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Corresponding Member of the Academy of Sciences of the USSR
M. A. STYRIKOVICH,

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Fig. 1. Dependence of the solubility of boric acid in saturated water vapor on its content in water at pressures (in ata): 1 –p = 1, 2 –p = 3, 3 –p = 5, 4 –p = 7, 5 –p = 10, 6 –p = 40, 7 –p = 80, 8 –p = 100, 9 –p = 150, 10 –p = 200

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Abstract

Full Text

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Corresponding Member of the Academy of Sciences of the USSR M. A. STYRIKOVICH,
D. G. TSKHVIRASHVILI, and D. P. NEBIERIDZE

INVESTIGATION OF THE SOLUBILITY OF BORIC ACID IN SATURATED WATER VAPOR

When a boric acid solution is used to regulate the reactivity of boiling solutions, it is necessary to know the solubility of boric acid not only in water but also in water vapor.

Investigations of the solubility of boric acid in saturated water vapor were carried out on a special apparatus by the method of evaporating a small portion of a solution of specified concentration. In the apparatus, measures were taken to minimize entrainment of droplet moisture by the vapor, and a steam jacket was provided to prevent condensation of vapor on the walls. The content of boric acid in samples of the steam condensate was determined by a colorimetric method using carmine and by a volumetric method with mannitol. The experimental procedure ensured acceptable accuracy of the investigation. The relative error of the bulk of the experiments was 2–5%.

The investigation (see Fig. 1) covered a very broad range of pressures (from 1 to 200 ata), of interest not only for boiling reactors but also for nuclear-power-plant evaporators, as well as for geothermal stations. The concentration of boric acid in water was also varied over wide limits (from 0.2 to 22 g/kg).

Fig. 1. Dependence of the solubility of boric acid in saturated water vapor on its content in water at pressures (in ata): 1 $-p = 1$, 2 $-p = 3$, 3 $-p = 5$, 4 $-p = 7$, 5 $-p = 10$, 6 $-p = 40$, 7 $-p = 80$, 8 $-p = 100$, 9 $-p = 150$, 10 $-p = 200$.

As a result of the investigation, a linear dependence was found between the

Figure 2

Figure 2: Figure 2

Figure 3

Figure 3: Figure 3

concentration of B_2O_3 in saturated vapor and its concentration in water. Consequently, the distribution coefficient of boric acid between the vapor and liquid phases of the solvent in the investigated region does not depend on concentration. In comparison with other inorganic compounds, boric acid dissolves very well in saturated water vapor even at low pressure.

In Fig. 2, the values of the apparent distribution coefficients of boric acid obtained in the experiments are presented as a generalized dependence on

ratio of the densities of the solvent phases ([2]). For boric acid this dependence is expressed by a power function:

$$K_{\mathrm{p}}^{\mathrm{vis}} = \frac{C_{\mathrm{p}}}{C_{\mathrm{v}}} = \left(\frac{\gamma_{\mathrm{p}}}{\gamma_{\mathrm{v}}}\right)^{0.885},$$

where C_{p} and C_{v} are the concentration of B_2O_3 in the steam and in the water, and γ_{p} and γ_{v} are the specific weights of the steam and the water. As is seen from Fig. 2, the values of the distribution coefficient

Fig. 2. Dependence of the apparent distribution coefficient $K_{\mathrm{p}}^{\mathrm{vis}}\frac{C_{\mathrm{p}}}{C_{\mathrm{v}}}$ on the steam pressure p and on the ratio of the densities of steam and water $\gamma_{\mathrm{p}}/\gamma_{\mathrm{v}}$.
1 –data of the Institute of Power Engineering of the Academy of Sciences of the Georgian SSR; 2 –data of the Moscow Power Engineering Institute

are in good agreement with individual points obtained at the Moscow Power Engineering Institute. It proved noteworthy that the indicated dependence is obeyed down to 1 ata, although at a temperature of 200–210° (in the pressure range 16–20 kg/cm) the form of the solid phase precipitating from a saturated boric-acid solution in water changes. As is seen from Fig. 2, of all the compounds studied, boric acid is characterized by the largest value of $K_{\mathrm{p}}^{\mathrm{vis}}$ and, correspondingly, by the smallest exponent $n = 0.885$. Even for silicic acid it is

Fig. 3. Dependence of $K_{\mathrm{p}}^{\mathrm{vis}}$ of boric acid on the additive:
1 –NaCl, 2 –Na_2SO_4, at a pressure of 10 ati

$n = 1.9$. This is connected with the fact that boric acid is very weak ($K_{\mathrm{d}} = 7 \cdot 10^{-10}$) and, like silicic acid, is present in aqueous solution practically in the undissociated state. Therefore these experiments once again confirm the theoretical proposition ([3]) concerning the preferential transition into steam of compounds that are present in aqueous solution in the form of molecules.

This is also indicated by the results of experiments (see Fig. 3) carried out with binary solutions, one of whose components was boric acid. The addition of considerable amounts of NaCl or Na_2SO_4 to aqueous solutions of boric acid has practically no effect (at constant pressure) on the apparent distribution coefficient of boric acid. It can apparently change only at very high solution concentrations, when the effect of depression begins to be reflected in the ratio γ_p/γ_v.

As a result of the work carried out, and on the basis of the behavior of boric acid in superheated steam ([4]), a number of practical conclusions may be drawn. The behavior of boric acid in the steam circuit of a nuclear power plant, including blowdown evaporation installations, is completely determined by the laws governing its solubility in water vapor, since even at atmospheric pressure the distribution coefficient many times exceeds the usual values of the coefficient of mechanical entrainment of moisture with steam.

Institute of Power Engineering named after A. I. Didebulidze
Academy of Sciences of the Georgian SSR

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REFERENCES

[1] M. A. Styrikovich, *Proceedings of the Conference on the Thermodynamics and Structure of Solutions*, Moscow, 1959.
[2] M. A. Styrikovich, I. Kh. Khaibullin, D. G. Tskhvirashvili, DAN, 100, No. 6, 1123 (1955).
[3] M. A. Styrikovich, O. I. Martynova, I. Kh. Khaibullin, E. I. Mingulina, *Teploenergetika*, No. 9, 50 (1959).
[4] D. G. Tskhvirashvili, D. P. Nebieridze, *Communications of the Academy of Sciences of the Georgian SSR*, 23, No. 6, 695 (1959).

Note: Figure translations are in progress. See original paper for figures.