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HEAT AND MASS TRANSFER AND PROPERTIES OF WORKING FLUIDS AND MATERIALS

Implementation of the Library of Properties of Sodium Vapor on the Basis of the *s* (*p*, *h*) Formulation in the Thermohydraulic Module of the SOKRAT-BN Integral Code

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Abstract—The paper presents the results of incorporating into the SOKRAT-BN code a new library of properties of sodium vapor on the basis of the *s* (*p*, *h*) formulation: the entropy of sodium vapor as a function of pressure and enthalpy. A double increase in the computational speed and a good agreement with the results of the previous version of the library of properties of sodium vapor are attained.

Keywords: sodium, equation of state, the library of properties

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The SOKRAT-BN integral code [1] is developed for computation of emergency regimes of the BN reactor with a sodium cooler. At the present time, verification of its thermohydraulic module is underway. The models describing the behavior of the cooler are implemented in a program complex consisting of separate blocks or modules, including the module of thermophysical properties of sodium. Such organization of the code enables one to make changes in its separate parts without changing the entire code.

The module of the properties of sodium consists of two libraries, one of which makes it possible to calculate the thermodynamic properties of sodium (density, temperature, etc.) in the liquid state and, the other one, in the gaseous state. The parameters of liquid sodium differ only a little from those on the saturation line, and determination of them does not require much computational time. The library of properties of liquid sodium is based on [2]. The old version of the library of properties of sodium vapor employs the equations proposed in [3], application of which requires procedures of iterative inversion, which increases the computation time. In order to remove this drawback, the new version of the library of properties of sodium vapor was developed on the basis of the *s*(*p*, *h*) formulation [4], which was complemented by the authors with the equation for the saturation line.

The main advantages of the *s*(*p*, *h*) formulation is its polynomial form and the use of variables (pressure and enthalpy) that are basic ones in the thermohydraulic module of the SOKRAT-BN code.

In this work, the results of incorporating the new library of properties of sodium vapor into the SOKRAT-BN code are presented.

EQUATIONS OF THE SATURATION LINE

The saturation line for the *s*(*p*, *h*) formulation is the dependence of the saturation enthalpy of sodium vapor on pressure: $h_s(p)$. The equation for the saturation enthalpy is the following:

$$\left[\frac{h_s(p)}{h^*} - 0.95\right]^2 = \sum_{i=1}^{9} n_i \left(\frac{p_s}{p^*}\right)^{I_i}, \qquad (1)$$

where $h^* = 5008.032$ kJ/kg, $p^* = 30 \times 10^5$ Pa (here and below, asterisks denote normalization constants), and p_s is the saturation pressure. The numerical values of the coefficients and exponents are summarized in Table 1.

The saturation temperature and the sodium vapor density on the saturation line at a given pressure can be found from the formulas presented in the next section with the use of relationship (1). Figure 1 shows the comparison of the saturation formula calculated from expressions (1) and (2), with the results of [2].

THE NEW LIBRARY OF PROPERTIES OF SODIUM VAPOR

On the basis of the *s*(*p*, *h*) formulation [4] complemented by relationship (1) for the saturation line, a new library of the properties of liquid sodium was developed. It can be used for computation of various