TEMPERATURE COEFFICIENT OF ADIABATIC COMPRESSION FOR PURE WATER

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Data on the speed of sound are used to obtain values of the temperature coefficient of adiabatic compression for water at pressures to 1000 bar.

The tempeature coefficient of adiabatic compression

$$\beta_s = \left(\frac{\partial T}{\partial P}\right)_s = \frac{T}{C_p}\left(\frac{\partial v}{\partial T}\right)_p \qquad (1)$$

is a partial derivative of a function, knowledge of which allows good definition of the thermodynamic surface in composing an equation of state for a liquid. Data on derivatives is specially important for water because of the very anomalous changes in its properties. On the other hand, β_s values are used in the thermodynamic method of calculating hydraulic machine efficiency [1], which demands high accuracy. However, as was shown in [2], calculations of state possible for water yield significantly different β_s values, and to obtain reliable values [2] carried out an experimental measurement of the temperature coefficients of adiabatic compression over the temperature range 2.74-80°C at pressures to 840 bar.

In the technique used in [2], finite temperature and pressure differences are measured, and their substitution into Eq. (1) leads to some averaging of the β_s values obtained, which can prove significant in the region of the water anomaly. This shortcoming can be avoided if to calculate β_s we utilize data on the speed of sound propagation.

In the present study β_s values were calculated with Eq. (1), in which the quantities C_p and $(\partial v/\partial T)_p$ were defined from data on the speed of sound, as given by an equation in [3]. To do this step-by-step iteration was used to obtain the equation of state proposed in [4]. The calculated β_s values are presented in Table 1.

A comparison of the calculated values with data of [2] is shown in Fig. 1. For temperatures from 20 to 80°C the divergence is basically no more than 0.5%, which was the estimate made in [2] of the experimental uncertainty in this parameter range. With decrease in temperature the relative divergence increases, since the β_s values themselves decrease (at the maximum density point the value of β_s passes through zero). However, in absolute value

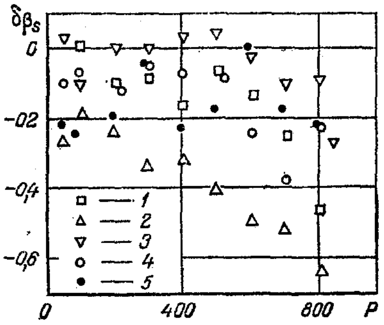

Fig. 1. Divergence of experimental and calculated values of β_s values for temperatures: 1) 10; 2) 20; 3) 40; 4) 60; 5) 80°C. P, bar; $\delta\beta_s = 100\ (\beta_2[2]-\beta_s)/\beta_s$, %.

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TABLE 1. Temperature Coefficient of Adiabatic Compression of Water $\beta_s \cdot 10^3$, °K/bar

P, bar	Temperature, °C											
	0	2,74	10	20	30	40	50	60	70	80	90	100
1	—0,44208	—0,13315	0,59437	1,4518	2,2095	2,9097	3,5791	4,2355	4,8909	5,5534	6,2301	6,9286
50	—0,32162	—0,02643	0,67508	1,5045	2,2396	2,9222	3,5763	4,2183	4,8594	5,5076	6,1699	6,8535
100	—0,20197	0,08005	0,75602	1,5574	2,2701	2,9349	3,5741	4,2020	4,8289	5,4629	6,1108	6,7796
200	0,02978	0,28708	0,91288	1,6604	2,3302	2,9610	3,5711	4,1718	4,7719	5,3791	5,9999	6,6470
300	0,25126	0,48542	1,0623	1,7590	2,3893	2,9876	3,5697	4,1445	4,7197	5,3021	5,8980	6,5130
400	0,46093	0,67343	1,2039	1,8533	2,4467	3,0143	3,5695	4,1198	4,6718	5,2314	5,8042	6,3954
500	0,65770	0,85009	1,3376	1,9433	2,5021	3,0406	3,5704	4,0977	4,6278	5,1661	5,7174	6,2865
600	0,84141	1,0153	1,4638	2,0289	2,5551	3,0662	3,5723	4,078	4,5876	5,1057	5,6369	6,1855
700	1,0127	1,1698	1,5829	2,1103	2,6055	3,0909	3,5749	4,0604	4,5508	5,0498	5,5620	6,0915
800	1,1729	1,3147	1,6954	2,1874	2,6534	3,1146	3,5780	4,0448	4,5169	4,9979	5,4923	6,0039
900	1,3234	1,4515	1,8018	2,2603	2,6889	3,1375	3,5816	4,0307	4,4857	4,9497	5,4274	5,9225
1000	1,4658	1,5880	1,9028	2,3291	2,7420	3,1596	3,5855	4,0180	4,4567	4,9049	5,3670	5,8467

the divergence is not high, comprising $4.5 \cdot 10^{-6}$ deg K/bar at the lowest temperature presented in [2], 2.74°C. All the divergences are significantly less than those noted in [1] for values calculated with equations of state, which again illustrates the fact that in the liquid region equations of state based on P, v, T data which describe density well can lead to significantly diverging values of derivative properties.

We note that in our calculation experimental data on density and isobaric heat capacity are necessary only at atmospheric pressure. For the high-pressure region only data on the speed of sound are required [4]. The results obtained indicate the possibility of accurate calculation of β_s from acoustical studies without performing complex experimental measurements of this quantity.

NOTATION

β_s, temperature coefficient of adiabatic compression; T, absolute temperature; C_p, isobaric heat capacity; v, specific volume; s, entropy; p, pressure.

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VOLT—AMPERE CHARACTERISTICS OF AN AC ARC IN A TRANSVERSE GAS FLOW

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An analytical dependence of the volt—ampere characteristic of an arc on the velocity of the incoming transverse gas flow is obtained. The stability threshold of arc combustion is determined.

The ac electric arc is widely used as an intense heat source in various devices: steel-smelting furnaces, welding instruments, plasmotrons, etc. The existing theoretical investigations in the literature are basically calculations of an arc without a gas flow [1] and with a cotraveling flow [2]. There are practically no data on an arc in a transverse flow. Only in [3] was the experimental volt—ampere characteristic (VAC) of an arc moving in air under the action of a rotating magnetic field investigated.

In deriving the theoretical equations for an arc in a transverse gas flow, the following assumptions are made: the form of the arc is cylindrical; the axis Ox is parallel to the direction of the incoming flow; the axis Oz coincides with the arc axis; the influence of the intrinsic magnetic field of the arc and the pressure gradients in the gas flow is neglected; processes occurring close to the electrodes are neglected; a constant mass velocity $\vec{u} = \rho\vec{v}$ is assumed inside the arc; and the pulsations of enthalpy and gas velocity following the arc are not taken into account.

First consider the enthalpy distribution in the arc. The energy equation for the given arc model is written in the form

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