HEAT CONDUCTIVITY OF AQUEOUS SYSTEMS AS A MAIN TRANSPORT PROPERTY OF WORKING FLUIDS OF THE THERMAL POWER INDUSTRY

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ABSTRACT

The results of the experimental investigations of the thermal conductivity of aqueous solutions of CsCl, aqueous solutions CsBr and aqueous гдеир to 473 K, are given in the article. An equation for thermal conductivity was derived for correlation of experimental data.

Keywords: aqueous systems, power industry, thermal conductivity, electrolytes

I.INTRODUCTION

Aqueous solutions of electrolytes are widely used as heat bearers in the different branches of industrial thermal engineering, setups of heat and nuclear power stations, geothermal energetic and hallurgs. Aqueous solutions of salts are used practically in production of all inorganic substances and reagents in which the chemical process are preceded.

One of the main problems of studying of electrolyte solutions is the investigations of their thermal properties and setting of the guantative regularities between thermophysical characteristics of aqueous solutions and electrolyte concentrations. One of properties is the thermal conductivity.

Thermal conductivity of solutions plays an important part in the calculation constructions of thermal setups and heat exchangers. Knowledge of thermal conductivity and other properties of aqueous system allow solving many problems connected with equipment design amid technology optimization by calculation.

At present investigations of thermal conductivity of solutions becomes actual in connections with the progress achieved in studying of water structure on the basis of ion hydrations in solutions.

II. BODY OF THE TEXT

Measurements of thermal conductivity of solutions have been carried for a long time and great number of our works is devoted to them [1-6].

Thermal conductivity of five a aqueous CsCl solutions of molality (0.660, 1.485, 2.546, 3.960, 5.940) $\mathrm{mol \cdot kg^{-1}}$, five aqueous CsBr solutions of molality (0.5372, 1.209, 2.072, 3.224, 4.836) $\mathrm{mol \cdot kg^{-1}}$ and five aqueous CsI solutions of molality (0.2026, 0.4275, 0.9620, 1.650, 2.566) $\mathrm{mol \cdot kg^{-1}}$ have been measured with a concentric-cylinder (steady-state) technique [4]. The thermal conductivity at temperatures from 20 to 473 K was measured at atmospheric pressure, after which all measurements were performed at the saturations pressure of solutions under study (this pressure varied versus temperature from 0.5 to about 5 MPA). All solutions of salt have been prepared from the reagents market "chemically pure" on common received methodic. The measurements principle of thermal conductivity layer is based on the fact that in constant power of heating element temperature differences ΔT in the investigated substance layer meared by differential thermocouple, are defined by thermal conductivity of the investigated liquid, that is

$$\Delta T = \varphi(\lambda) \qquad (1)$$

where λ is a coefficient of thermal conductivity.
Using the theory of similarity [7] instead of (1), we get

$$y = f(x) \qquad (2)$$

where $x - u^2/\Delta E$, $y - x/\lambda$ here u is the heater voltage; ΔE is the thermo electromotive force of differential thermocouple.

The relationship (2) is established by graduating the instrument with the respect to liquids with the known values of thermal conductivity. In this case water was used to graduate the setup. The data of thermal conductivity of water were taken from [8]. The setup was also graduated at pressures 10, 20, 30, 40 and 50 MPa. The error of experimental data been estimated as 0.14 %.

III. RESULTS

The experimental values of thermal conductivity near the saturation line for aqueous solutions of CsCl, CsBr, CsI are shown in table 1.As it seen from the table thermal conductivity of investigated solutions decreases by increasing electrolyte concentration. Decrease of thermal conductivity of solutions by increasing electrolyte concentration and increase of λ in dependence on temperature about 140 ^{0}C - are explained according to the theory of thermal conductivity of water.

It has been found on the basic of the experimental data that the ratio of the thermal conductivity of solutions λ_S to that of water λ_W or "relative thermal conductivity" for the given concentrations of electrolyte with the maximum error of 0.4 % is dependent of temperature, that is,

$$\lambda_S/\lambda_W = \Lambda \neq f(T) \qquad (3)$$

where Λ - relative thermal conductivity.

IV. CORRELATION

In order to approximate the experimental results versus the concentrations, the dependence of λ_S/λ on square root of molality $\sqrt{m}$ is theated, this dependence being described within ±0.5% by the equation

$$\lambda_s = \lambda_W(1 + Am + Bm^{3/2} + Cm^2)\ , \qquad (4)$$

where the coefficients *A, B* and *C* do not depend on temperature.

For the H_2O + CsCl, H_2O + CsBr , H_2O + CsJ systems under study, the coefficients A, B and C have the following values:

H_2O + CsCl:
A= -0.03181
B= -0.00385
C= 0.00243

H_2O + CsBr :
A= - 0.05698
B= 0.00572
C= 0.00179

H_2O + CsJ :
A = -0.07083
B = 0.00869
C = 0.00274

The calculated values of thermal conductivity by formula (4) differ from our experimental results by 0.6 % at most. Formula (4) makes it possible to use a simple method (without long and labor-consuming experiments) to determine the thermal conductivity of little studied mixed solutions in a wide range of temperatures.

V. CONCLUSION

1. The experimental data on the thermal conductivity of aqueous CsCl, CsBr, CsJ solutions have been received in the temperature range of 293-473 K at the saturation pressure of solutions under study (this pressure varied versus temperature from 0.5 to about 5 MPa).
2. It is shown that the heat solvent water plays a definite role in heat transfer in the aqueous solutions of electrolytes. The new equation for thermal conductivity of aqueous of salts has been received.

Table 1. The experimental values of thermal conductivity of H_2O + CsCl, H_2O + CsBr , H_2O + CsJ system nearly saturation line, λ, $W \cdot m^{-1} \cdot K^{-1}$

m, mol·kg^{-1}	***T, K***	***λ, W·m^{-1}·K^{-1}***
H_2O + CsCl		
0.660	292.78	0.577
	303.12	0.590
	313.01	0.604
	332.69	0.626
	352.47	0.644
	373.32	0.658
	393.21	0.661
	402.83	0.660
	423.30	0.659
	472.68	0.633
1.485	292.47	0.550
	303.74	0.563
	313.51	0.579
	331.77	0.597
	352.83	0.614
	373.63	0.627
	393.90	0.630
	402.01	0.630
	424.12	0.629
	472.54	0.60
2.546	293.53	0.519
	302.37	0.530
	314.22	0.542
	333.04	0.562
	353.59	0.578
	372.83	0.591
	394.11	0.593
	401.88	0.593
	424.51	0.592
	471.92	0.568
3.960	293.88	0.482
	302.79	0.493
	314.05	0.504
	334.69	0.523
	352.17	0.538
	373.24	0.549
	393.58	0.552
	401.54	0.551
	422.79	0.550
	471.75	0.528
5.94	291.93	0.440
	304.08	0.450
	313.53	0.459
	332.47	0.478
	354.18	0.492
	373.63	0.501
	392.14	0.505
	404.18	0.505
	422.17	0.502
	473.79	0.483

H_2O + CsBr		
0.5373	292.21	0.572
	303.88	0.5860
	312.59	0.600
	334.31	0.6215
	353.87	0.639
	371.73	0.653
	392.17	0.655
	402.82	0.656
	424.24	0.654
	473.18	0.628
1.209	293.48	0.542
	304.11	0.556
	312.28	0.568
	334.05	0.589
	352.19	0.606
	374.25	0.618
	394.33	0.622
	403.58	0.622
	424.72	0.619
	472.11	0.595
2.072	294.16	0.508
	303.94	0.521
	312.53	0.533
	332.48	0.552
	353.82	0.568
	372.67	0.580
	393.48	0.583
	403.38	0.583
	421.99	0.581
	472.35	0.558
3.224	293.78	0.471
	302.11	0.483
	312.49	0.494
	334.59	0.512
	352.12	0.527
	372.87	0.538
	394.72	0.541
	402.37	0.540
	424.28	0.539
	472.22	0.518
4.836	291.97	0.429
	305.01	0.442
	313.59	0.453
	331.82	0.469
	352.78	0.483
	373.12	0.492
	394.61	0.495
	401.18	0.498
	423.17	0.492
	471.77	0.473

H_2O + CsJ		
0.2026	294.19	0.586
	303.23	0.600
	312.78	0.613
	334.42	0.636
	352.17	0.654
	373.57	0.668
	392.18	0.671
	401.78	0.669
	424.13	0.669
	473.04	0.643
0.4275	293.13	0.572
	304.09	0.586
	332.64	0.621
	354.19	0.639
	372.14	0.652
	392.14	0.656
	403.61	0.656
	424.32	0.635
	472.16	0.628
0.962	292.47	0.542
	302.68	0.550
	312.42	0.568
	334.15	0.589
	352.92	0.606
	372.81	0.618
	391.21	0.621
	403.70	0.621
	422.52	0.619
	471.91	0.595
1.650	291.87	0.5079
	302.17	0.521
	313.48	0.533
	334.71	0.552
	352.90	0.583
	374.18	0.580
	392.08	0.583
	403.19	0.582
	422.71	0.581
	471.42	0.558
2.566	292.48	0.471
	303.21	0.483
	314.17	0.494
	332.71	0.512
	354.01	0.527
	372.53	0.537
	394.27	0.540
	402.71	0.541
	422.56	0.538
	473.03	0.578

REFERENCES

1. *Abdulagatov I. M; Akhmedova-Azizova L. A, Azizov N. D.* Thermal Conductivity of Aqueous $Sr(NO_3)_2$ and $LiNO_3$ Solutions at High Temperatures and High Pressures. *J.Chem. Eng.Data* 2004, 49, 688-703.
2. *Abdulagatov I. M; Akhmedova-Azizova L.A., Azizov N.D.* Thermal Conductivity of Binary Aqueous NaBr and KBr and Ternary H_2O+NaBr Solutions at temperatures from (294 to 577) K and Pressures up to 40 MPa. *J. Chem Eng*. Data 2004, 49, 1727-1737.
3. *Akhmedova-Azizova L. A., Guseinov K. D.* Heat Conductivity of Solutions the Main Components of Working Fluids of the Thermal Power Industry. *Conference proceeding. Second International Conference on Technical and Physical Problems in Power Engineering*. Tabriz-Iran, 2004.
4. *Eldarov V.S.* Thermal Conductivity of Aqueous Solutions System KCl-$NaCl_2$ at high temperatures and pressures. *High Temperature*. 2003, Vol.41, 3, 381. (in Russian)
5. *Eldarov V.S.* Thermal Conductivity of Aqueous Solutions System NaCl, $CaCl_2$ and KCl near the saturated line // Energy. 2004. .№1, p.57(in Russian)
6. *Abdullayeva G.K; Eldarov V.S; Mustafayev A.M.* Thermal Conductivity of Aqueous Solutions of NaCl-$CaCl_2$ system. *High Temperature,* Vol.36, 3, 375-378. (in Russian)
7. *Novikov I.I; Borishanovskiy V.M.* The similarity theory in thermodynamics and themocond, Moscow. *Atom publish*, 1979, 184(in Russian)
8. *Kestin J.; Sengres J.V.; Kamgar-Parsi B.; Levelt Sengres J. M. H.* Thermophysical Properties of Fluid H_2O. *J. Phys. Chem. Ref.* Data 1984, 13, 175-189.