Complex
Control
Systems
ISSN 1310-8255
Proceedings of the International Conference"Robotics & Mechatronics and Social Implementations"2018

ABOUT THE POSSIBILITY OF INSPECTING GAS PIPELINES

Ivanka PEEVA[1] *, Chavdar KOSTADINOV[2]

[1)] Assoc. Prof., PhD, Department Manufacturing engineering and machine cutting, University of Ruse, Ruse, Bulgaria
[2)] PhD, Department Manufacturing engineering and machine cutting, University of Ruse, Ruse, Bulgaria

Abstract: *This article explores opportunities for exploring underground gas pipelines with so to detect natural gas leaks and in case of such to ensure safe operating conditions. The work requires a precise choosing of equipment, as well as developing of an appropriate observation plan. The analysis presents the possibility of using UAVs, equipped with the necessary technical instruments to find problematic sections of the gas transmission network.*

Key words: *inspection, pipeline, UAV, drones, robotic systems.*

1. INTRODUCTION

The Gas pipeline investigation is based on taking actions and introducing methods needed for detecting and locating breakthroughs in underground placed facilities transporting natural gas and with so to immediately prevent losses and uncontrolled leakage. The natural gas leakage coming directly from underground placed steel and/or polyethylene gas pipelines could be due to damages caused by earthworks, bad connection parts, corrosion of steel pipes, cracks caused by manufacturing defects, transport loads, etc. (Figure 1).

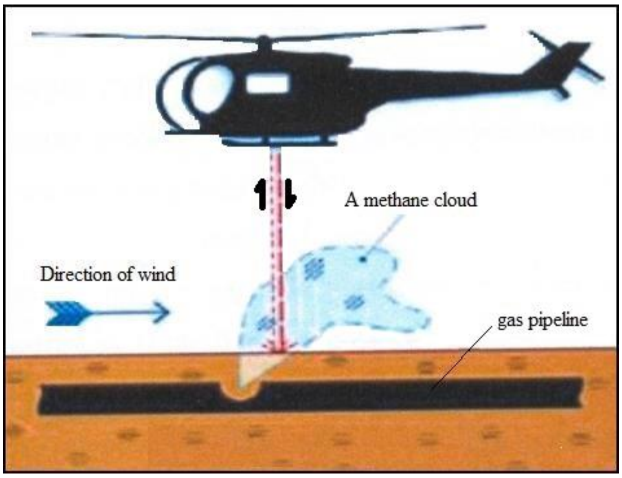

Fig. 1 Search for gas leaks with aircraft

The spread of the gas leakage depends on a variety of factors. The density of the surface above the pipelines is essential factor, a.k the gas amount can rise in height, so even a small break can lead to a high concentrations and wide spreads below the surface, for example underneath the street level. So when such areas with accumulated gas are found, especially under thick streets, they should be provided with special openings for ventilation purposes. Other factors are: soil climate, slope of the pipeline, the exhaust gases of automobile transport and the way of how gases penetrate into the soils [1].

There are many companies offering gas leak detectors such as Tokyo Gas Engineering - Japan, Testo, Vega, Kern, Herman Sewerin GmbH – Germany, Pergam – USA and others.

2. METHODS FOR THE INVESTIGATION OF GAS PIPELINES

The gas distribution companies in Bulgaria use mainly portable equipment for detecting leakage in facilities located under roadways in urban areas or even on locations with natural landscape, or a.k "walking on the ground" method. The method is based on a visual recognition of external signs, such as: dry vegetation, specific spots on a snow coverage, soil changes such as hardening around the area of leakage, or changes in its color and/or structure), bubbles on a water surface (as on swamps or lakes) or even on a road surface covered with rain water (Figure 2).

Fig. 2 Gas leakage spotted on the street

There are modern onboard laser systems (Figure 1) which are able to detect methane leakages on an operational height of 150 m and speed of up to 145 km/h, the achieved results are good even in wind gusts up to 13

* Corresponding author: 8 Studentska str., 7017, Ruse, Bulgaria
Tel.: +359 82 888 712;
Tel.: +359 82 888 742;
E-mail addresses: *ipeeva@manuf.uni-ruse.bg* (I. Peeva), *chkostadinov@uni-ruse.bg* (Ch. Kostadinov)

m/s [1]. Laser radiation is partially absorbed if there is methane in the path of the laser beam. The accuracy of the method depends on the wind speed, distance and surrounding. Such systems are being used to detect methane leakage in natural gas storage facilities, compressor stations, and many others. The method covers another types of gases that absorb radiation in a certain spectral range, which would require changes in laser parameters and later on the data processing. Nowadays, robotic gas pipeline monitoring systems are becoming more and more popular and reliable. There is a particular route mobile robots are programmed to use in order to observe in details the site where the pipeline is located. They have a special built-in navigation system to provide accurate tracking of the underground gas pipeline routes.

Unmanned Aerial Vehicles (UAVs) are increasingly becoming an universal tool in exploring variety of sites and territories. Putting additional equipment such as hi-res cameras, gas detectors and other sensors allows the inspection of pipelines to be managed on otherwise impossible to reach places such as under bridges, gas storage facilities, etc. [2, 3]. There are certain sites where "walking on the ground" creates difficulties or it is nearly impossible to be done by the service staff members. One example for the case is when the gas pipelines are passing through agricultural land and the survey could cause damage to the crops, which have to be compensated with certain amount of money. Alternatively, one another possibility is when a route passes through area surrounded by fences, which means there is no free access to the facilities.

UAV (or as called "drone") equipped with gas detector allows checking such zones quickly and conveniently. Despite the numerous benefits, their massive use is still limited because of many regulations and requirements applied on the usage of UAVs, as well as the battery capacity. Figure 3 shows a system of the American company "Pergam" which includes a drone, a laser methane detector and a camera for locating natural gas leakage.

Fig. 3 "Pergam" Equipment - United States [3]

The whole system can be programmed to follow certain routes and maps in order to optimize accuracy of collecting data, data export and calculation of an exact amount of methane and his concentrations in any leakage spots, storage images of it on memory card and some other functions as well.

3. PERFORMANCE PLANNING ALGORITHM

It is highly recommended to set up a plan with actions in order to observe accurately a section of the gas transmission network. The diagram of an algorithm for scanning such areas (Figure 4) includes the following characteristics, such as:

Step 1: In the part of task analysis, it is necessary to determine a base (initial point - hp), of which the survey device would start the observation.

The pipeline route is divided into sections that are within a certain distance, depending on the possibilities of using the UAV, the terrain, the infrastructure or other specific features.

At first, it will be monitored for visible signs of gas leakage. In the presence of such critical zones, it is necessary to check the gas concentration in those areas. For the purpose of it, it is necessary UAV to land, if possible, and to take a measurement with the gas detector onboard. Another option is to record the coordinates of the position and then to be followed by a gas detector on a different device.

The decision about the next steps is based on the inspection and the real-time data collected.

Step 2: When a problem area has been detected, the UAV must be lowered to a point that the terrain allows. If it is impossible to reach, the UAV should approach the ground as near as possible. The TV inspection continues as the data from the gas detector is added to the camera data record.

If necessary, several samples might be taken out of a different parts of a same area. The speed at which the UAV operates and the height at which samples are taken with the gas detector are specified by the characteristics of the terrain. The data broadcasts in real time, while being recorded as well so that it can be reviewed again.

Step 3: If more than one battery full capacity is required for inspecting the entire route, the UAV must be returned to the initial position (hp_i), recharged, and moved to the starting position of the next section ($hp_{(i+1)}$), after which it may continue the task.

Figure 4 is a diagram of an algorithm for working with gas pipelines. It sums up of the following elements:

● **(1)** Analysis of the route such as: its total length L, picking of characteristic points m, which later can is a base for division of the track into separate sections. Point out other differences such as the presence of infrastructure below, on and/or above the ground level.

● **(2)** Defining the required technical parameters of the surveyed area. Selection of the technical equipment for the inspection as well as an appropriate UAV model that best meets the requirements of the route (suitable dimensions, cameras, sensors, load capacity, control system, flight duration, etc.).

● **(3)** The route should be divided on suitable sections. These sections' length should be based on the UAV capacity.

● **(4)** Set a first section as well as its length, number of characteristic points and the terrain related. Set the route, speed and flight height.

● **(5)** Perform the flight on the selected route. An operator monitors the state of the field on the site. In case of gas leakage signs, it is necessary the UAV to approach the critical zone as near as possible in order to obtain additional information.

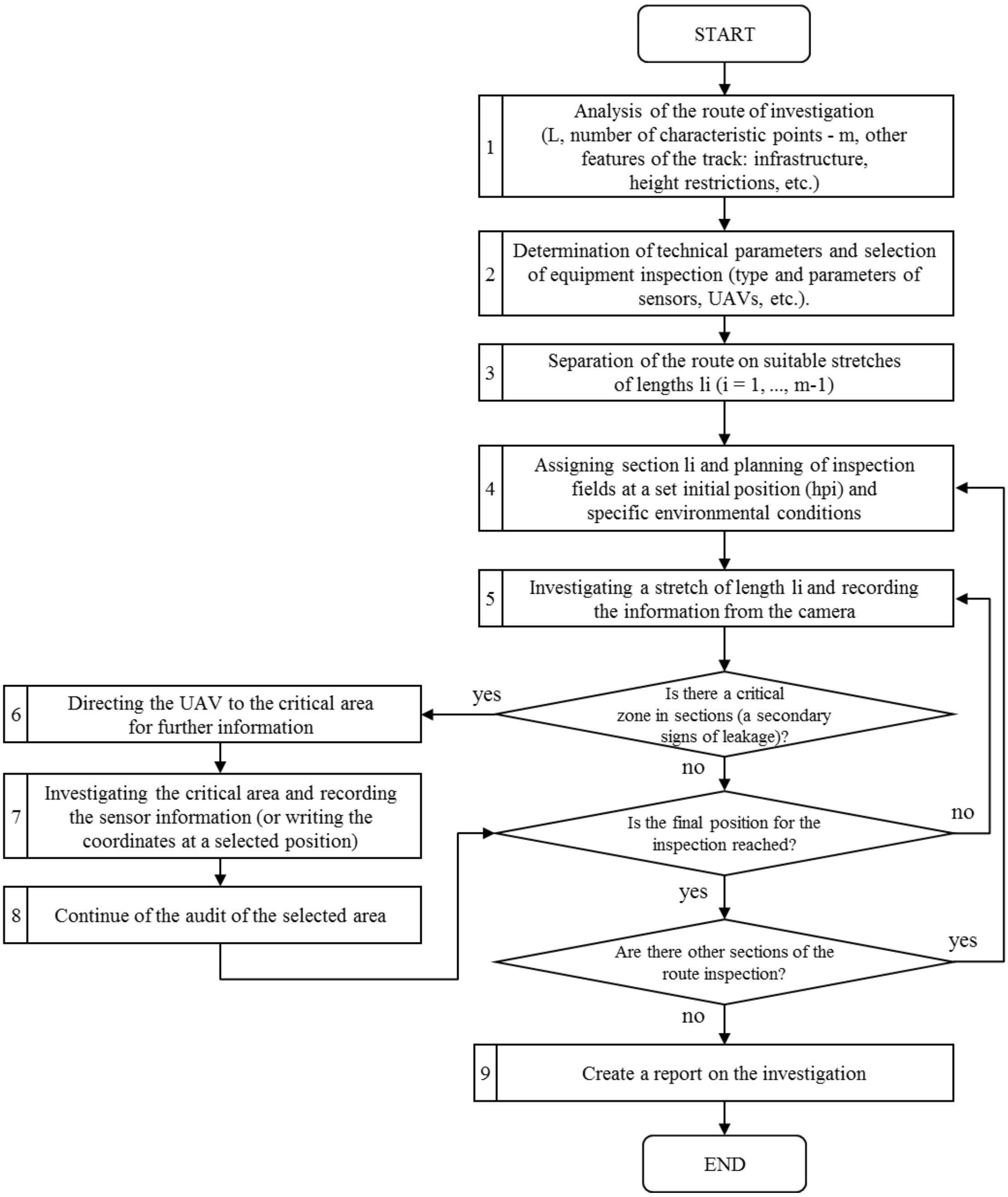

Fig. 4 Flowchart of an algorithm for working with gas pipelines

● **(6)** In order to check the condition of the pipeline network system in that particular critical zone it is necessary that the UAV land on the terrain, if possible, or to get as close as possible.

● **(7)** A record of the information from the gas detector available onboard. It is a possibility to collect the coordinates of a point in the critical zone, and the study itself to be carried out at a later stage.● **(8)** Continue the survey of the of a particular section.

These steps are repeated until the end point for the pipeline network inspection.

● **(9)** The survey of a section of the gas transmission network ends with a protocol containing information about its current status.

4. CONCLUSIONS

• The use of UAV-based system to control underground gas pipeline network enhances the efficiency of required repair works, assists work and creates safe working conditions for operators;

• The proposed gas network monitoring method can be used in difficult-to-access areas, saves time for organizing the access and actual observation and overviewing of the area, as well as decreases the need of many staff members.

• The use of laser gas sensors increases the accuracy of the measured parameters, not being fooled by specific environmental features such as climate, dust particles, etc.

REFERENCES

[1] Nikolov G. *Distribution and use of natural gas*. Sofia, Uconomics, 2007.
[2] www.pergamusa.com
[3] www.sewerin.com