Evaluation of explosive parameters of fuel oil additive manufacturing technology

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Abstract. The widespread use of fuel oil stimulates the development of fuel additives to improve its technological properties. In this work, the parameters of the explosiveness of the technology for obtaining an additive based on the use of industrial alcohols are estimated. The schemes of development of typical scenarios of accidents have been developed, zones of destruction of buildings and structures and zones of damage by thermal radiation from the flame boundary have been determined for the accepted conditions. The research results can be used in the design and implementation of the technology for producing fuel oil additives based on flammable liquids.

1. Introduction

Fuel oil is one of the main energy sources for thermal and power plants, boiler plants, industrial furnaces, housing and communal services in agricultural production. Various brands of fuel oil, being products of oil refining, contain organic compounds in their composition, which impede its transportation, efficient and complete combustion, during combustion they emit substances harmful to the environment and act aggressively on the metal surfaces of heating units.

To improve the quality of fuel oil, additives of various compositions are used, each of which improves one or several characteristics of the fuel. In total, over 100 different additives have been developed - depressants, polymer and copolymer compounds, anticorrosive inhibitors, neutralizers of hydrogen sulfide and mercaptans, liquid and solid additives based on carbon sludge, carbon nanotubes and others [1-8]. The additives reduce the pour point and thereby increase the rheological properties of the fuel, lower the ignition temperature and improve combustion, in which less harmful components are released (nitrogen and sulfur oxides, CO₂, benzo (a) pyrene, and others).

The use of additives today is an important way to improve the properties of fuel oil, for example, in the USA, over 90% of consumed fuel oil is treated with additives [6-7]. An insufficient amount of additives is produced in Russia and their production will increase in the coming years.

2. Materials and methods

The paper considers the technology of obtaining an additive to fuel oil, consisting of a flammable liquid (industrial alcohol - flammable liquid) and specialized additives. The content of flammable liquids in the mixture is more than 80-90% and therefore the additive itself belongs to the flammable liquids class. The practice of working with flammable liquids indicates that the potential dangers of such technologies are the loss of tightness of storage tanks, pipelines and equipment. In such cases, the flammable liquid will leak with subsequent evaporation. Vapors of flammable liquids can create a
toxic environment and cause personnel poisoning when they are in the zone where maximum permissible concentrations are exceeded. With the concentration of flammable liquids vapors in the region of the upper and lower concentration limits and the presence of ignition sources, an explosion of flammable liquids vapors will occur. The power of the explosion will be determined by the mass of flammable liquids vapors and the characteristics of the space (room or open space). Depending on the capacity, destruction of equipment, buildings occurs, and destruction of buildings in the environment is possible. At excessive explosion pressures of more than 5 kPa, a person is injured.

An explosion of flammable liquids vapors can occur during external uncontrolled heating of sealed containers (for example, from a fire). Such explosions are called "BLEVE" and they have significant power, so that significant volumes of flammable liquids vapors can be involved in the explosion.

In case of leaks (spills) of flammable liquids and the presence of sources of ignition, flammable liquids ignite, in which a person's thermal injury occurs. If you are in the area of ignition of combustible substances and materials, a fire is possible. The consequences of the fire will be determined by the volume of flammable liquids spills and the organization of extinguishing and eliminating the consequences of the fire.

Potential dangers of production with the participation of flammable liquids are realized in emergency situations, the probability of which depends on the production technology. The technology for obtaining fuel oil additives considered in this work is represented by the following technological blocks, the characteristics of which are given in table 1.

| Block number | Name block | Characteristics of processes and equipment |
|--------------|------------|------------------------------------------|
| 1            | Acceptance of raw materials (flammable liquids, special additives) and shipment of finished products at the overpass | Draining raw materials (flammable liquids, special additives) and filling finished products into vehicles (road or rail tank cars) |
| 2            | Moving raw materials to an open warehouse for temporary storage | Pumping raw materials through a pumping station into storage tanks |
| 3            | Storage of raw materials and finished products in an open warehouse | Temporary storage in containers at an equipped site |
| 4            | Transfer of raw materials for additive production | Pumping raw materials and special additives through a pumping station |
| 5            | Additive production | Mixing processes of additive components |
| 6            | Transfer of the additive through a temporary storage warehouse to the site for shipment of finished products | Loading and unloading operations through a pumping station |

3. Results
With a quantitative assessment of the energy indicators of technological units for explosion and fire hazard, carried out according to the normative methods [13-15], the following results were obtained:

- Explosion of flammable liquids vapors with the formation of an overpressure explosion is most likely in an open warehouse for receiving raw materials and finished products;
- A fire during the spill of flammable liquids with accompanying thermal radiation is most likely at the overpass for receiving raw materials and shipment of finished products.

The amount of hazardous substances involved in emergency situations is determined by the volumes of containers used and the volumes of vehicles supplied with raw materials (alcohols).
The parameters were estimated for the specified initial data:

- Flammable liquids - industrial alcohol-methanol;
- Volume of raw materials supplied at a time (tank truck) - 9 m$^3$;
- Tanks for technological storage of alcohols and additives - 20 m$^3$.

The calculation results for the most unfavorable scenarios are shown in tables 2-3.

**Table 2.** The values of the radius of destruction by excess pressure of the explosion.

| Radius of destruction and damage to humans | metre |
|-------------------------------------------|-------|
| Open warehouse for receiving raw materials and finished products | Destruction of open storage tanks | 7.6 |
| | The lower threshold of damage to a person by a pressure wave, 5 kPa | 56.2 |

**Table 3.** The values of the radius of destruction by excess pressure of the explosion.

| Radius of human affected areas | metre |
|--------------------------------|-------|
| Outdoor unit for receiving raw materials (overpass) | *Human defeat* | 2.2 |
| | *Safe impact zone* | 10.4 |

Explosion hazard categories of technological units were calculated based on the value of the total energy potential and the reduced mass of the substance forming an explosive cloud [2]. All technology blocks have the third category of explosion hazard.

4. Discussion and conclusion

The obtained results of potential hazardous factors of fire and explosion and the category of explosion hazard of technological units of the technology for obtaining additives to fuel oils based on flammable liquids can be used in design and production.

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