1.12.6. CAPABILITIES OF THE METHOD FOR ASSESSMENT OF DEFORMATION UNDER STRESS AT INSPECTION OF NUCLEAR POWER FACILITIES

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Non-destructive testing is one of the main elements in monitoring of construction and operation of nuclear power facilities. Mutual impacts from operational loads, temperature and radiation lead to accumulation of defects in the construction materials; development of such defects decreases operational life of pipelines and metal constructions as well as may cause failures and accidents. It is believed that main information regarding hazards imposed by specific defects is provided by dimensions and shape of such defects along with parameters of the mechanical stress field generated by these defects. Conventional non-destructive testing methods aimed at identification of discontinuity flaws in welded joints, bulk metal and overlaying are usually used at inspections of nuclear power facilities. Level of stress can be evaluated employing calculation models or destructive testing with cutting off samples from real construction element.

Development of instruments capable to identify zones with technological and construction concentrators of mechanical stress as well as to assess the levels of such stress are now actively developed. The mentioned above methods found their application at oil/petroleum industry for identification of potential accident zones in pipelines made of ferromagnetic steels. Quality of weld joints depends on various factors including operational ones what calls for a non-destructive testing method capable to provide assessment of stress-deformation states for a vide range of metal materials.

Present paper reports on investigation of stressed state in weld joints performed at research reactor WWR-K for pipelines and heat exchangers of the main cooling loop; this equipment has been in continuous operation for 40 years. The pipelines of ∅200 mm in diameter and heat exchangers are made of austenite stainless steel 1Ch18Ni9Ti; the pipelines of ∅397 mm in diameter are made of aluminum alloy SAB-1. During operation and due to circulation of desalinated water, the pipeline walls experience oscillating impact of temperatures (10 – 55°C), pressures (1.2 – 3.5 kg/cm^2) and radiation. For investigation we chose potentially accident parts of the pipelines at bends and joints of several welds. Employing magnetic-anisotropic scanning flaw detector “Stressvision-2”, we performed evaluation of stressed state in the vicinity of weld joints and in bulk metal with scan step of 40 mm; pipeline and heat exchange wall thickness was assessed with ultrasonic instrument “Betagage”. Then, distributions of mechanical stress concentrators, stress non-uniformity coefficients and mechanical stress gradients were plotted for identification of potential accident areas.

Scanning of weld joints in constructions made of austenitic steel has revealed an area of high stress concentration in vicinity of a triple joint in the heat exchanger; further analysis of gradients for main mechanical stress showed that this defect is not a dangerous one. During the investigation, main attention was paid to those parts of the steel pipelines subjected to vibration.

As the investigations showed, in vicinity of the weld joints of the aluminum pipeline there is a region with increased stress gradients and high mechanical stress with difference in magnitude for 4–5 times while in the bulk metal these figures vary slightly with coefficients close to 1 (see fig. 1 – 3). This can show for the existence of unstable with respect to external impacts concentrator of stress in the form of arising defect; further develop-

ment of this defect could cause an accident. One should note that application of the Stressvision-2 instrument for diagnostics of non-ferromagnetic metal construction is currently at development and obtained results require further verification based on reliable methods of non-destructive testing.

New, original application of the magnetic-anisotropic scanning flaw detector "Stressvision-2" makes it possible to reveal zones of high concentration of mechanical stress in the weld joints of WWR-K main cooling loop made of stainless steel 1Ch18Ni9Ti and aluminum alloy SAB-1. In spite the required development and verification of the method used for assessment of stress-deformation state, the obtained results make it possible to reduce the scopes of other NDT methods such as RT and UT and focus regular inspections with these methods on revealed potential accident areas.

Fig. 1. Part of the pipeline of aluminum alloy SAB-1

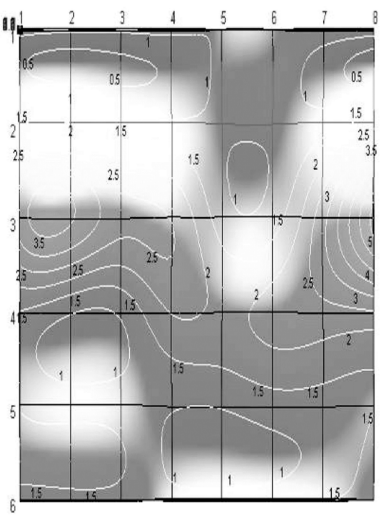

Fig. 2. Distribution map for coefficients of stress non-uniformity in vicinity of weld joint in the pipeline made of SAB-1 aluminum alloy

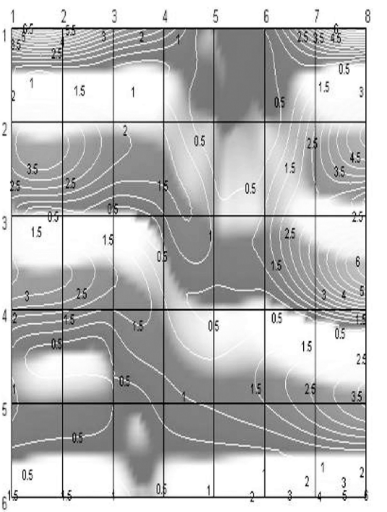

Fig. 3. Distribution map for difference gradients of main mechanical stress in vicinity of weld joint in the pipeline made of SAB-1 aluminum alloy