CERTAIN PROBLEMS IN THE OPERATION OF
ATOMIC POWER STATIONS

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The experience acquired in operating the atomic power station of the Central Committee on the Use of Atomic Energy for the Council of Ministries, USSR, is evaluated. It is assumed that the reader is acquainted with the main characteristics of the reactor and the technological layout of the power station. A method of fuel-channel reloading is described in which only parts of the core are reloaded; using this scheme it is possible to achieve a greater burnup of the nuclear fuel (up to 20%) as compared with that which can be achieved when total reloading is used (11%). The partial reloading scheme increases the useful life of the fuel channels and makes it possible to use them more economically. It is shown that using the partial reloading scheme, in an effective day (24 hours of operation at full power) 1.2 channels are consumed whereas 1.7 channels are consumed when complete reloading is used.

Furthermore, the use of the partial reloading scheme results in a considerable improvement in the uniformity of the neutron field at varying distances from the center of the core. The various problems which arise in starting up the atomic power station from "zero" level to the nominal level are described. The change in reactivity due to the temperature rise is found to be \( \Delta k = 0.027 \pm 0.003 \). The feasibility of dispensing with cooling in the side reflector of the reactor, because of the low heat dissipation is discussed. Heat dissipation in the fuel channels following shutdown is also considered. It has been found that the fuel channels can be removed without cooling two hours after the reactor is shut down. The results of a chemical analysis of the coolant water of the primary circuit after various periods of operation are given and it is found that the insignificant amount of washed down contaminants means that operation can be carried on without the use of bidistillate and the condensate from the turbine condenser can be used. Finally, there is a discussion of questions bearing on biological safety and dosimetry. The operation of the station and its technological plant does not constitute a source of danger to the personnel of the station or the population of the surrounding region.

INTRODUCTION

The first atomic power station in the world has been in successful operation in the Soviet Union for more than two and one-half years. All the auxiliary installations and the primary equipment (the reactor, the main circulating pumps, the steam generators, the headers and feed-pumps of the primary circuit, etc.) have been found more than satisfactory.

The performance of the main components of the power reactor – the uranium heat-generating elements – has been extremely good. During the entire period of operation not one of these elements has been removed from service.

We note that each of the 128 fuel channels of the reactor contains 4 shell-and-tube heat-generating elements cooled by water at a pressure of 100 atm which is at a temperature of 190°C on entering the reactor and ~ 270°C upon exit.
The reliable operation of the heat-generating elements has made it possible to extend the operating life of the fuel channels beyond the design values and to increase the \( \text{U}^{235} \) burnup.

Some data which characterize the operation of the fuel channels are shown in Table 1.

It is apparent from the table that a considerable number of the channels have been operated in the hottest zone of the reactor for more than 200 effective days; this period exceeds the design life of the channels by a factor of 2.

A considerable amount of operational experience has been obtained at the atomic power station. Within the scope of the present paper it is not possible to discuss all the problems which have been encountered so that we shall limit ourselves to those which are of the most importance.

**Partial Reloading Scheme for the Reactor Fuel Channels**

It is well known that \( \text{U}^{235} \) burnup is different in different fuel channels of the reactor as a function of distance from the center of the core, because of the variation in heat dissipation. It reaches a maximum value in the center channels and falls off at the periphery of the core. Consequently, the relatively large fraction of the reactor charge at the periphery of the core "burns" comparatively weakly (Fig. 1). Because of this situation a partial reloading scheme is used; in the first run, instead of a full charge of fresh fuel channels, only a part of the reactor core is charged. Fuel elements from the periphery of the core are subsequently moved to the center to increase burnup; that is, by charging the core with fresh elements at the periphery and moving these toward the center in gradual steps, a more complete burnup is achieved.

As an example, we shall consider this method as applied to the first three reloading operations. It is convenient to divide the core of the reactor into 3 zones as shown in Fig. 2:

Zone I - 42 fuel channels,
Zone II - 42 fuel channels,
Zone III - 44 fuel channels.

At the end of the first run, which was 75 effective days, the \( \text{U}^{235} \) burnup in the reactor averaged 11\%. In this run, the reactor was operated with a charge of 128 fresh fuel channels with 5\% content of \( \text{U}^{235} \).

In the first reloading of the reactor, fresh fuel channels were used only to replace the channels in Zone I which had a burnup of 8\%; the channels in the other two zones were allowed to remain for further "burning."

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**Table 1**

Performance Indices for the Fuel Channels as of October 10, 1956

<table>
<thead>
<tr>
<th>No. of fuel channels</th>
<th>Effective operating days</th>
<th>( \text{U}^{235} ) burnup in %</th>
<th>Thermal loading, kcal/m²/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>6**</td>
<td>250</td>
<td>31.2</td>
<td>( (1.0 - 1.5) \times 10^6 )</td>
</tr>
<tr>
<td>22</td>
<td>232</td>
<td>24.4</td>
<td>( (1.0 - 1.5) \times 10^6 )</td>
</tr>
<tr>
<td>22</td>
<td>149</td>
<td>19.6</td>
<td>( (1.0 - 1.5) \times 10^6 )</td>
</tr>
<tr>
<td>11</td>
<td>108</td>
<td>19.0</td>
<td>( (1.0 - 1.2) \times 10^6 )</td>
</tr>
<tr>
<td>33</td>
<td>150</td>
<td>15.0</td>
<td>( (0.8 - 1.0) \times 10^6 )</td>
</tr>
<tr>
<td>133***</td>
<td>100-150</td>
<td>12-15</td>
<td>( (0.8 - 1.0) \times 10^6 )</td>
</tr>
</tbody>
</table>

* Effective day taken to be an operating period in which the reactor is operated at full power for 24 hours.
* The channels were placed in the reactor for an extended test to determine the limits of "robustness" of the heat dissipation elements.
* At the present time the channels are in a purification bath and in subsequent reloadings will be placed in the reactor for further burnup.

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**Fig. 1.** \( \text{U}^{235} \) content by percentage along the reactor radius at the end of the first run.

**Fig. 2.** Partial reloading zones of the reactor. The numbers indicate the zone radius in cm. The crosshatched channels are the control system and the protection system.