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Study of the possibility of the phenomenon of fugitive emissions in current petrochemical productions

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Abstract. All processes in the chemical and petrochemical industries generally consist of a number of comparable standard processes, although the products produced may be different. In the chemical engineering industry and related industries, a standard process is a basic stage in technology. For example, in the production of ammonia (NH3), gasification, reforming and NH3 synthesis are standard processes that are linked to each other and create a complete technology. In practice, the technological chain of methanol production also follows this sequence. So does the production of urea. The technology of individual production may consist of a large number of standard processes to obtain the desired product. However, the mechanisms of formation of fugitive emissions in any aggregate state differ little, except for the chemical composition of the emissions. It became possible to use the results of this study and methodology successfully and other installations and industries.

Keywords: technology, processes, production, methanol, organized, fugitive emissions, ecology, thermal imaging control.

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Introduction. As is known, technological installations, emissions into the atmosphere are divided into 2 types: organized and unorganized. Analysis of unorganized emissions acquires special significance after a long period of operation of the installation, after the elimination of major technological accidents, when starting up newly introduced into operation after capital construction and fundamental technical re-equipment and reconstruction to avoid loss of resources and pollution of the environment. It is noted that the petrochemical industry is only a secondary source of emissions for most pollutants (1, 2). In this paper, we will consider the possibilities of analysis and calculation of unorganized emissions in the current production of methanol after long-term operation and relocation.

Conducting the experiment

The studies were conducted at all potential locations (points) of fugitive emissions (leaks) on process pipelines, units, vessels and devices of auxiliary, main production and tank farm.

The survey of "points" of potential leaks was carried out using thermal imaging control technologies. Experimental studies in operating conditions were carried out according to the main provisions of the developed thermal imaging control technology. Before conducting thermography, all necessary preparatory operations were performed. As diagnostic equipment, a FLIR GF320 thermal imager was used. The device is capable of quickly surveying large areas and determining the presence of hydrocarbon gas leaks in real time (3). Recently, intelligent thermal imaging equipment has been successfully used, which is an effective tool for monitoring any changes in temperature in a wide variety of areas and industries, to ensure safety at production facilities in order to identify defects and prevent leaks of hazardous substances (the accuracy of the determination is up to $\pm 2^0$ or ±2%) (4).

The number of surveyed "points" of potential leaks was initially determined by analyzing process flow charts based on working drawings. Their preliminary estimated number was 7,579. Of these, 270 "points" relate to auxiliary production, 498 to the tank farm, i.e., tanks for storing finished products, raw materials and reagents, intermediate semi-finished products that participate in the technological process of production, waste obtained as a result of side reactions, which are subsequently processed into target products (5).

Results and their discussion

As a result of using thermal imaging control technologies on process pipelines, units, vessels and devices of the entire production, 7579 possible leak points were analyzed. Of the total 7579 inspected "points", leaks were detected in 29 "points". Of these, 1 "point" related to the tank farm, the rest directly related to process equipment, communication pipelines, elements of the contour of measuring and actuators. All analyses

of unorganized emissions, namely their volumes are calculated in kg per year. Based on the analysis and calculations, the total annual volume of unorganized emissions for the main components was established. The calculation results are shown in Figure 1.

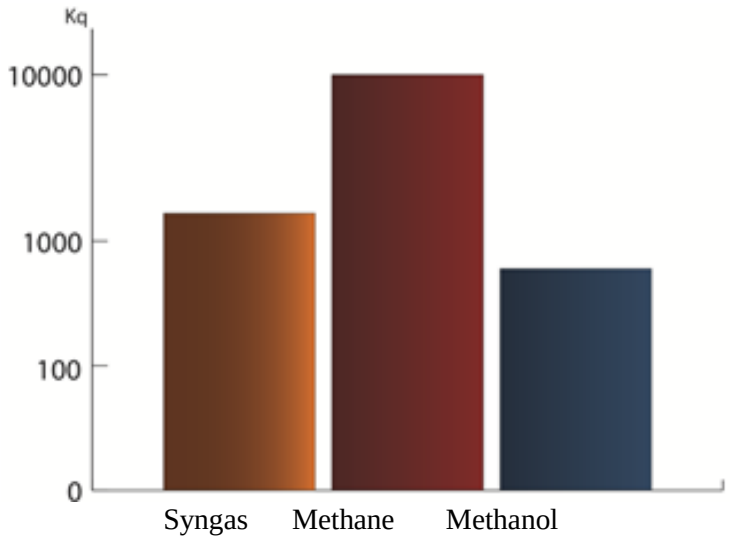

Fig. 1 The final calculated volume (mass fraction) of unorganized hydrocarbon emissions, kg/year. Based on the analysis of this diagram, it can be noted that the mass fraction of methane prevails and is 19995.43 kg/year. The mass fractions of synthesis gas and methanol are 1997.28 kg/year and 963.60 kg/year, respectively. Consequently, the final calculated volume (mass fraction) of unorganized hydrocarbon emissions is 22956.31 kg/year.

The analysis of possible leak points and calculation of the volume of unorganized emissions of fuel gas - methane by element type was carried out. The analyses were carried out in 5188 "points", 24 of which were noted leaks. Since methane is used in the methanol production process and the quality of raw materials, and the quality of fuel with the first considered losses before the distribution of flows. According to the analysis of unorganized methane emissions in the initial Bosch process flows, several fuel gas leak points were found below:

1) stuffing box - 1401.60 kg / year
2) threaded connections - 262.80 kg / year
3) other - 18331.03 kg / year

Total: 19995.43 kg / year.

Detection of fuel gas - methane emissions leaks by element type was carried out using the thermal imaging method of photographing possible leak points according to the process flow chart. The results of thermal imaging of fuel gas leak locations are shown in Figures 2, 3, 4, 5.

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
10	Coupling connection of nozzle D-7(American)	Natural gas
Photo of the object Thermal imaging		

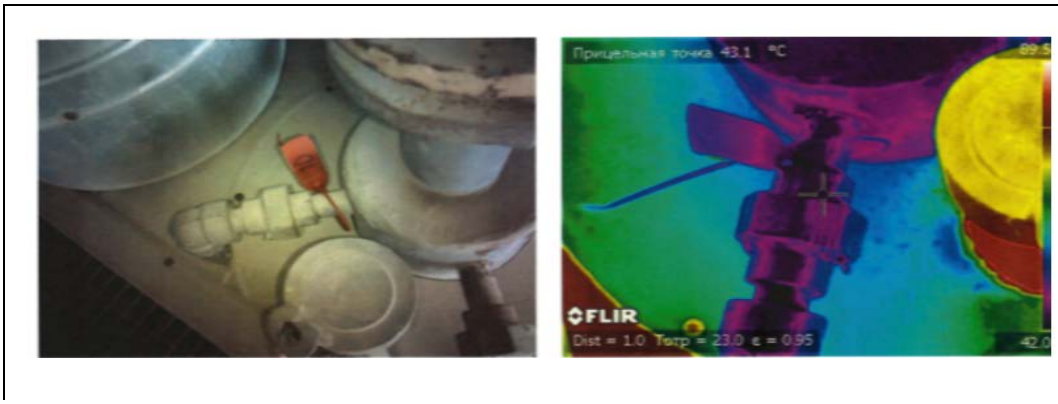

Fig. 2. D-7 injector coupling (American)

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
10	Welded seam on line of fuel gas to nozzle İ-5	Natural gas
Photo of the object		Thermal imaging

Fig.3 Welded seam on the fuel gas line to the İ-5 injector

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
10	Coupling connection of nozzle Q-2	Natural gas
Photo of the object		Thermal imaging

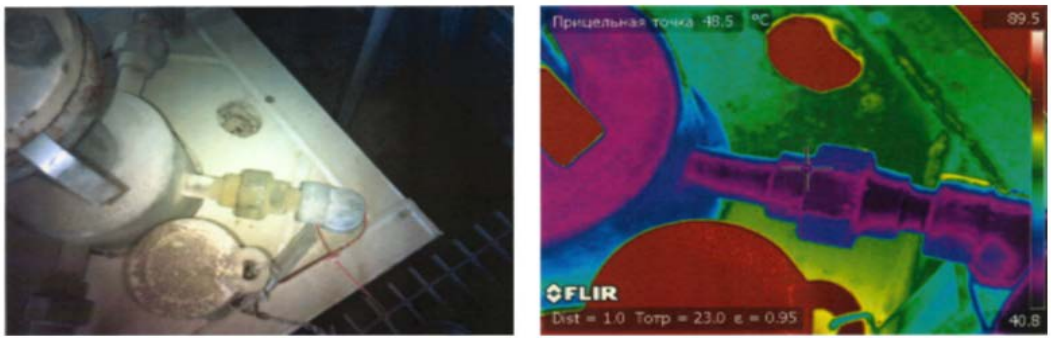

Fig.4. Coupling connection of the Q-2 injector

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
10	Threaded connection of flexible connection of nozzle A-7	Natural gas
Photo of the object	Thermal imaging	

Fig. 5. Threaded connection of the flexible connection of the A-7 nozzle

The estimated volume of unorganized emissions of natural gas is shown in Figure 6.

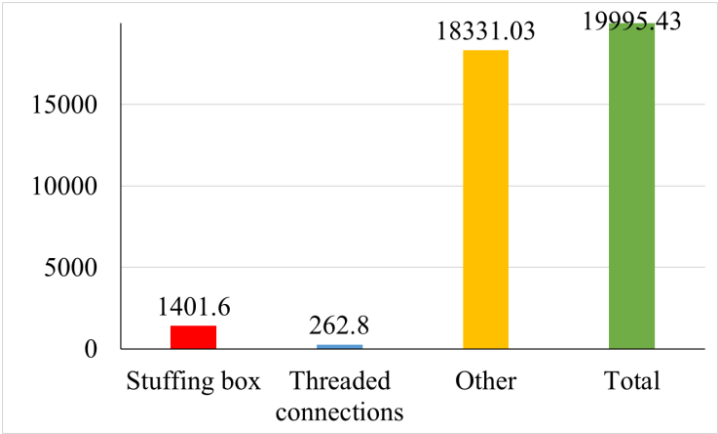

Fig. 6. Estimated volume (mass fraction) of unorganized emissions of natural gas kg/year

Considering that methane entering the reaction environments already ceases to exist as methane in the future, its loss is considered in the context of hydrocarbon loss. After distribution, the second flow is the fuel circuit. Dali conducted an analysis of unorganized emissions of methane in the fuel circuit. According to the analysis, specific places of unorganized emissions in the process equipment of the following units were established:

1) nozzle connection - 7992.42 kg/year:
threaded connection 1 - 7729.62 kg/year
threaded connection 2 – 262.80 kg/year
2)welded seam – 1927.20 kg/year
3)ball valve – 1401.60 kg/year
4)non-hermetic device – 8674.21 kg/year
Total: 19995.43 kg/year.
A graphical representation of the obtained results is shown in Figure 7.

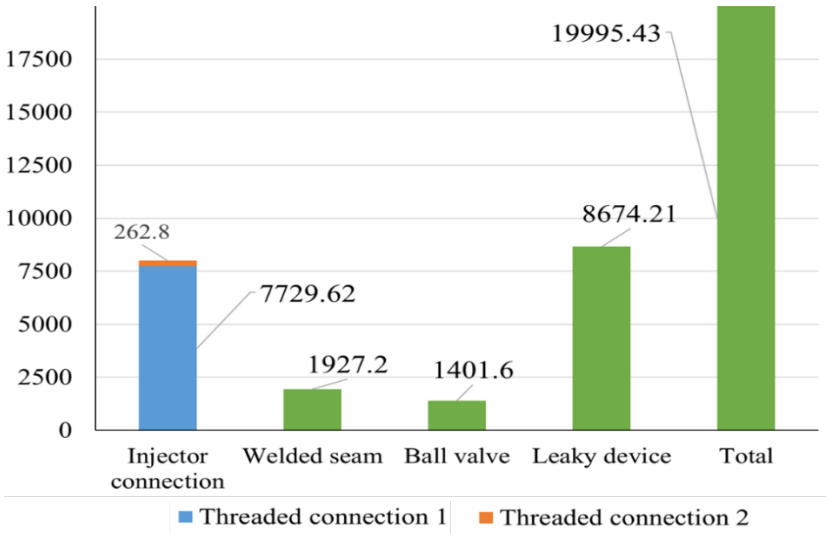

Fig. 7. Estimated volume (mass fraction) of unorganized emissions of fuel gas by positions kg/year

The second source of gaseous loss in the methanol production process is synthesis gas. It should be noted that the technological communication circuit of synthesis gas is much shorter than that of fuel gas. Accordingly, the checked control point is also comparatively smaller.

Analyses were carried out in 601 "points". Detection of synthesis gas emission leaks by element type was also carried out using the thermal imaging method of photographing possible leak locations according to the process flow chart. The results of the thermal imaging image of synthesis gas leak locations are shown in Figures 8, 9.

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
24	Threaded connection of valve of selection on device item FE-2789(HE-401)	synthetic gas
Photo of the object		Thermal imaging

Fig. 8 Threaded connection of the sampling valve on the device item FE-2789(HE-401)

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
25	Threaded connection of valve of selection on device pos. AT-18794(R-401)	synthetic gas
Photo of the object Thermal imaging		

Fig. 9. Threaded connection of the extraction valve on the device item AT-18794 (R-401)

Based on the analysis of the calculated volume of unorganized emissions of synthesis gas by element type, the following results were obtained:
1) flange connections - 1471.68 kg/year
2) stuffing box - 525.60 kg/year
Total: 1997.28 kg/year.
A graphical representation of the obtained results is shown in Figure 10.

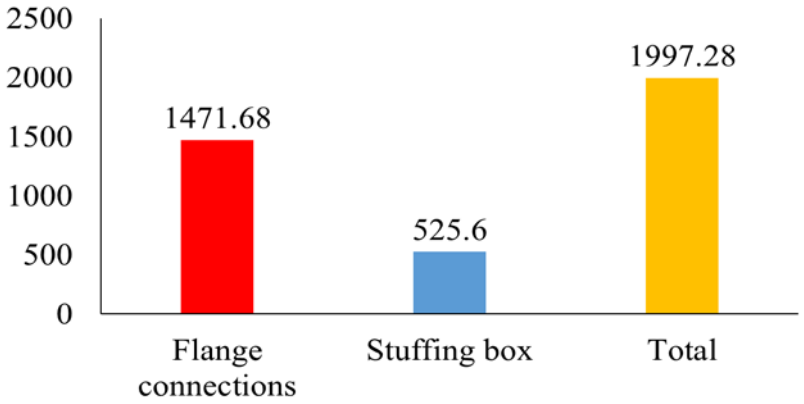

Fig. 10 Estimated volume (mass fraction) of unorganized emissions of synthesis gas kg/year

A control analysis was carried out for a specific equipment position and connection point in the process circuit of synthesis gas and the following results were obtained:
1) flange connections - 735.84 kg/year
2) threaded connection - 525.60 kg/year
3) valve - 735.84 kg/year
Total: 1997.28 kg/year

A graphical representation of the obtained results for specific places - equipment of unorganized emissions of synthesis gas is given in Figure 11:

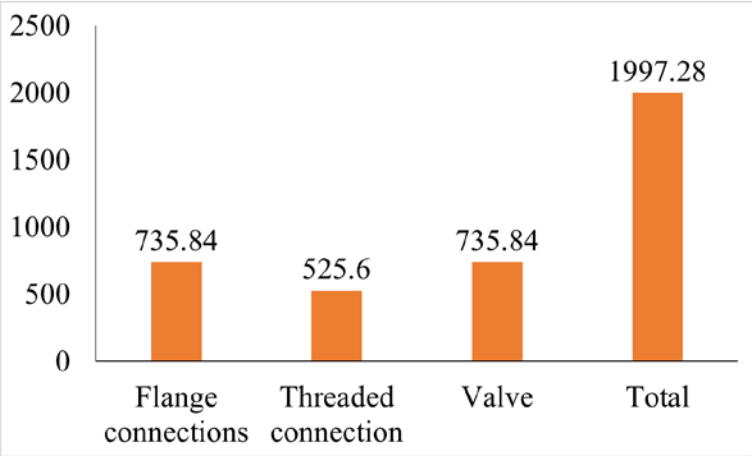

Fig. 11 Estimated volume (mass fraction) of unorganized emissions of synthesis gas by items, kg/year

As noted technological installation has 498 tank equipment. Taking into account the harmful properties of methanol were conducted analyzes in 1790 "points". It was established in one place - equipment of unorganized emissions of methanol:

1) shut-off lid - 963.60 kg / year.

Photo image of the detected checkpoint is shown in Figure 12.

Serial number	Type of pipeline element, pipeline fittings, device, unit	Environment
29	Cover of measuring device of tank 24TK-0024	Methanol

Photo of the object Thermal imaging

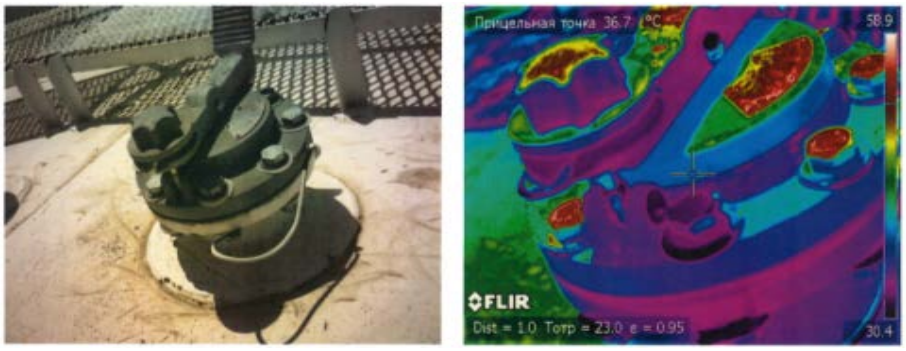

Fig. 12. Cover of the measuring device of the tank 24TK-0024

The analysis of the above data shows that there is a high overall level of hydrocarbon losses and an extremely high level of hydrocarbon losses relative to the amount of unorganized emissions after a certain time of operation of the equipment. Based on this, after long-term operation of the production unit, it is necessary to conduct a control survey of the technical condition of the process equipment, communication pipelines, connecting nodes and the tightness of the seals. Systematic qualified analysis of the state of unorganized emissions at the production enterprise is also a guarantee of safety, explosion-fire safety, stable operation, high economic efficiency.

Conclusions

According to the analysis results, it can be noted that the mass fraction of methane prevails and amounts to 19995.43 kg/year. The mass fractions of synthesis gas and methanol are 1997.28 kg/year and 963.60 kg/year, respectively. Consequently, the final calculation of the volume (mass fraction) of unorganized hydrocarbon emissions is 22956.31 kg/year. The number of surveyed "points" of potential leaks using thermal imaging control technologies on process pipelines, units, vessels and devices of the entire production is 7579.

Of the 7579 surveyed "points", 270 "points" relate to auxiliary production; 6811 - to the main production, 498 - to the tank farm.

In 498 tank equipment, analyzes were carried out at 1790 "points" and only one case of unorganized emissions was detected, and 6811 points in the main production 29 cases of unorganized emissions. It has been established that the main share of unorganized emissions fall on the system of technological communication of methane and logistics. Based on this, in the quality of the applied significance of this study, similar enterprises are recommended to systematize and strengthen control in the presence of such systems and units.

Conflict of interest.

The authors declare that they have no conflict of interest in relation to this research.

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