The Effects of Pipeline Parameters on Dispersion Process of Odourant in Natural Gas Mixture

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Abstract**—** *This article discusses the possibility of natural gas odourisation, which is performed due to the fact that natural gas has no smell of its own. In order to facilitate the detection of potential gas leaks from distribution networks by the human sense of smell, the gas must be combined with an odourant. A concentration of such an odourant should be constant throughout the entire distribution network in order to facilitate the earliest possible detection of potential gas leaks.*

This article also deals with the issues related to the odourisation of natural gas in a high-pressure pipeline in a gas distribution network. It presents a theoretical overview of the used types of odourants, odourant control methods, and a model of odourant behaviour in a distribution network in various conditions, which was created using numerical simulations performed in ANSYS software.

Keywords— ***natural gas, odourisation, ANSYS, pipeline.***

I. INTRODUCTION

Natural gas is an important fossil fuel, which is used in multiple industries. When compared to other fossil fuels, the amount of harmful substances produced during the combustion of natural gas is smaller; moreover, natural gas does not produce any mechanical impurities, such as carbon black. Therefore, it may be classified as an ecological fuel. Due to the fact that it is odourless and lighter than the air, it is regarded as a problematic material in terms of safety. As a result, the detection of potential leaks of natural gas from a distribution network is conditioned by the presence of an odourant in a mixture.

II. NATURAL GAS ODOURISATION

Odourisation means the addition of substances with strong scents to natural gas. The odourisation process belongs to the fundamental processes in every company that operates in the field of gas transportation. Precise addition of an odourant, appropriate monitoring techniques and maintenance represent important factors that affect the development of an effective odourisation process. The importance of odourisation consists in providing an early warning for people in the event of an accidental gas leak from a gas pipeline or from an end-user gas facility. A choice of a correct odourant depends on a particular area of application and is affected by a variety of safety-related and economic factors. The odourants which are typically used in natural gas odourisation include sulphur-containing odourants (mercaptans, sulphides, and heterocycles containing sulphur).

III. ODOURANT CONTROL IN A MIXTURE WITH NATURAL GAS

A concentration of an odourant in natural gas changes due to the effects of various physical and chemical factors. However, in order to ensure safety, the gas must be treated so that it acquires a required level of scent at each point of a distribution network. The presence of an odourant in natural gas must be controlled on the regular basis. At present, a concentration of an odourant is usually tested by olfactometry, in which a smell intensity of the odourised gas is assessed by a human sense of smell. This method belongs to subjective control methods. Objective methods for the control of an odourant in a mixture with natural gas include chromatography. It is a laboratory separation method, which is used for the precise identification of an odourant concentration in natural gas. The underlying principle of chromatography is the separation of the individual mixture components between the mobile and the stationary phases based on different velocities of the individual mixture components. The presence of an odourant is identified using also electrochemical sensors that use electrodes placed in a gel electrolyte. The electrolyte and electrodes are separated from the surrounding atmosphere using a diffusion barrier, through which molecules of the measured gas penetrate and subsequently react with the electrolyte. An oxidation-reduction reaction on the electrodes results in a change in the cell potential. A rising potential means that a gas concentration increases.

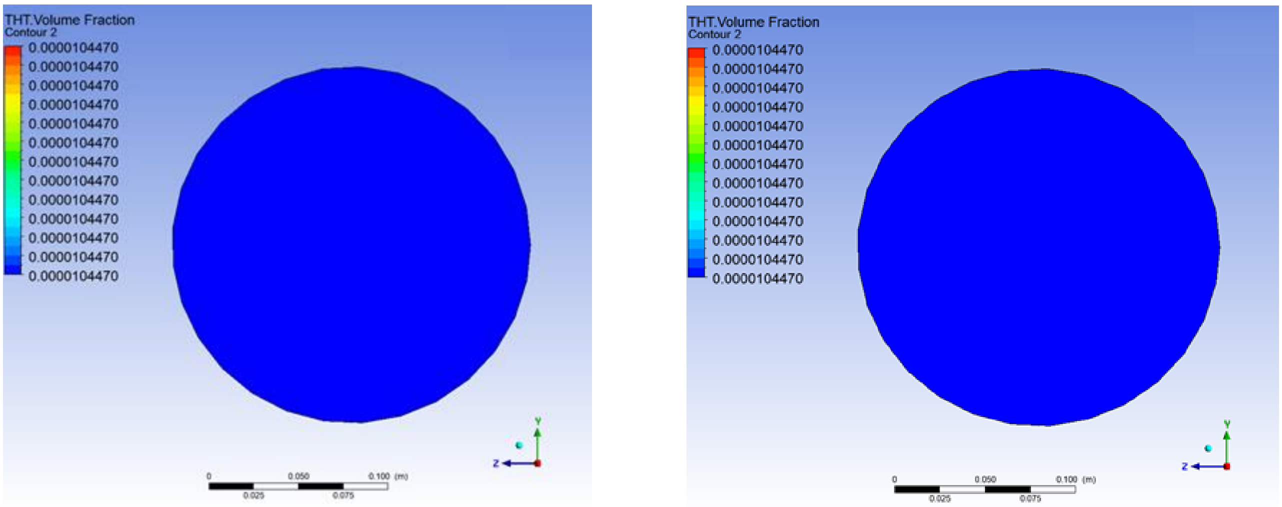
IV. THE PROCESS OF ODOURANT DISPERSION IN NATURAL GAS IN THE CFD SOFTWARE ANSYS CFX

A model of odourant dispersion in a high-pressure pipeline was created using numerical modelling, which may be used in addition to, or instead of, traditional experimental procedures. The modelling consists of designing a model, performing a simulation, and analysing the obtained data. The model designing step includes the determination of the initial and boundary conditions and the creation of the model itself. During the simulation, it is important to visualise and observe the problem. The advantages of a numerical simulation include a possibility of verifying several problem solution alternatives without reaching a high-cost level; if the adjustments are made after the device is already manufactured, the costs are high. The advantages also include the possibility to simulate the unacceptable long process in shorter duration.

The ANSYS CFX software environment uses the Finite Volume Method (FVM), which is based on the principle of representing differential equations in a form of a system of differential equations. The solution accuracy depends on a selected mesh density and on a differential scheme. It can be expected that as the finite volume mesh becomes finer, the more precise the problem solution will become.

V. THE EFFECT OF A PIPELINE LENGTH ON ODOURANT DISPERSION IN A MIXTURE WITH NATURAL GAS

For the purpose of investigating the effects of different pipeline lengths on odourant dispersion in a mixture, a simulation was carried out with two pipes of different lengths − 3 m and 30 m, but of identical diameters ($D = 200$ mm). The input parameters, i.e. the odourant concentration, natural gas flow rate and the pressure inside the pipeline, were identical for both types of pipe. The simulation results were evaluated by comparing the changes in concentration along the lengths and cross-sections of both pipes with different lengths.



a) A 3 m long pipe b) A 30 m long pipe

FIGURE 1: Odourant concentration in a mixture with natural gas at a cross-section at the pipe outlet

The changes in odourant concentration in a mixture with natural gas along the entire length of the investigated pipes are shown in Fig. 2 and Fig. 3; they show that the odourant concentration did not exhibit any changes throughout the entire investigated section of the pipeline.

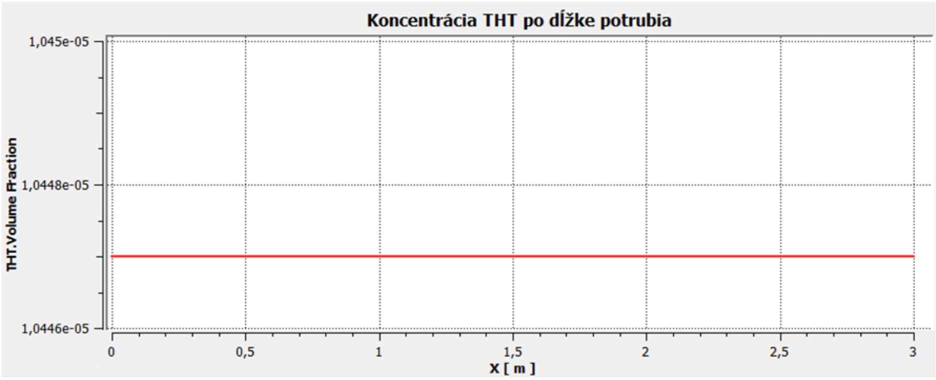


FIGURE 2: Changes in concentration along the length inside a 3 m pipe

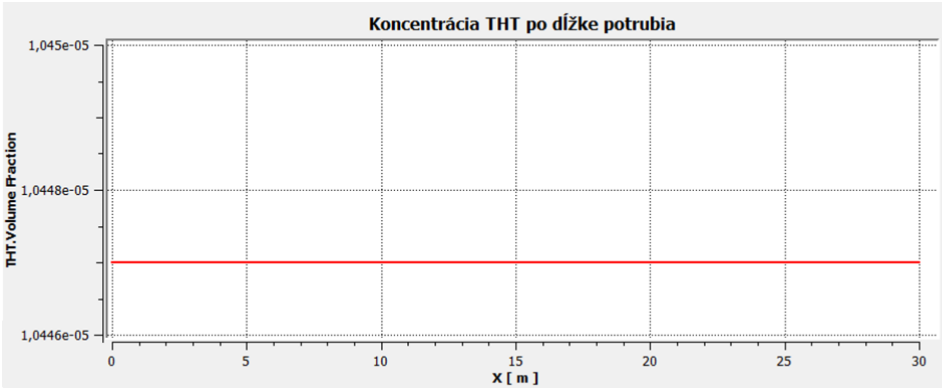


FIGURE 3: Changes in concentration along the length inside a 30 m pipe

Based on these findings, it is possible to state that with identical input parameters, i.e. the mass flow rate, pressure and the odourant concentration, the length of the pipe has no effect on changes in the odourant concentration in a mixture with natural gas.

VI. THE EFFECT OF PIPELINE ELEVATION ON ODOURANT DISPERSION IN A MIXTURE WITH NATURAL GAS

The investigation into the effects of pipeline elevation was carried out using two predefined pipeline sections, similar to those in the previous case. In these sections, changes in the odourant concentrations resulting from by different elevation values were compared, while the input parameters remained unchanged. In the first case, the flow in the main pipe with a diameter D = 200 mm was monitored. A delivery pipe with a diameter *D* = 80 mm was attached to this pipe at an angle of 45° and 5 m below the level of the main pipe (Fig. 4). In the second case, the pipes used were of identical diameters, but the delivery point was 5 m above the level of the main pipe.

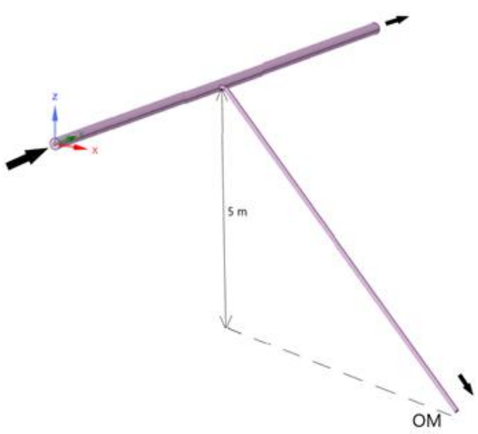


FIGURE 4: A model of a pipe with a delivery point (OM) 5 m below the level of the main pipe

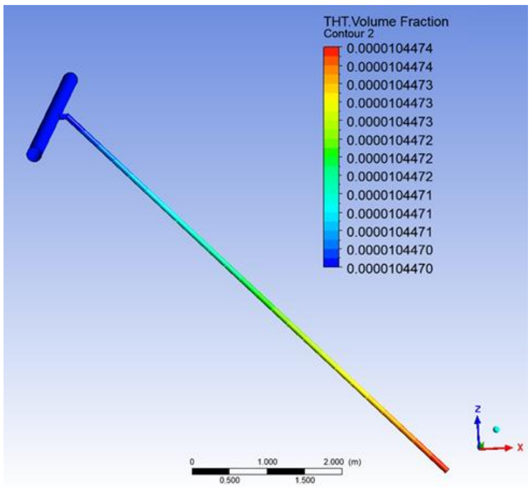


FIGURE 5: Changes in concentration with a descending elevation of -5 m

Fig. 5 indicates that a lower attitude of the investigated pipeline point correlates to a higher odourant concentration. However, it must be noted that in descending elevation of -5 m, an odourant volume fraction only begins to change at 10th decimal place. Such changes in concentration are practically immeasurable, and hence negligible. The same result may be observed with ascending elevation (Fig. 6). Despite the fact that the odourant concentration in the mixture decreases as the altitude of the delivery point increases, such a change occurs again at the 10th decimal place; this means that the change is negligible.

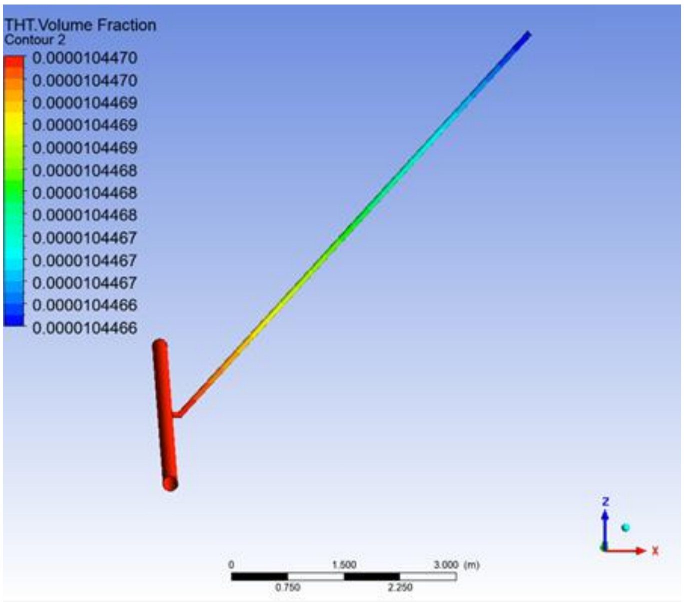


FIGURE 6: Changes in concentration with ascending elevation of 5 m

Based on a comparison of the results of both simulations, it is possible to state that pipeline elevation, similarly to a pipeline length, has no significant effect on changes in a concentration of an odourant contained in natural gas.

VII. CONCLUSION

The addition of odourants to natural gas is an important process, as it facilitates warning people in the event of an accidental gas leak from a gas distribution pipeline or from an end-user gas facility, and hence it prevents the risk of fire, explosion and intoxication. In our investigation, dispersion of an odourant in a natural gas distribution network was homogeneous, and the odourant together with natural gas formed a homogenous mixture, which remained unchanged in practically all sections of the pipeline. The pipeline inclination and length had no significant effects on changes in the odourant concentration.

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