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REMOTE MONITORING SYSTEM OF MAIN GAS PIPELINE LINEAR PART SECTIONS POSITION AND CONDITION

The practice of gas transportation systems in challenging environments has revealed a lack of pipelines reliability, that are laid in marshes, swamps and flooded areas. Soils in this area are characterized by structural instability, significant compression and small grounding ability. Gas pipeline sections in non-designed situation are potentially dangerous areas. Analysis of their technical condition must be comprehensive.

Concept of creating a remote monitoring system of main gas pipeline linear part sections at the presence of geodynamic effects is developed in Ivano-Frankivsk National Technical University of Oil and Gas (Ukraine). This concept provides for:

- identification of potentially and accident-dangerous pipelines sections;
- localization of active geodynamic zones and tectonic disturbances;
- identification of hidden cracks of soil separation and surfaces of soil masses slipping in slopes areas while pipelines laying and operation;
- detecting corrosion processes areas.

As an example, typical main gas pipelines sections at the non-designed situation include (Fig. 1):

- gas pipeline with damaged soil backfill and exposing the pipe;
- gas pipelines sections rising the surface;
- buckling of gas pipeline sections (buckling and arched emissions);
- gas pipeline sections subsidence (sag);
- gas pipeline sections that sag (sagging).

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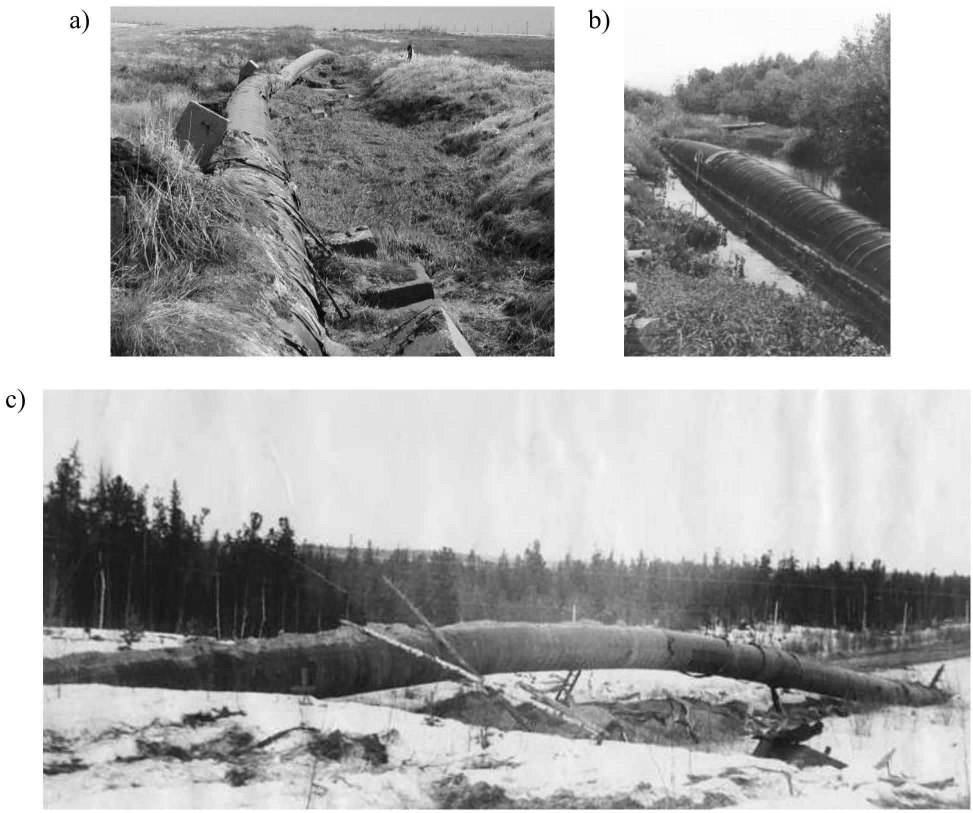

Fig. 1. Non-design positions of gas pipeline sections: a) bare part; b) part sagging; c) section arch buckling

Lack of continuous monitoring for above presented main gas pipelines section, especially in difficult terrain, can lead to irreversible emergency processes.

For remote monitoring of such potentially dangerous sections position and condition, we propose to use the system, which is shown schematically in Figure 2.

Decline control module network (2), which attach to the pipeline surface (1), allows to determine the spatial location of the pipeline relatively to the designed in real time. The basis of the decline control module has two electrical conductive sensors, placed on mutually perpendicular axes on joint basis. Structurally electrical conductive decline sensor (Fig. 3) consists of a reservoir partially filled with electrically conductive fluid.

At the bottom of the sensor reservoir electrodes are placed perpendicular to the axis of its inclination. While applying an alternating voltage across two electrodes, a scattered electric field occurs. Liquid level reducing, which occurs at sensor inclination, causes a „levy” (reduction) of this field. This, in its turn, causes proportionally to liquid level the electrical resistance changes of the electrolyte, which has continued conducting ability. Placed at the bottom (on the right and left parts of the reservoir), two pairs of electrodes allow, according to differential measurement principle, to get at the sensor output alternating signal proportional to the angle of inclination (Fig. 4). Electrical conductive sensors can measure angles from 0 to 45^{o} with a resolution of 0.01^{o} at ambient temperatures from –40 to +105 ^{o}C.

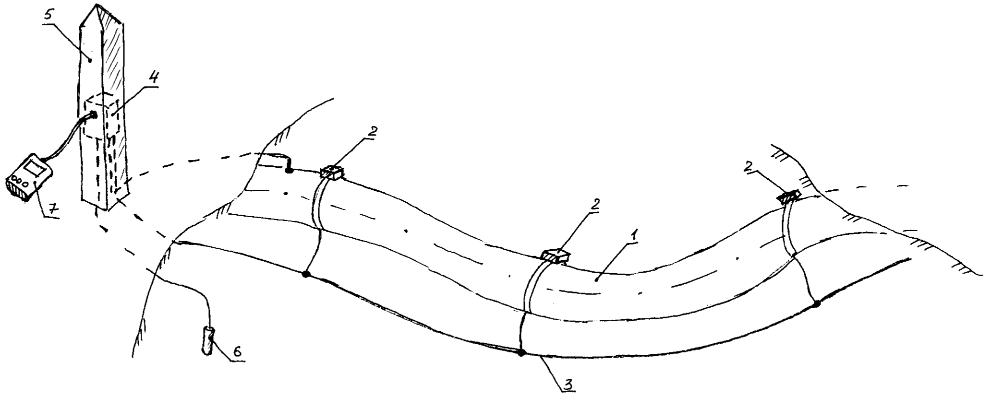

Fig. 2. Schematic implementation of monitoring system for potentially dangerous main gas pipeline sections position and condition: 1 – pipeline, 2 – decline control module, 3 – connection cable, 4 – processing and data storage unit, 5 – control wheel, 6 – matching electrode, 7 – control unit

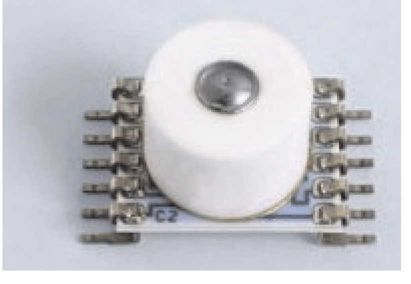

Fig. 3. View of electrical conductive decline sensor

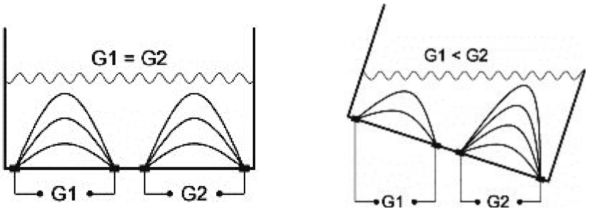

Fig. 4. Electrical conductive method of inclination angle measurement

Control module allows to determine inclination angles and, respectively, offset of the pipeline part to which it is attached. Structurally, the decline control module is designed in a sealed and explosion-proof frame (protection class IP67), that is structurally fixed to the pipeline surface with a special clamp without destroying the insulating coating. Each module has a unique digital address for its identification and is connected to an information network using a connection cable, 3 (Fig. 2). Data processing and archiving are performed by using the data processing storage unit 4 (Fig. 2).

It should be noted that the above presented study of gas pipeline sections belong to the most dangerous corrosion parts.

As is known, the corrosion rate of the pipeline metal external surface depends almost entirely on these two main factors:

- corrosion coating quality, that is determined primarily, by the size of the transition resistance and adhesion strength to the pipe surface;
- pipe metal surface polarization, that is sufficient by magnitude and stability over time, and reached by the correct application of electrical and chemical protection.

Subject to slow change of the first factor, the main reason influencing significantly on the corrosion defects rate, remains the second factor. Taking into account the opinion of the leading Ukrainian and Russian experts on corrosion protection (S.G. Polyakov – IEW n.a. Paton, Yu. Kuzmenko „VNIPTRANSGAZ" – Kiev, N.P. Glazov, „VNIST", Moscow), each break in the work of electrical and chemical protection means inevitably accelerates the development of corrosion defects. Thus, the quantity and availability of electrical and chemical protection means for gas pipeline in time put on the condition of anticorrosive coatings determine pipeline reliability. Based on this and on the requirements of Ukrainian regulatory document DSTU 4219-2003 (Steel main pipelines. General requirements for corrosion protection), it is necessary to provide continuous security control for the gas pipeline in time.

Electrical and chemical protection condition of potentially dangerous main gas pipeline part is determined by continuously measuring potential „pipe – comparative copper-sulfate electrode 6" (Fig. 2), using processing and data storage unit 4. This unit is placed in measuring and control column 5. Testing and measuring wheel (1, Fig. 2) is simultaneously used as information and warning sign to indicate buffer zone and gas pipeline route (Fig. 5).

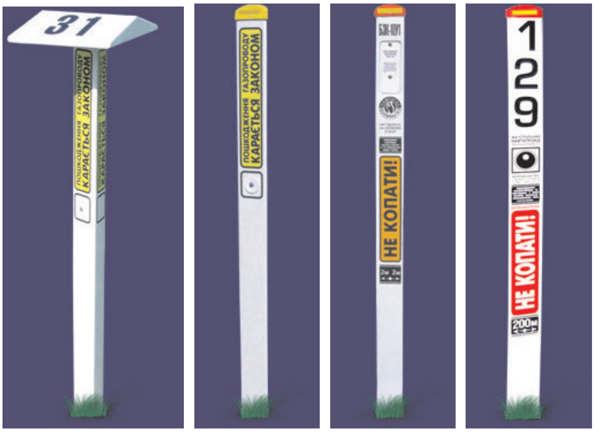

Fig. 5. View of main gas pipelines control measuring columns

Information about changing the monitored gas pipeline enters the tower with computer system for processing and visualization of monitoring results in real time. In case of absence the possibility for remote data transmission from control column 5 (Fig. 2) the accumulated block 4 information can be downloaded to the portable control unit 7 for further cameral processing.

Implementation of the described system will allow to evaluate on a timely basis the change of spatial position and to define security of main gas pipeline in the area of potentially dangerous parts in order to prevent accidents. It should be noted that the implementation of the proposed system is more economically feasible than systems, based on the use of fiber optic cables.