ISSN 0040-6015, Thermal Engineering, 2013, Vol. 60, No. 5, pp. 338–344. © Pleiades Publishing, Inc., 2013.
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NUCLEAR POWER STATIONS

Preventing Inadmissible Erosion–Corrosion Thinning from Occurring in the Diffuser Segments of Feedwater Supply Control Systems of Power Units at Nuclear Power Stations Equipped with RBMK-1000 Reactors

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Abstract—Results obtained from investigations of erosion–corrosion processes that occur during operation of the feedwater supply control systems used in power units of nuclear power stations equipped with RBMK-1000 reactors and the sensitivity of these processes to variations in the chemical composition of metal and in the flow path geometry are presented. It is found that local erosion–corrosion thinning of the walls in the diffuser segments of feedwater supply control systems occur mainly due to intense mass transfer in the near-wall region taken in combination with a low content of chromium. Hydrodynamic simulation was carried out, and it was shown based on its results that local erosion–corrosion thinning of the walls of pipeline segments downstream of the valves controlling the supply of feedwater to power units of nuclear power stations equipped with RBMK-1000 reactors can be prevented by subjecting them to appropriate modernization. It is found that the above mentioned diffuser parts can be made more resistant to erosion–corrosion wear by keeping the content of chromium in the main metal and weld joints at a level of no less than 0.25% and concurrently reducing the hydrodynamic effect in the zones of weld connections.

Keywords: local erosion–corrosion, control valve, feed water, power unit, nuclear power station

DOI: 10.1134/S0040601513050091

As the time for which the power units of nuclear power stations (NPSs) have been in operation reaches 30 years or more, erosion–corrosion damages accumulate, and inadmissible thinning occurs with an increasingly growing rate in the walls of pipelines and equipment components operating in contact with single- and two-phase flows. This is especially the case for components falling in the group susceptible to the risk of intense metal thinning that were revealed in the condensate-and-feedwater path of power units at NPSs equipped with RBMK-1000 reactors in the course of works performed within the framework of the Rosenergoatom Concern's comprehensive program on coping with the erosion–corrosion problem, as well as from the results of additional field surveillance of pipelines at Russian NPSs carried out according to the Mihama program [1–3]. The diffuser segments downstream of the control valves used in the feedwater supply system in some power units of RBMK-1000-based NPSs have been related to such components.

Cases of inadmissible thinning of the walls of such components and their failures were also observed at earlier times. These phenomena have the following characteristic features:

—Through flaws develop in a feedwater pipeline.

—In some cases, numerous zones with local erosion–corrosion thinning are revealed.

—Damages locate in the weld joints of the diffuser segment downstream of control valves.

Such damages give rise to serious concern because they can have a significant influence on the safety of NPS operation. Experience has shown that the situation can be aggravated by the fact that numerous locally thinned spots occur on wide areas. In addition, attempts to obtain valid and timely information about the damages to metal encounter considerable difficulties due to the fact that they locate in the near-weld zones and welded connections.

It was found from the results of previous investigations that the nature of damages inflicted to the diffuser segments downstream of feedwater control valves used in power units of NPSs equipped with RBMK-1000 reactors corresponds to the mechanism of local erosion–corrosion thinning [4]. The curves shown in Fig. 1 qualitatively characterize the erosion–corrosion rate as a function of the key factors and parameters (water chemistry, temperature, content of chromium in the metal, and channel geometry) that determine the possibility and relative rates of general and local erosion–corrosion (GEC and LEC) in the metal of welded connections in the diffuser segments of feedwater control systems.