Development of a Calculation Methodology for the Ventilation on a Besis of a Mobile Unit

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Abstract: An algorithm for the analysis of safety and efficiency of the processes, which are located inside the mobile unit are developed. It follows from the calculations that the safe concentration of combustible material in the space of industrial premises is about 3.69%. Automation systems must be focused on this value. The time of occurrence of the maximum permissible concentration of pollutant was determined and amounted to 160 seconds. It is shown that the ventilation rate of 0.5 would be sufficient for functioning of the object.

1.Introduction

Technological processes, occurring in the territory of the mobile units, require both safety and operation efficiency. The analysis order and reviwering the situation development is urgent because the operation stability of the facility and staff safety health depend on the successful application of the developed actions. Emergencies, related to the ignition of flammable gases in the mobile unit, may occure in case of nonobcervance of general hygiene requirements for the air of working area, as well as fire and explosion safety. In most cases, these accidents are accompanied by high material costs for the companies involved in operation of the facility and the significant environmental damage [1,2].

The aim of this work is to develop methods (algorithm) of choice of ventilation for mobile units, which spaces are used as an industrial premises.

2.Analysis of the object

The object, for which the algorithm was developed, is a mobile unit, located in a standard 20-foot container, that allows to provide transportability, autonomy, the ability to model different operating conditions in a confined space.

Traditionally container is insulated with 10 cm styrofoam layer, floor strengthening is made by metal beams, the door is cut through for the access to the maintenance of working capacities with feedstock.

The container is lined with plasterboard inside, equipped with electrical panels and means of fire safety. Power outlets and lighting are set.

All metal parts are made of stainless steel in order to avoid premature corrosion of the metal, because operation temperature of the object varies from -30 ° C to +70 °C. Instalation design is optimized to maximize the use of final products: pipes, fittings.

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3. Analysis of the facility safety

Installation, that is located in a mobile unit, is under overpressure of 0.04 atmospheres. Based on the fact that the gas is promptly removed from the gas tank - maximum pressure in the system does not exceed 1.04 atmospheres.

Part of methane obtained after purification is used for the gas electric generator disposed in the container, providing the work of all electrical systems and serving as a source of heat. The power of generator is 1000 watts. Burning of 4 m^3 of methane in power generator provides 12 kW of power and 24 kW of heat.

The main hazard in the operation of the facility is methane gas. Table 1 summarizes the main characteristics of methane [3].

Table 1. Main characteristics of methane

Indicator	**methane**
Chemical formula	CH_4
The density of the gas phase under NC*, kg/m^3	0.717
Net calorific value under NC *, MJ/m^3	35.76
The lowest concentration limit of inflammation of mixture with air under NC* , ^0C	5.0
Weight explosive limit, %	5.0...15.0
MPC in the air of working area, mg/m^3	7000
MPC in atmospheric air, mg/m^3	50

NC * – under normal conditions (t = 0 ^{0}C; p = 101.3 kPa)
MPC – maximum permissible concentration
Fire extinguishing means: inert gases

It follows from the analysis of the results that inflammation area in air is 5,28-14,1% vol., concentration limit of inflammation (reduced to 25 °C): lowest 5.28, top. 15% vol.

We are interested in the lowest concentration limit of inflammation - about 5.28%.

Measures to ensure fire and explosion safety processes were developed according to the requirements of State Standard 12.1.004 and State Standard 12.1.010.

According to these documents to ensure fire and explosion safety of production processes, processing, storage and transportation of substances and materials it is necessary to use data rates of fire and explosion hazard of substances and materials with a safety factor *φg no ≤ 0.9 (φn – 0.7 R)*

where φg safety - a safe concentration of the flammable substances,% vol. (gm-3); φn - the lower flammability limit of a mixture of a fuel with air,% vol. (gm-3); *R* – reproducibility of the method of determining the fire danger rating at 95% confidence level.

Calculations show that a safe concentration of the flammable substance is about 3.69%.

4. Definition of the time to reach maximum permissible concentration (MPC) or explosive concentrations of pollutant from the material balance

When production area has no forced ventilation or ventilation is not reliable (there are no redundant fans, electric power is not carried out by two independent feeders), the most favorable conditions for the formation of explosive concentrations in case of damages and accidents at production facilities and pipelines are created.

In this case, the amount of flammable material coming out of the equipment during the time interval $d\tau$, must be equal to the increment of the amount of flammable material in the air volume over the same period of time $d\tau$, or

$$qd\tau = VdC \tag{1}$$

where q – amount of substance emitted to the outside in the unit of time; V – volume of the room; dC – increment of the concentration of flammable material during $d\tau$.

$$\tau = \frac{C_{ЗАГ}}{q} V \tag{2}$$

Figure 1 shows a graph of a linear relationship - the result of the calculation using the equation (2), which clearly shows that the increase in the concentration of the pollutant is uniform over time. The graph shows that the time to reach a dangerous situation, if the exhaust velocity of methane in the volume space is 160 seconds. The rate of inflow of methane in the areas was taken from statistically average datas - 0.00072 g / s. The time of hazard situation was determined based on the fact that the lowest flammable limit was taken (5.28 vol.%), which was converted based on the safety factor (0.32%). Finally we got the concentration (3.69% vol.), which was correlated with the dependence graph, thereby the occurrence time of a dangerous situation was determined. The obtained time plays an important role in the choice of technological equipment of ventilation systems, which the operation of automation systems will focus on.

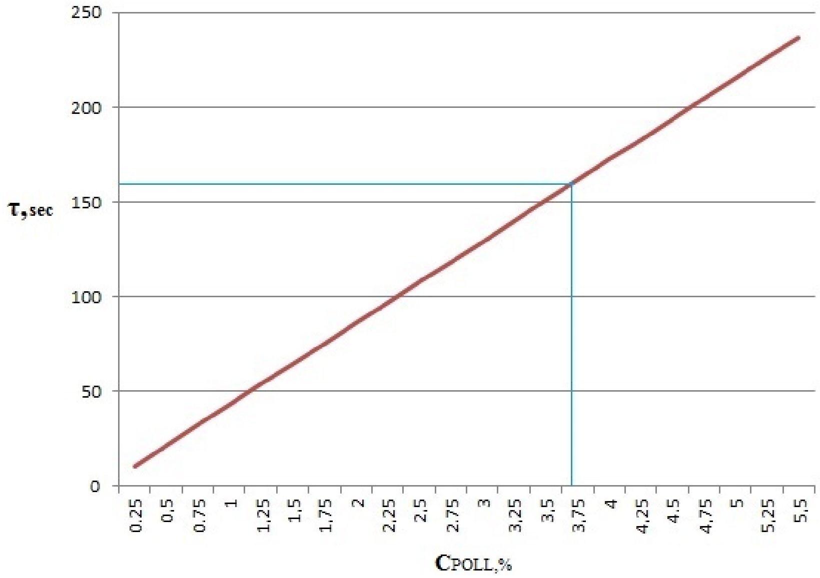

Figure 1. Graph of a linear relationship.

During the calm weather, general ventilation, which is carried by the deflector will not be effective. In this case, when the concentration of the pollutant reaches its limit, the start of emergency ventilation must be operated automatically.

Figure 2 shows the results of further calculations, taking into account the ventilation rate in the room. Analyzing the chart we see that the ventilation rate of 0.5 would be sufficient for the safe operation of the facility. This value is important in the selection of ventilation systems, because it shows the required volume of air to be disposed from the room.

In case of guaranteed ventilation rate a part of an outgoing vapors or gases in the accident are continuously withdrawn from the production area to the outside, as a result the increase in the concentration to dangerous limits will relatively slow down.

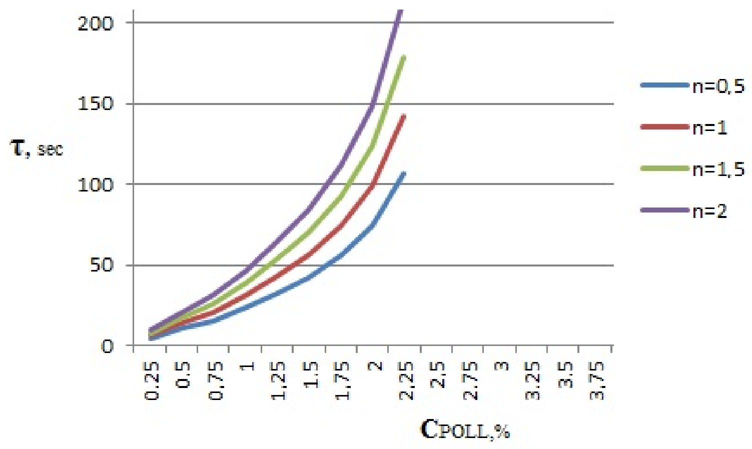

Figure 2. The rise time of the concentration of flammable vapors and gases in the volume of the mobile unit based on the ventilation rate.

In significant damages and accidents devices or pipelines with flammable vapors and gases in the premises an explosive concentration may form even when the operation of ventilation (including emergency), and so quickly that it would be impossible to implement the necessary emergency actions manually [1, 2, 4–6].

The inclusion of the ventilation system is performed when a safe concentration of a fuel (methane) is exceeded, which is about 3.69%.

5. Development of the algorithm of research for the ventilation system of the object

Figure 3 provides an algorithm for the research of the object on the basis of the mobile unit.

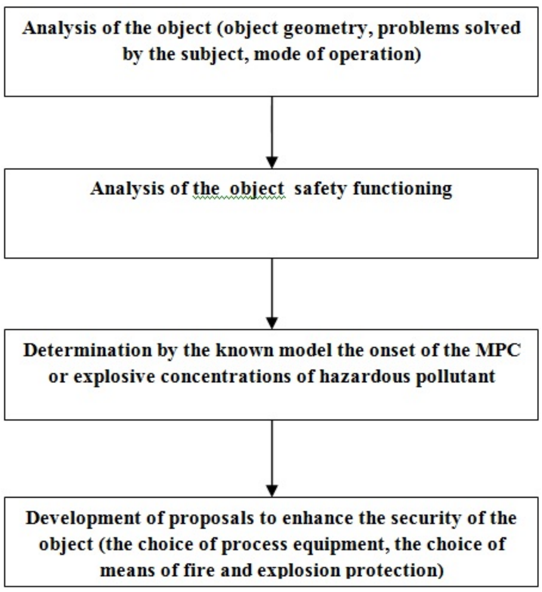

Figure 3. The research algorithm for the object on the basis of the mobile unit.

6. Conclusion

In the result of the research the algorithm to analyze the safety and efficiency of the processes, which are located inside the mobile unit was developed.

It follows from the calculations that the safe concentration of combustible material in the space of technological premises is about 3.69%. Automation systems must focus on this data.

The time of occurrence of the maximum permissible concentration of pollutant was determined and amounted 160 sec. It was shown that the ventilation rate of 0.5 would be sufficient for the investigated object.

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