Technological processes parameters evaluation in the fire risk industrial objects analysis

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Abstract. The article discusses the simulation modelling use to improve the industrial facilities fire hazard analysis solving the problem efficiency on a thermal power plant example. The fuel supply system in the SimInTech software environment model is presented, as well as the fire risks calculation results for the research facility using the received model pressure values in the oil pipeline. The estimated fire risk estimated by and without simulations was compared.

1. Introduction
The production facilities fire danger analysis in the Russian Federation is carried out on the methodology basis for determining the fire risk estimated levels at production facilities, approved by the Russian Ministry of Emergency Situations Order of 07.10.2009. N 404 [1]. This technique contains the procedure for calculating the fire risk amount at production facilities, including the thermal power complex. The fire risk calculation is based on the object fire danger analysis, the data obtained at the same time, are used to solve all subsequent problems in assessing fire risks, and therefore their quality largely depends on the final result reliability.

A processes parameters large part studied in the production facilities fire hazard analysis can be obtained from the relevant documentation or determined by direct measurements when inspecting the facility, but parameters such as pressure, gas temperature or liquid in tanks or pipelines may vary depending on many external factors, including the modes in which the process is taking place. At the same time, these parameters real values may differ significantly from nominal, so for the dangerous fire factors and fire risks fields more accurate calculation, it is advisable to use the technological processes characteristics as close to the actual ones as possible. One of the solving this problem most effective methods is a simulation, which allows reproducing with high accuracy the processes basic parameters in the dynamics. The SimInTech software complex is equipped with the corresponding capabilities, which is a universal environment for complex technical systems dynamic modelling, including processes taking place in various industries with simultaneous management modelling. Focused on non-stationary processes detailed analysis in nuclear, thermal power plants, automatic control systems, etc. SimInTech features the models’ expansion based on specialized modules, which allows to significantly reduce the building labour costs the necessary models.

2. Methods
This article's research object is a combined heat and power plant built according to the CHPP-300 standard design. The object fire hazard analysis was carried out on the methodology [1] basis using the
parameters obtained as their simulation result in the SimInTech [2] environment as the technological processes initial characteristics.

Since the technological processes list at the thermal power plant is quite extensive, the most dangerous of them were identified. For this, a CHPP territory model was built with the main objects: buildings and structures (figure 1).

![Abakan CHPP territory model](image)

**Figure 1.** The Abakan CHPP territory model.

Of the facilities presented in figure 1, the most dangerous is the fuel oil sector with fuel oil pipelines. The fire hazard of the fuel oil economy and fuel oil pipelines is determined by the following characteristics [3]:

- fuel oil storage tanks volume and dimensions;
- fuel oil characteristics as a combustible load;
- fuel oil temperature and height of the liquid column in the tank;
- the pipeline length and internal diameter;
- fuel oil supply method;
- the pipeline laying method
- fuel oil pressure in the pipeline.

Most of these parameters are determined by structural and space-planning solutions used on the CHPP territory. However, the fuel oil pressure in pipelines directly depends on the technological processes modes. Moreover, it is these parameters that largely determine the estimated fire risk [4]. Therefore, to obtain them as close as possible to the actual values, it is advisable to use the corresponding technological processes simulation. Figure 2 shows a fuel supply system simulation model fragment.
3. Results
Technological processes simulation modelling in various modes was carried out to determine the main parameters necessary for the fire hazard analysis. For a dedicated system, this is the pressure in the oil pipeline that supplies fuel to the main building. The simulation results are shown in figure 3.
As you can see, the pressure operating parameters in the pipelines reach a maximum value of 1.15 MPa. Based on the data obtained, a computational analysis of fire hazard was performed using the PromRisk software environment [5], which results in the most dangerous scenario are presented in figures 4-6.

Figure 3. Modelling the fuel oil supply system results.

Figure 4. A scenarios tree fragment for the fire hazardous situations development for a fuel oil pipeline.
Figure 5. Overpressure graphs for an explosion scenario when a fuel oil pipeline is destroyed.

Figure 6. The destruction probability graph for the scenario of an explosion when the oil pipeline is destroyed.

On the potential risk obtained values basis the individual fire risks calculation was also carried out, according to [1]. The calculation results, as well as their comparison with similar data obtained for the nominal pressure values in the oil pipeline [6], are presented in table 1.
Table 1. Calculation of individual fire risk R in buildings and on the investigated object territory.

| Person group                      | R taking into account the nominal pressure values (year\(^{-1}\)) | R taking into account the model pressure values (year\(^{-1}\)) |
|-----------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| The administrative building staff | 9.509 ∙ 10\(^{-7}\)                                          | 1.227 ∙ 10\(^{-6}\)                                          |
| Fuel oil pump station personnel   | 5.495 ∙ 10\(^{-7}\)                                          | 6.111 ∙ 10\(^{-7}\)                                          |
| The CHPP main building personnel  | 5.935 ∙ 10\(^{-8}\)                                          | 1.184 ∙ 10\(^{-7}\)                                          |

4. Discussion

As can be seen, when using pressure model values in the fuel oil pipeline, the calculated individual fire risk for the administrative and household building personnel of the exceeds the standard value 10\(^{-6}\) year\(^{-1}\) [7], therefore, it requires the appropriate measures' development. When using the nominal values, the obtained value is within the permissible limits. Thus, in the considered scenario, a relatively small numerical difference (about 22%) in the fire risk obtained values is critical in exceeding the standard value terms.

5. Conclusion

Based on the results obtained, it can be concluded that the complex technological processes simulation modelling use to determine their parameters makes it possible to more effectively solve the analyzing fire hazard problem, using the obtained values as initial data.

References

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