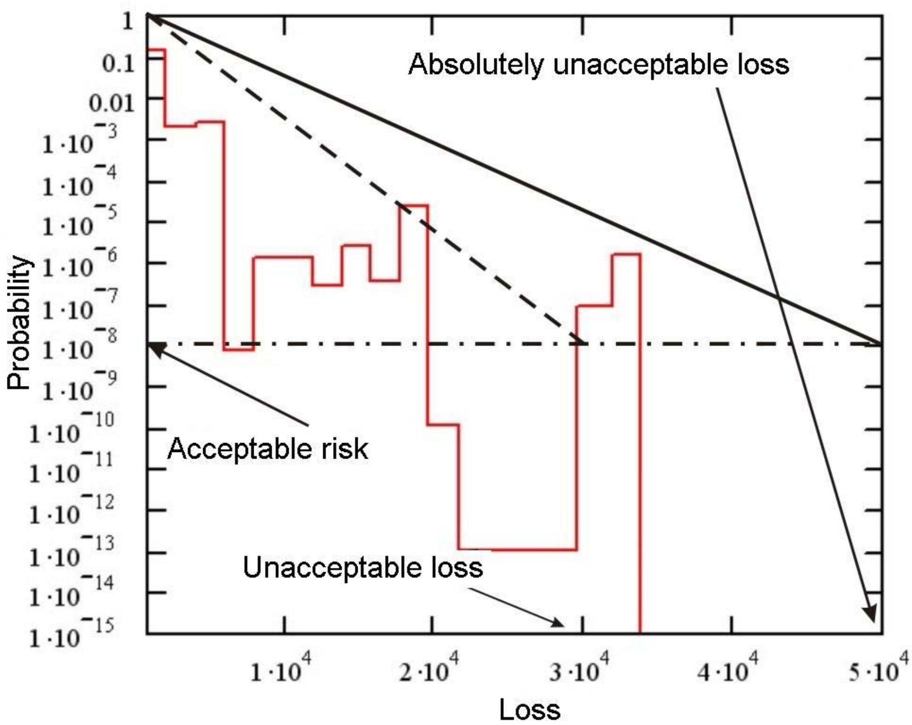

Fig. 3. The acceptable loss analysis

where P_r – failure probability; P_j – probability of j-outcome occurrence when failure is progressing, $P_{m/j}$ – conditional probability of material loss when j-outcome is realized.

Conclusions

Proposed methods of technogenic risks analyzing allow to provide the optimization for decision making procedures in technogenic risks management and to ensure acceptable risk level. It can be reached by developing technical and organization plans to decrease damage ranges and by safety activities selecting. Such technology can be useful for making actuarial calculations as well.

Literature

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