SODIUM TECHNOLOGY AND EQUIPMENT OF THE BN-350 REACTOR


UDC 621.039.526+621.039.534.6

Information relating to the installation of a dual-purpose atomic station with a BN-350 reactor on the Mangyshlak peninsula in the USSR was presented in contributions to the Third International Conference on the Peaceful Use of Atomic Energy (Geneva, 1964), and the Detroit Conference in 1965. The present paper is devoted to a description of the main technological equipment and experimental work carried out in the construction process; it also includes a discussion of certain questions on sodium technology.

CIRCULATION PUMP

A console pump with a free fixed level of sodium, biological shielding, and mechanical sealing was chosen for the BN-350 reactor. Adequate experience in the use of such pumps has been gained in the USSR. The parameters of the pumps of the first and second circuits are shown in the table.

There is no fundamental design difference between the pumps of the first (Fig. 1) and second circuits. The pump in the second circuit has no biological shielding.

The shaft of the pump has one radial and one radial-thrust slide bearing. The distance between the axes of the working wheel and lower bearing is 2 m. The biological shielding is situated inside the pump tank and part of the shielding is in the sodium. Between the roof of the pump tank and the lower bearing is a cooling belt for reducing the axial flow of heat in the direction of the bearings, and also for preventing sodium vapor from passing into the bearing cavity of the pump. A sodium-potassium alloy is used to cool the belt. A system for cooling the shaft, operating from a common oil supply, is provided, and measures are taken to prevent the passage of oil vapor or the oil itself into the sodium. The pumping part proper is removed from the tank without cutting the sodium-containing conduits. The bearings and upper oil seal may be inspected and repaired without withdrawing the removable part of the pump. The gas cavity is sealed in this case by a special "standing" seal, which operates with the pump disconnected. Part of the coolant flow is closed "on itself"; the remainder is taken away through a special overflow line to the pump inlet. No speed regulation is provided, but the pump is able to operate under different conditions. Three, four, or five pumps may be connected in parallel, and in addition the pump may operate at one-quarter speed.

Design Parameters of the Circulating Pumps of the First and Second Circuits

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Rating, m³/h</th>
<th>Head of sodium column, m</th>
<th>Shaft speed, rpm</th>
<th>Maximum power of electric motor, kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>3220</td>
<td>110</td>
<td>1000/250</td>
<td>1700</td>
</tr>
<tr>
<td>Second</td>
<td>3850</td>
<td>70</td>
<td>1000/250</td>
<td>1100</td>
</tr>
</tbody>
</table>

Fig. 1. Sodium circulation pump of the first circuit: 1) flow of oil from the shaft gas-sealing unit; 2) water from shaft gas-sealing unit; 3) water for cooling the shaft gas-sealing unit; 4) oil passing into the shaft gas-sealing unit; 5) gas for scavenging; 6) oil passing into the upper bearing; 7) oil passing into the pivot; 8) oil passing into the shaft; 9) oil from the pivot, upper bearing, and shaft; 10) oil passing into the lower bearing; 11) Na-K for cooling the shaft; 12) oil from the lower bearing; 13) initial lining level; 14) maximum level.

Experiments in developing the design of the pump are continuing at the present time.

A 1:4.5 scale model has been used to choose the geometry of the flow section and the control apparatus, to determine the number and direction of internal flows, to carry out cavitation tests, to determine the degree and direction of hydraulic forces, and to find the efficiency of the pump (which turns out to be 70%).

The pump uses sealing of the type used in hydrogen-cooled generators. The heat from the friction pairs is transferred to the oil and eliminated with a built-in cooling system. A special testing system was set up to develop the construction and select the materials of the friction pairs. Preference was given to a combination of graphite and a chromium-plated steel surface.

A full-scale test-bed, comprising the under-carriage of the pump with all its components except the rotor (the weight of which was imitated by a metal disc), was set up to finish the bearings and to check the thermal state of the shaft, both when the oil-cooling system and cooling belt were in operation and when they were switched off.

At the present time a sodium test-bed has been set up for testing standard pumps. This is equipped with all necessary measuring and control systems. The test circuit contains about 20 m³ of sodium. The test-bed will be used to test pumps under conditions similar to those found in practice and also to test the electric motor and its auxiliary systems, the fittings, the reverse valve, the level gage, and the flow meter. The main purpose of the test-bed, however, is the all-round "capability testing" of earlier-developed principal components of the pumping system and the pumping system as a whole.

The test-beds for the pumps of the first and second circuit are placed together; by setting up a connection between them, it is proposed to carry out tests on the reverse valve under conditions simulating the shut-down of one of the pumps in the BN-350 reactor.

**INTERMEDIATE HEAT EXCHANGER**

The intermediate heat exchanger (Fig. 2) of shell-and-tube construction consists of two parallel sections. Each section is made in the form of a horizontal rectangular tank with three heat-transfer pipe beds immersed in it. Each bed consists of 343 U-shaped pipes 28 mm in diameter and 2 mm thick with a spacing of 35 mm along the front and in depth. Kh15N9 steel is used. The beds in each section are connected in series. The sodium of the first circuit passes into the inter pipe space, where it transfers heat to the sodium of the second circuit moving inside the pipes. The vertical U-shaped pipe