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NUCLEAR POWER PLANTS

Experimental Study of the Effect of Spacer Grid on the Flow Structure in Fuel Assemblies of the AES 2006 Reactor

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Abstract—Results from an experimental study of the local hydrodynamic structure of liquid flow in a 37-cell model simulating a fuel assembly used in the AES-2006 reactor are presented. Special attention is paid to the effect of spacer grid on flow hydrodynamics. Data on variations of the local and integral values of the liquid axial velocity and friction stress on the fuel rod simulator's wall with distance from the grid are given.

Keywords: AES-2006 project, VVER, fuel assemblies, spacer grids, flow hydrodynamics, friction stress

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Spacer grids (SGs), which are an important component of the reactor core, are among the main sources of pressure drop in the reactor's heat-transfer loop [1, 2]. In [3–8], the influence of spacer grids on the fluid flow pattern near them was pointed out. Foreign specialists have collected an extensive base of experimental data on thermal and hydraulic characteristics of coolant flow in the cores of power units operating at nuclear power stations (NPS) with fuel assemblies (FAs) having a square arrangement of fuel rods. With such information at hand, it becomes possible to develop and validate computation codes describing the thermal–hydraulic characteristics of reactor operation. At the same time, such important matters as the influence of spacer grid-induced disturbance on the flow and heat transfer, on the neighboring grids, on selection of the optimal distance between the grids, on the flow near the FA guiding channel, and the influence of two-phase flow pattern on the flow structure still remain unknown.

In view of what was said above, it is important to carry out a cycle of detailed experimental research works aimed at studying how local thermal–hydraulic characteristics of flow pattern are distributed in channels with a hexagonal geometry under field and model conditions. The purpose of this work is to experimentally study a local hydrodynamic structure of fluid flow in a 37-cell FA simulator when there is a spacer grid.

THE EXPERIMENTAL INSTALLATION

The experiments were carried out on a hydrodynamic setup made as a closed circulation loop (Fig. 1). The circulation pump used as part of the installation supplies fluid to the inlet of a vertically arranged working section, which has an FA simulator at its end. The supply pipeline is fitted with a flow metering orifice. On leaving the working section, fluid flows back into the tank via a removing pipeline. To obtain a uniform fluid flow field at the FA model inlet, a honeycomb made of 150-mm long stainless steel tubes with an outer diameter of 8 mm and 1-mm thick walls is installed in the working channel upstream of the FA.

The studied 1.2-m long simulator of the FA used in the reactor for the so-called AES-2006 project (belonging to the family of standard projects of VVER-based nuclear power stations) consists of 37 metal rods serving as fuel rod simulators and five spacer grids. Two SGs are placed at a distance of 50 mm from the ends of fuel rod simulators, and two other grids are placed at a distance of 250 mm from the fuel rod simulators. These grids serve for positioning the rods. The studied SG is installed at the middle of a rod bundle. It should be pointed out that in carrying out high-precision hydraulic measurements, all possible leaks of fluid between the SG and wall of the channel in which it is installed must be positively excluded. With this in mind, the FA simulator under study was fabricated so that its cross section has the shape of 37 regular hexagonal cells assembled together with a pitch corresponding to the parameters of FAs used in VVER reactors. The flow section area in such model remains constant over its length.

The flowrate of fluid through the working section was varied from 8.2 to 13 dm^3/s, which corresponded to the range of average liquid flow velocity through the simulator $V_L = 3–4.8$ m/s. The temperature of working fluid was maintained during the experiments at a constant level of 25°C. To this end, an automated thermostating system was fabricated, which consists of platinum thermoresistors, liquid heat exchangers, electromagnetic valves, and an electronic control sys-