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ANALYSIS OF RELIABILITY OF HEAT TRANSFER PIPES AT NUCLEAR POWER PLANTS

The steam generator pipe system is an important component of the heat exchange of the primary and secondary circuits of VVER [1]. Many studies have shown that in a steam generator pipe system, fluid movement causes vibration of the pipes. This causes wear and tear between the heat transfer pipe and the anti-vibration structure. As a result, the pipe walls become thinner and can break, which leads to colossal economic losses and environmental disasters. In this regard, to ensure reliable operation of the power system and, as a consequence, uninterrupted supply of thermal energy to consumers, it is necessary to pay special attention to the technical condition of power equipment [5]. This problem is very relevant today. Therefore, it is very important to study the wear of heat exchange pipes.

Wear resistance of a material is a mechanical property that resists surface destruction during dynamic movement along the surface [3]. Destruction is a complex, multi-stage process, which is influenced by a large number of factors, and there is no generally accepted approach to assessing their significance [4]. To study the wear of heat transfer tubes, many scientists have conducted research related to fretting wear. Fretting is described as a type of wear that occurs on two contact surfaces subject to small amplitude vibrations [2].

The fretting phenomenon is most reliably described by the Archard equation:

$$V = KF_{\Pi}K$$

When research is carried out on the wear of heat exchange pipes, theoretical studies are not completely combined with measurements carried out in practice. An in-depth study of various parameters including wear and wear behavior analysis needs to be carried out. This is why a finite element method such as ABAQUS is used to calculate and analyze the pipe model [1]. The finite element model is created according to the U-shaped heat exchanger design and based on the mean flow field data.

The flow elastic force is calculated by successively removing the active support, and the wear of the pipes is analyzed by studying the wear analysis method and establishing a wear rating system over the service life of these pipes [1].

The authors of the article [1] took 304L stainless steel with a size of 9.525×0.889 mm as the material of the heat exchange pipes, the density of the liquid inside and outside the pipe was 1000 kg/m^3, and the calculated equivalent density of the heat transfer tube was 16845 kg/m^3. According to the results of the analyzes and calculations of the authors of the article [1], the wear of the heat exchange pipe in contact with the 3rd partition reaches 0.0122 mm after 60 years, which is 1.4% of the wall thickness of 0.889 mm. The depth of wear at the contact with the 4th partition after 60 years reaches 0.0016 mm, which is 0.17% of the wall thickness. In total, the calculated readings give less than 10% of the wall thickness. After removing the 3rd and 4th baffle supports, respectively, the fundamental frequencies of both baffles are 16.11 and 6.99 Hz, respectively, and the corresponding elastic flow stability coefficients are 1.34 and 2.08, respectively.

Thus, by analyzing the reliability of pipes, it is possible to obtain the key factors influencing the degree of wear of heat exchange pipes over the entire service life. The reliability analysis method can be applied to analyze the wear resistance of the steam generator pipe system.

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