EQUIPMENT FOR INTERNAL AND EXTERNAL DIAGNOSTICS OF PIPELINES AND ITS DEVELOPMENT AT SOL – SKTC 147 OF FACULTY BERG, TECHNICAL UNIVERSITY,KOŠICE

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SUMMARY

Underground gas storage in Slovakia has 25 years history. The first phase of building, the object for underground reservoir Láb began in 1977. The underground reservoir is separated to five independent parts, phases of building. All parts are concentrated in central control area. The oldest part of equipment for underground reservoir need overhaul and maintenance today. The maintenance process uncovers a lot of problems, that were created trough building process. The great problems are uncovered in the area of pipeline system diagnostics. In the past, maintenance operators faced difficult decisions, to choose the best method or combination of methods to evaluate pipeline condition.

Keywords: *pipeline, maintenance, diagnostics, reservoir, magnetic*

1. INTRODUCTION

Steadily growing consumption of natural gas in European states must be, in substantial proportion covered by imports from three main resource areas: Russian Federation and states of Community of Independent States, North Sea and North Africa (Algeria, Tunisia). As most other European countries, Slovak Republic is unable to cover its demands of natural gas from its own production. We are only able to cover 4% of our gas consumption from deposits in Eastern Slovakia, the rest is covered by import from the Russian Federation. Slovakia, thanks to its geographical location is an important transit link in European gas network. International Gas pipeline “Bratstvo” the only trunk pipeline facilitating transfer of gas from Russian deposits to Western Europe is routed along all of the Slovak Republic’s territory. Immense distances negotiated by the gasline impose great demands on safety and systems ensuring trouble-free operation. International Gas pipeline has already exceeded its estimated lifetime, so nowadays it is important to stress its extension. One of the ways to assure trouble-free operation of the gasline is diagnostic monitoring of its pipes.

Besides nondestructive testing of materials, with which we have been dealing for several decades in our test laboratory, we have also focussed in the last few years on research, design and development of new devices for fault detection and diagnostics by internal and external inspection of pipes. We have done this through the means of applied research project financed from the resources of Ministry of Education SR and from privatization sources.

2. STANDARD STN EN 473

There are six methods recognized by the specification STN EN 473 for nondestructive diagnostics of materials. Testing by Foucault currents, capillary methods, magnetic flux leakage, isotope radioscopy, ultrasonic and leakage test. Prevalent methods used for inspection of welds prior to laying pipes into a trench are isotope radioscopy, capillary and magnetic flux leakage. For flaw detection on the pipelines in operation, procedures are divided into two areas according to the manner of inspection, i.e. internal or external. Most widely used and at this time the only appropriate method for internal diagnostics of pipelines is magnetic flux leakage phenomenon. For external inspection this method can be applied only on surface laid or elevated pipelines.

3. METHODS OF MAGNETIC FLUX

Magnetic flux leakage method is based on distortion of the magnetic field in the area of material defect due to increased reluctance in it and is most effective in detecting flaws that are perpendicular to the direction of magnetic field lines. Based on this fact there are two different techniques used for internal inspection. MFL (magnetic flux leakage) technique oriented towards detection of flaws perpendicular to the pipe axis, i.e. longitudinal magnetization (figure 1). TFI (transverse field inspection) technique, which is oriented towards detection of flaws parallel with the pipe axis, i.e. lateral magnetization (figure 2). Figure 1 shows difference in sensor reaction to the same type, but differently oriented faults using longitudinal magnetization.

Figures 1 and 2 illustrate the dependence of sensor signal magnitude on orientation of the flaw and direction of magnetization. Peak formed by passage over the flaw located transversely to the direction of magnetization is higher and obviously reaching beyond the unfiltered background noise of flawless sections of material in the recorder chart. Indication of the flaw located parallel with the direction of

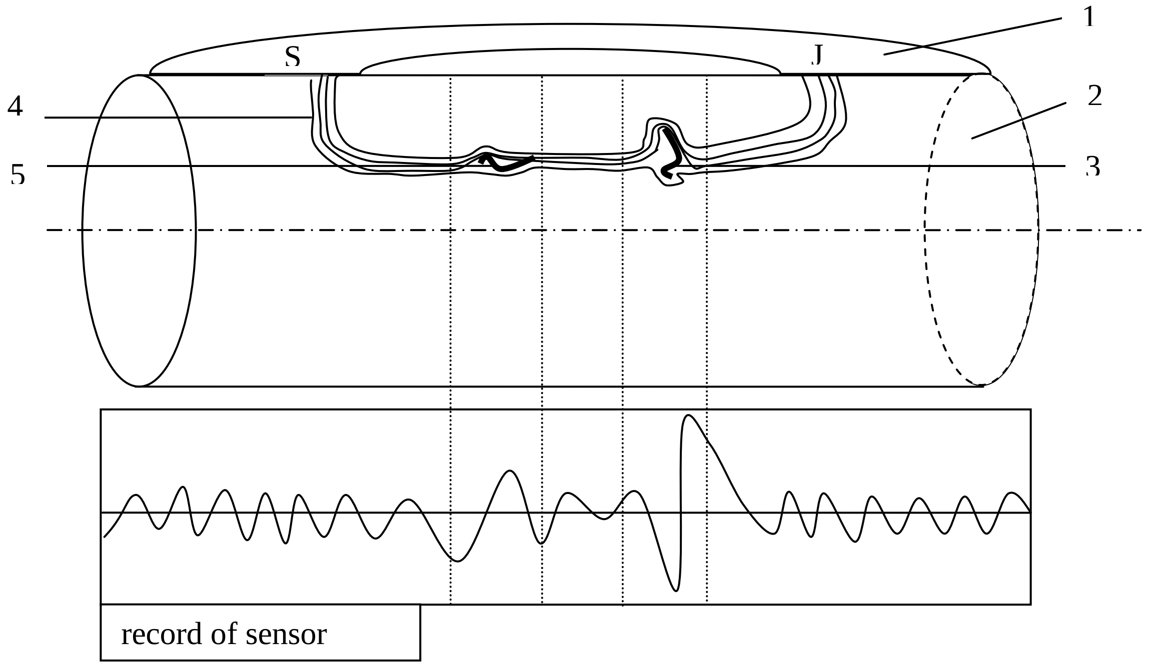

Figure 1. Longitudinal magnetization and reaction of magnetic field lines to the flaws of identical shape oriented in a different way, 1 – magnet, 2 – pipe, 3 – flaw located transversely to the direction of magnetization, 4 – magnetic field lines, 5 – flaw located parallely to the direction of magnetization.

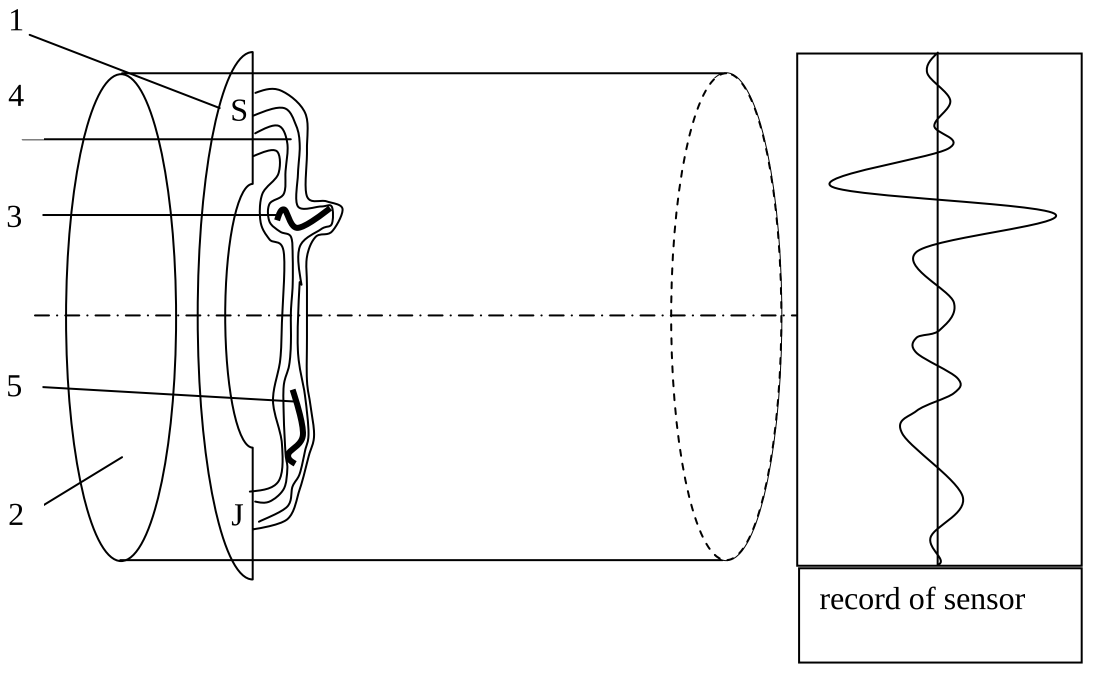

Figure 2. Lateral magnetization and reaction of magnetic field lines to the flaws of identical shape oriented in a different way, 1 – magnet, 2 – pipe, 3 – flaw located transversely to the direction of magnetization, 4 – magnetic field lines, 5 – flaw located parallely to the direction of magnetization.

magnetization however, is weak, drawn out and nearly merges with the background noise.

For the needs of research and design in the area of diagnostics methods for pipeline inspection we have created a bench test setup (Figure 3). On this setup it is possible to model variously situated flaws and so test developed sensing elements in their relation to many parameters influencing their sensitivity. It is also possible to change the direction and speed of sensor movement at both kinds of magnetization. The stand is built from paramagnetic materials in order to avoid undesirable effects on simulated magnetic flux and to prevent irrelevant indications of tested sensing devices. Sensor carrier allows for several combinations of sensors in various positions and distances from pipe wall. Output signal from sensors is amplified and with the help of analog to digital converter is processed by computer software. Digital record is logged on the hard disk of decoder and simultaneously displayed on the monitor in real time (Figure 4).

When developing new defectoscopic device it is necessary to verify magnetic circuits, sensing elements, position, sensors of velocity and others. In selection of defectoscopic method and design of magnetic circuits it is necessary to take into account pipe material. It must be known, before selection of the method, whether the material being dealt with is ferromagnetic, diamagnetic or paramagnetic. Magnetic properties of the material also greatly influence the structure of magnetic circuit. Before deployment of the device it must be ascertained that when inspecting using proposed configuration, the material is sufficiently magnetized, whether created magnetic fields will detect material flaws specified as dangerous to the pipeline operation. At the same time it is necessary to prevent undesirable dispersions of magnetic fluxes that could induce irrelevant indications causing the registration to be illegible. Chosen defectoscopic method then effects the construction of sensing elements. Pipeline defectoscopic methods mentioned above would use some of the most frequently employed sensing elements, such as coils, halo probes, magnetodiodes and ferromagnetic diodes. Each of the listed sensing elements has its advantages and disadvantages and that is why, for construction of defectoscopic instrumentation it is necessary to know the all important criteria of the particular test. Sensors may need various conditions satisfied for their proper function, i.e. movement, constant temperature and others. When performing defectoscopic inspections it is, besides indication of flaw, important to know its location and shape. For this reason it is

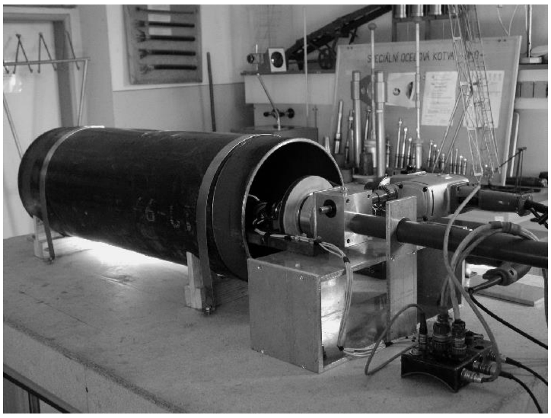

Figure 3 Bench test setup for modeling of pipeline flaws

Figure 4 Sensor recording displayed on monitor. Arrow points to the spike on unfiltered recording – reaction of sensor to the simulated pipe flaw.

important to have the defectoscopic apparatus equipped with movement monitoring sensors. For tracking sensor of velocity and position it is possible to use incremental sensors, optoelectronic sensors, electromagnetic sensors, gyroscopic systems etc. The position sensors like flaw sensing elements have their advantages and disadvantages such as ideal transfer of movement (sensibility), ability to determine the position with the required precision (accuracy) and so on.

Based on experiments with our bench test setup, optimal configuration of sensing elements with satisfactory sensibility was designed. Sensor reacts even to most minute changes in the magnetic field caused by increase in reluctance. Sufficiently fast hardware was designed for evaluation of output signals from defectoscopic sensor head. This evaluation is performed by its own software able to accept four input channels.

4. CONCLUSION

Functional prototype of this defectoscopic sensor head has passed first tests in our laboratory's bench test setup using pipe with simulated flaws. Sensor is suitable for internal, but also external pipe inspections.

Next goal is design of sensor combination for use on actual pipe and its incorporation into the defectoscopic configuration able to perform the diagnostics of the pipeline. Result of this work should be equipment for external and later also for internal pipeline inspection.

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Biography:

Stanislav Kropuch was born on 10.6.1953.In 1977 he graduated (Ing.) with distinction at the department of Mining Mechanization and Drilling of the faculty of Mining at the Technical University in Košice. He defended his PhD. in the field of defectoscopic tests of steel wires. Since 1979 he worked with the Department of mining mechanization. Since 1999 he is working with the Department of logistics and Production Systemms and with the Department of Testing center SKTC-147. His scientific research is focusing on the defectoscopic tests of steel wires, tubes and construction.

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