The Alternative to the In-Line Inspection Exists

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A technology for a non-contact (from the Earth surface) magnetic diagnostics of pipelines is developed by Transkor-K Centre (Russia), which represents an alternative to the standard in-line (Intelligent Pigging) inspection method. Diagnostic inspection device SKIF MBS-04 was demonstrated in the 6th Moscow International Show of the Industrial Property in 2003 and awarded gold medals and rewards at the prestigious international exhibitions – the International Invention Show in Geneva (Switzerland), 1999, and «Eureka» Innovation Summit (Brussels), 2005.

Non-contact magnetic technology can be used for inspection of metal pipelines including the pipelines in oil-and-gas complex, in municipal and gas networks and pipelines of compressor and pumping stations where the in-line inspection is difficult or impossible.

The non-contact magnetic method enables:
- to precisely locate (in linear and angular coordinates) the sections with metal and insulation coating defects in underground pipeline by inspecting it from the surface of the Earth;
- to determine the type of the defects of maximum size and assess its potential danger;
- to carry out monitoring and maintain a database on pipeline current technical condition;
- to carry out pipeline system certification.

Types of defects to be detected: crack-like defects (laps, rolling skins, guide marks, stress corrosion cracking), weld defects, pipe wall thickness variations (local corrosion, internal groove corrosion), compression marks, corrugations, deviation from the design laying axle, exfoliation and non-metal inclusions.

Detection rate: up to 2 m/sec.
Distance between the magnetometer SKIF and the pipeline (axle deviation, laying depth): up to 20 pipe diameters depending on operating pressure. Magnetometer design enables to follow pipeline axle and laying depth.

Starting from 2002, more than 5000 km of pipelines were diagnosed with Transkor-K method in Russia, Ukraine, and Uzbekistan. Standard in-line inspection of these pipelines is time consuming, and it requires significant labor investments in terms of tool launching preparatory work.

Reliability of metal defects revealed by the non-contact magnetic method is greater than 80%. Probability of detection of the sections that reveal disruptions in protective properties of insulation coating is as high as 95%.

The non-contact magnetic inspection is irreplaceable in diagnostics of technical conditions of underwater (sea/river bed) pipes and back-stay river crossings. This method makes monitoring of riverbed pipeline sections possible. It allows determining vertical profile of these sections. It also allows locating mechanical defects in metal pipe (resulting from major repair made with the use of standard internal polyethylene pipe “pulling through” method).
The non-contact magnetic diagnostics significantly improves the process of decision making and pipeline management, as it provides essential information about pipeline’s actual technical condition. It guarantees correct choice of the pipeline sections subject to replacement or repair.

The high praise to the non-contact magnetic method gives Bashtransgaz (one of Gazprom organizations). The authorities of Bashtransgaz organization consider the method is highly efficient in providing the complete work package which includes:

1. diagnostics
2. pre-repair inspection
3. repair in the shortest time
4. monitoring

Nowadays the general overhaul of pipelines is carried out basically by a method of complete replacement of pipes with stoppage and dismantling of repaired sections. It requires significant expenses. In some instances a random repair based on estimation of experts is carried out for the objects unavailable for the in-line inspection. But world experience testifies that repair based on random opening of pipes and non-destructive testing in separate pits is ineffective. Electrometric measurements do not give trustworthy information of metal state along all pipeline length and cannot predict its reliability.

Right up to the present time only the data of in-line inspection served as the background for establishing priorities in repair. Unfortunately this “basic” method is not always applicable for inspection of certain pipelines particularly in urban municipal and gas distribution economy, pipelines of compressor and pumping stations, refineries and field and old production pipes. What are the reasons? Below some of them are presented.

1. Lack of flaw detecting tools for all pipe diameters (oil-field, urban pipelines, and facilities of old constructions),
2. Lack of technical availability of a pipeline to the inspection (welding burr, pipe inner washers).

Besides there are economic reasons constraining such inspection: in particular the high price of tool launching preparatory works; expensive cleaning and preparation of a pipeline for the inspection.

For the last years Gazprom and Transneft made the efforts to create new technologies of pipelines diagnostics based on integrated numerical analysis of pipelines safety, and the analysis of the mechanism of its destruction and social, ecological and economic aftereffects of its destruction.

In particular, the technique of pipeline condition estimation from the point of view of safety is used. The criteria of its usage are:

- Safety margin (according to the normative documentation);
- Pipe load-carrying capacity (according to the normative documentation);
- Simulation of ductile or brittle failure (with the use of LS-DYNA3D program);
- Results of destructive testing on specimens.

If strength analysis shows an opportunity of destruction during the use of pipeline then a mathematical modeling of various versions of hypothetical failures is carried out. At the same time during failure
investigation a version approach is used. Thus the failures risk analysis is carried out according to the results of calculations.

Analysis of the problem of pipelines technical condition estimation shows that the weakest point is determination of an actual level of local stress concentration in a field of defect or in a faulty place. The estimation of serviceability of a pipeline is made on precisely this parameter. Defects essentially differ in hazard degree not so much in connection with their dimensions but first of all in a level of stress concentration in the field of defect. While in service the destruction of pipe metal occurs after stress in the field of defect achieves a critical value. The critical level of local stress depends on physical and mechanical properties of metal and also on local impact conditions.

Nowadays practically all existing flaw detectors including in-line tools do not register actual values of mechanical stress therefore do not show the degree of the defect hazard. Besides the majority of known flaw detectors do not detect the areas of residual weld stress and areas with residual plastic deformation. And as a consequence a hazard degree of the found defects is determined by the calculation method from their dimensions and topology. Transition to the analysis of actual stresses up till now is made only by the calculation method. Reliability of estimation completely depends on a model and a method of calculation, at this the substantial part of the in-line inspection data is not used for calculation.

Besides local stress concentrations arise not only in the vicinity of continuity rupture (cracks, corrosion pits) or an inclusion but also on internal mechanical expose, temperature deformations, and saturation of metal with hydrogen. Therefore such local stress concentrations can be omitted by known methods of flaw detection and technical diagnosing with all the ensuing consequences.

Is there a possibility of the actual technical state inspection of pipelines including ones where the in-line inspection on technical or other reasons is not possible?

In recent years providing access to the tested object (in excavated check pits) diagnosing of metalwork technical condition considering stress conditions by the metal magnetic memory method has made a good progress. This method is based on the use of magneto-elastic and magneto-mechanical effects.

The following step in magnetic technologies is the non-contact magnetic method – magnetic tomography method - the development of R&DC “Transkor-K”. The “Transkor-K” engineers created the devices: magnetometer non-contact SKIF which from the surface of the Earth can find locations of anomalies of stress-deformed condition caused by the defects of any type and sections with sagging, bending and landslips. The device is able to carry out 100 % scanning of electromagnetic field with the given spacing, with an automatic recording, and the software allowing detect automatically the sites of metal defects. We call them “out-line” flaw detectors.

While operating the pipelines under the influence of various factors (deformation and pipe rolling defects, metal loss - internal and external corrosion, etc.) there arises the changes of metal structure and the zones of longitudinal and transverse stresses concentration occur. The faulty weld also increases stress. Such defects as pipe geometry changes (compression marks, corrugations, out-of-roundness), scores, guide marks, etc. also are stress concentrators. In the process of operating a pipeline the irreversible change of metal magnetization arises in the direction of maximal stresses caused by workloads.

The non-contact magnetic diagnostics of pipeline technical condition by magnetic tomography method (passive magnetic flux-gate meter non-destructive testing or other magnetic transformers) is based on measuring of magnetic field and analysis of relative distribution of residual magnetization of base metal
and weld joints along pipeline axis. Natural magnetization developed in the process of pipeline production and operation in geomagnetic field is taken into consideration.

As mentioned above the engineers of R&DC "Transkor-K" developed non-contact magnetometers in the SKIF series for the purpose of pipeline metal magnetic anomalies location from the Earth surface without opening the pipeline. Such anomalies are connected with defects and faulty places. Magnetometer SKIF "MBS-04" is able to scan the self-magnetic field of a pipeline (100 % control) with the prescribed spacing of measuring. The obtained information is automatically memory-stored. Then the data are mathematically and statistically processed and compared with the database received earlier. It allows to localize a situation of anomalies of metal stress-deformed condition sites in the areas of defects and to estimate the value of the anomalies. As a result the defects of metal are revealed on extensive sections of a pipeline and arranged in order of hazard degree. Dangerous defects require urgent excavation and additional testing in pits for identification and hazard estimation during pre-repair inspection. Potentially hazardous defects are included in a scheduled repair or monitoring program.

The magnetic tomography method allows us to determine the following types of metal defects. They are: 1) metal loss - underfilm corrosion (local corrosion damages underneath the insulation coating which lost adhesion), or internal corrosion, that is deviation in pipe wall thickness (local pitting corrosion, groove corrosion), 2) stress corrosion cracking (low pH SCC of pipeline steels), crack-like defects (laps, rolling skins, guide marks), 3) weld defects, 4) anomalies of stress-deformed conditions caused by failure in pipeline stability or mechanical damages: compression marks, corrugations, deviation from the design laying axle.

Areas of application of the magnetic tomography method are not only in oil and gas sectors but also urban municipal and gas distributing networks as well as other facilities of pipeline transport where the in-line inspection is hampered or is not possible (for example technological pipelines of compressor gas distributing or oil pumping stations)

The technology of non-contact magnetic diagnostics succeeded at the stage of industrial approbation. Over 8000 km of pipelines were inspected for the last 2 years. Our main clients were: GAZPROM, YUKOS, Tatneft, Transnefteproduct, Alrosa. Recently “Transkor-K” has started projects in UK, Croatia, Argentina, USA – there are representative offices in these countries. Reliability of metal defects revealing is quite on a par with the results of in-line inspection.

One more advantage of this method is a possibility of diagnostics of underwater (river/seabed) pipeline sections. As an example we would like to mention the diagnostics of riverbed sections of petroleum product mainlines on the Volga and Kama rivers. The pipelines laying depth was from 18 up to 23 m. The diagnostics was carried out in winter time on the ice of the rivers.

Additional advantages of the non-contact magnetic method are:
1. High quickness and technical effectiveness of inspection allowing to carry out the complete work package on diagnostics, design work and overhaul repair of the pipeline in extremely deadlines.
2. Accuracy in metal defects positioning.
To reduce an error in defect positioning during an in-line inspection it is necessary to make a calculation with proper corrections. But it leads to inevitable systematic errors and as a result the length of pits opened for the additional flaw detection is rather big. On the contrary in the process of non-contact
inspection the error of positioning is considerably cut down because the same system of distance measuring is used while inspecting and defects positioning.

3. The length of pipeline sections to be inspected is not limited. It can be 1m in the field of defect, or large-scale operations on several objects can be carried out simultaneously by several teams that will allow executing complete volume of diagnostics of a large pipeline network during a season.

4. Monitoring of potentially hazardous defects which have not reached rejection parameters yet. The non-contact technology provides an optimum mode of repeated inspection according to any plan within the framework of technical necessity. On the contrary receiving information on defect growth rate by means of in-line inspection monitoring is economically inexpedient because it requires expensive repeated run of in-line tools.

Thus the new technology is suggested – an alternative to the standard in-line inspection method.

The benefits and comparison of Transkor vis-a-vis In-line Inspection are as follows;

**PREPERATION FOR INSPECTION**

A. No requirement to run pigs through the pipeline
   1- to CLEAN the inside or
   2- to determine the pipeline PROFILE
   3- for defect inspection and evaluation

B. No requirement to provide TRAPS to LAUNCH pigs or to RECEIVE pigs or INJECTOR VALVES, MARKERS, BACK UP RING removal etc

C. No requirement for magnets installed along the pipeline

C. It follows no expensive pigs required

D. It follows that where pipelines cannot utilize internal pigging processes; and internal inspection was thereby not possible – that these lines can now be internally inspected

**PIPELINE FEATURES**

Pipelines of any DIAMETER, any CROSS SECTION and any detail of construction such as BENDS, PIPE WALL THICKNESS and OPERATING PRESSURES can be inspected

No magnetization which is required with Intelligent Pig MFL inspection

**TYPE OF DEFECTS**

- EXTERNAL areas where the pipe coating has lifted – ie loss of adhesion and corrosion has occurred beneath this coating area
- INTERNAL
- longitudinal cracks
- vertical cracks
- PITTING
- General corrosion showing extent of reduced wall thickness
- Cracks resulting from stress corrosion and/or hydrogen embrittlement  SCC low PH
- Laps
- Rolling skin
- Guide marks
- Corrugations
- Deviation from the design laying axis

LOCATION OF DEFECTIVE SITES
All locations including underside. The location of defective sites (group of defects) are defined within an accuracy of +/- 1.5 meters thus facilitating further investigation or repair.

ECONOMIES
No costs for pigging processes – cleaning, profiling and intelligent pigging.
Minimum time for inspection preparation.
Decrease in overall inspection time.