The State and the Perspectives of the Electromagnetic Techniques and NDT Means Development for Gas Pipelines Inspection and their Reisolation

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Abstract. Some events and problems which are connected basically to corrosion cracks energized by stress, and which have defined high level of need in flaw detection for the inspection of the main gas pipelines are described. Ways of the decision of problems of flaw detection, results of using them in exploitation, a rating of a status of these problems today have been shown in the paper. Perspective decisions of these problems are offered too.

1. Problems of inspection of main gas pipelines

1.1 Issues of aged equipment maintenance, monitoring of corrosion cracks energized by stress in pipes of the main gas pipelines and means of its decision

For last 15 years an exploitation of means of flaw detection at inspection of the main gas pipelines (further - GM) has received significant development in connection with an aggravation of status of problem of corrosion cracks energized by stress (further in the text - SCC). Processes SCC occur on the surface of pipes predisposed to SCC, under an exfoliating cover in the case of penetration under him of electrolyte in places of crossing of the pipeline by water-currents and drains of waters, basically, in clays which create conditions of non oxygenating.
Formation of the predisposed surface of pipes to SCC is connected to the increased residual stresses and deformations, risks, scratches, teases, cracked scale, arising at manufacture of pipes because of imperfection of technologies of their manufacturing. Finally, processes SCC lead to formation of a surface cracks of pipes, with their growth and explosions of pipelines. The picture of cracks of SCC on a surface of a pipe of the working GM is submitted in fig. 1.
SCC was detected in various forms of spots of defects, and in various orientations of cracks on pipes of GM, and in connection with various external conditions of functioning of GM. Opportunity of detection of small cracks of SCC certainly before they become a reason of emergency failures, and also getting of exact ratings of depths of dangerous cracks of SCC for definition of possible time of trouble-free operation of a pipe, are of great importance in the prevention of emergency failures on GM and in planning repair work. From reports about business meetings and conferences it follows, that the increase in volumes of flaw detection applying in the past has significantly lowered growth of quantity of breakdown inspired by SCC, growth of losses of gas and expenses on carrying out repair work. In connection with growth of term of exploitation of GM, amounts of works on SCC revealing and on the prevention of its emergency consequences are required to be increased.

Primary goals of inspection of the gas mains predisposed to SCC, are detection, definition of parameters and a rating of a degree of danger of defects SCC. Basic means of revealing of SCC defects today is in-pipe inspection (IPI) of GM by magnetic pigs with the magnetization across pipe and with revealing longitudinal cracks. According to characteristics of these pigs, IPI reveals defect SCC with depth more than 20 % from thickness of a wall of pipe. The bulk of significant defects SCC remains unregistered. Thus the omission of SCC defects, and also a mistakes in ratings of parameters of defects are possible. Therefore for decision-making about repair of SCC defects revealed by IPI the performance of inspection of these defects SCC in opened sites of a gas main by expert methods is necessary.

Annually participating in works on research SCC on working GM, "Spectrum RII " (further in the text - "Spectrum") in cooperation with Open Company "VNIIGAZ" develops and improves as the means of detection and a rating of parameters of SCC defects, and also methods applying of these means for GM.

1.2 Problem of carrying out a certification and replacements of unusable materials

In connection with finishing of a resource, and also in view of direct communication SCC with a status of an isolation of GM, for exploitation it has become such an urgent problem as replacement of the old isolation, which has come to unsuitability on a number of sites of GM. In fig.2 the picture of a surface of a pipe under the damaged isolation of the working GM is presented.
Additionally, simultaneously with replacement of isolation, there are carrying out the complex works: checking and certifying of all equipment of a linear part of site of GM, repairing of GM bed, installation of new armature, etc. Also thus it is possible to carry out full checking of a surface of a pipe of GM on presence of SCC. It is the second problem, which is putting forward new requirements to means of flaw detection for GM. For example, it is necessary, that new flaw detector, intended for the inspection of GM at isolation replacement, possessed considerably more high efficiency of the operation to not break a rhythm of mechanized industrial equipment during carrying out isolation replacement.

2. The decision of problems of search and a rating of parameters of defects at operation of GM

2.1 Inside pipe flaw detection system

The stage of the decision of the first problem has caused a development of new means of flaw detection, one of which it is possible to name because of its most significance is the magnetic in-pipe pig. This project has received in due time both sufficient financing, and significant research and engineering. Before that, there was an attempt of detection of SCC cracks by an ultrasonic in-pipe pig, but for use inside pipes of GM it has turned out expensive and not so suitable, despite high reliability of revealing of cracks SCC. Operation of magnetic in-pipe pigs in the general opinion today feels necessity of increase of reliability of revealing of real defects SCC at field conditions. For checking IPI data listed in report about presence SCC on each defective site of a pipe of GM and for studying features of defects SCC other experts and devices of other branches of flaw detection are constantly involved to these researches.

2.2 Expert means of local detection of SCC defects

2.2.1 Eddy current flaw detector

Search eddy current flaw detectors solve a problem of detection of cracks on a surface of pipes of GM as on the surface of metal cleared of isolation, so and on the GM surface covered with protective nonmetallic isolation of thickness up to 3…5 mm.
Eddy current flaw detectors, equipped with transducers of pencil type, as it is known, are capable to reveal very small cracks on a surface of metals (with depth of 0,2 mm). Ways of avoiding an influence of a backlash between metal and the transducer allow to provide, at revealing defect SCC, a suppression of influence of change of isolation thickness in a range from 0 up to 5 mm.

On the basis of these positions our company, for rating depths of cracks SCC of GM, has recommended the eddy current flaw detectors.

Eddy current flaw detector VD-12NFM is presented in fig.3.

With the help of VD-12NFM (and VD-89NM) of eddy current flaw detectors created at enterprise "Spectrum", and of magnetic particle inspection (further in the text - MPI) for the period from 1995 to 2004 it is found and surveyed 10 km of defective pipes of GM.

Often at inspection of GM the search eddy current flaw detectors VD-12NFM are influenced by electrochemical activity of environments, variable and constant mechanical loading, local magnetization. But they have recommended itself as reliable means of authentic detection and a rating of depth of defects SCC on GM pipes from all used steel grades at conditions when metal of these pipes was exposed to numerous and repeated influences of external adverse factors such as humidity, variable water-currents, differences of temperatures outside and inside. In flaw detectors, the use of static and dynamic modes of eddy current transducer operation is stipulated. In a dynamic operating mode the signal from defect practically does not depend on disorder of magnetic properties between sites of an inspected surface. It also allows flaw detector to use one standard sample with artificial defects for calibration in view of amendments at the inspection of pipes of the majority of pipe steels. Also this flaw detector responds such requirements, as portability and high efficiency at the manual operation of it at GM.

2.2.2 Increasing of operation productivity of a surface surveying of pipes of GM

For detection and depth ratings of depth of cracks SCC on GM the special computerized eddy current flaw detector VD-89NM – 16 has been developed. (See fig.4).

Flaw detector provides a recording and preservation in its memory the ratings of defects depths of a surface strip up to 20 cm in width under speed of movement of the block of transducers along a strip – 1 cm per sec, under maximum continuous length up to 7,5 meters; immediate printing both of the plan of defects on the surface strip and profile of ratings of defects depths, as on a line of each transducer on a strip, so and full describing of defect danger ratings of all transducer. Exploitation has shown, that this device is effective for planning repair, when calculation of term of probable trouble-free operation of a site of a pipe with the found out defect in pipe of GM is necessary.
2.2.3 Choice of means of eddy current flaw detection

Due to the job, which has been led in the past on inspection of SCC defects on GM by experts of Open Company "VNIIGAZ" and of our enterprise "Spectrum", we have an opinion that on GM the eddy current flaw detectors have advantages in comparison with flaw detectors of other types. The signal from cracks remains practically identical at various local magnetizations of sites of a pipe, in comparison with magnetic flaw detectors. Getting rating of a cracks depths is possible as much as position of defect close to the transducer in comparison with an ultrasonic method, and the ratings reliability grows with transducer approaching to defect. Inspection of defect can be performed closely to him on surface of GM, and it also is an advantage of eddy current flaw detectors. Additionally, advantages of our eddy current flaw detectors for detection SCC in conditions of the working GM are small weight, simplicity of the operation, convenience and easiness of working with the transducer by one hand, high resistibility of a construction of the transducer to deterioration.

For improvement of division of signals from separate cracks at the GM inspection and for reception and preservation of an image and parameters of defect in external computer, the Joint-Stock Company "RII_MSIA "SPECTRUM" has developed the processor variant of phase VD-12NFP eddy current flaw detector (see fig. 5) with using such various algorithms of the operation, as making recording and viewing of a profile of results of the inspection, and operating of automatic system of processing of casual "tap" of the transducer, and operating of the optical interface made and offered to use for connection with an external computer.

2.3 Means of Magnetic particle inspection

After detection and ratings of defects by flaw detectors as an obligatory action, the revealing of SCC cracks on a surface of GM by means of MPI is to be performed. This picture must be photographed, or picked up, and preserved by methods of copying. It gives necessary visual acknowledgement of detection of SCC cracks. It gives the exact information on positions of separate cracks on a defective site. Our enterprise "Spectrum" has developed and makes magnetizing device on constant magnets UN-5 (see fig.6), providing required magnetization of a surface of GM pipe for all widespread brands of
magnetic powders and suspensions. Thus the method MPI in such variant does not demand power supplies at all, and this is its important advantage.

Our enterprise makes the complete set of means for MPI with device UN-5, a set of non-polluting dispensed materials and the device of ultra-violet illumination (see fig.7).

3. The decision of problems of search and rating of parameters of defects at GM isolation replacement.

3.1 Necessity of carrying out full checking of a surface of GM pipes on presence SCC at carrying out isolation replacement

At present an inspections IPI of all linear part of GM system for the different reasons are impossible to provide. Also inspections IPI do not reveal small cracks of SCC and the factors of their development. And also there are sites of GM with actively developing damages SCC, which cannot be found out through their external attributes, of which the landscape and vegetation are the mostly main. For these reasons an applying of inspection means of presence SCC on GM, at a stage of the decision of the second problem of mass replacement of GM isolation, is recognized necessary. Thus for the pipe, an access to which received in process of isolation replacement, is required to be most effectively used for
carrying out the inspections of a pipe for getting guarantees of its safe operation on prospect. Opening of GM for isolation replacement is a unique opportunity of full checking of as pipes, so and of surrounding conditions on presence of working threat of SCC or the possible one.

3.2 Technical requirements on flaw detection of GM at isolation replacement

At replacement of GM isolation for application of means of flaw detection there are some requirements formed of conditions, which are essentially different from requirements to means of flaw detection of another objects. Some variants of sets of such technical requirements and common faults of their majority as volume and requirement to combine a carrying out many inspections simultaneously in one device are known. The basic problem thus is necessity of the organization of effective interaction of processes of the GM inspection and industrial work on isolation replacement. Productivity of used means of the inspection would correspond to productivity of isolation replacement. They would be concentrated on the site both limited and unequivocally inconvenient for access to a pipe surface near to dangerous heavy equipment. Means of the primary inspection, means of detection of defects would possess the greatest possible sensitivity, and actions on arbitration survey of the found out defects would be immediate, almost simultaneous with the basic inspection. To this it is necessary to add also requirements of high resistibility of systems, and an opportunity of full automation and mechanization of process providing an absence of people about pipe during the processes.

3.3 Offers on creation of an equipment basis for the automated inspection of all surface of GM pipe

In our opinion a prospect of the decision of this problem is creation of the automated monitoring system. For replacement of GM isolation our enterprise "RII_MSIA "Spectrum" offers a creation of multichannel self-propelled eddy current scanner - flaw detector for detection, first of all, of SCC defects on a surface of a pipe of GM. In "Spectrum" the concept of such system is developed. The basis of creation of an electronic part of the scanner is flaw detector as the module. It is the computerized eddy current flaw detector VD-89NM, whose block of transducers at the inspection tests a strip in width of 20cm. Calculations have shown, that the design, weight and dimensions of the block of flaw detector transducers are optimum suitable for creation on his basis of the multibank mechanized system. Into the concept of a mechanical part it is entered a modular ring providing configuration of system for a lot of the sizes of pipes of GM - 1020mm, 1220mm, 1420mm, which can be towed along a pipe by any mover from a manual one up to a heavy GM isolation cleaner. If it is necessary, one can manually move the ring along a pipe. Advantage of this design is the speed of assembling, so and of disassembling, installation at any place and an opportunity to make independently the inspection of any site of GM pipe without of attracting of a special equipment. Installation of additional means of the inspection like electromagnetic-acoustic thickness meter would allows us to reveal already existing stratification of a wall of a pipe, which can lead to damages of GM in conditions of growing deterioration of GM. Taking into account growth of volumes of repair of pipes of the GM, the similar universal mechanized installation could be used in a plant conditions.
Conclusions

Now eddy current flaw detectors VD-12NFM are actively used at inspections of GM on presence of SCC. 
Experience in job on GM flaw detection on presence of SCC has shown an opportunity and advantages of applying of eddy current flaw detectors as means of detection and reliable rating of depth of SCC defects.