A NEW METHOD FOR THE CALCULATION OF THERMAL CONDUCTIVITY OF BINARY GAS MIXTURES

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A new method for calculating the thermal conductivities of binary gas mixtures has been suggested on the basis of Eucken approximation and applied for six monoatomic non-polar and six other gas mixtures. The essential feature of the present method is that it avoids the use of experimental thermal conductivity values of gaseous mixtures as well as the viscosity of pure components. There is no need of adjustment for the best experimental fit. Thermal conductivity values calculated by the present method show good agreement with the experimental values for the twelve gaseous mixtures. The accuracy is of the same order or better than those of Lindsay-Bromley method.

INTRODUCTION

AMONGST the various formulae proposed for calculating the thermal conductivity of gas mixtures, Wassiljewa equation (Wassiljewa, 1904) has been found to be the most successful and has theoretical justification. Wassiljewa expression

$$\lambda_{mix} = \frac{\lambda_i}{1 + A_{ij}\frac{X_j}{X_i}} + \frac{\lambda_j}{1 + A_{ji}\frac{X_i}{X_j}} \qquad ...(1)$$

has two adjustable parameters A_{ij} and A_{ji}. A_{ij} is interpreted (Cowling, 1961; Wright & Gray, 1962; Cowling *et al.*, 1963) as the ratio of the efficiencies with which molecules j and i respectively impede the transport of heat by molecules i. Accurate estimation of Wassiljewa coefficients is the main problem in the theoretical evaluation of λ_{mix} of gases. Some workers (Gray *et al.*, 1969, 1970; Maczek & Gray, 1969, 1970) have computed the values of A_{ij} and A_{ji} for a large number of pairs utilizing the experimental data of λ_{mix} λ_i, and λ_j. Out of all the pairs computed only those are selected which give the smallest algebraic mean deviation from experimental values. Such selected values of A_{ij} and A_{ji} are thus used for theoretical calculations of thermal conductivity of binary mixtures from eqn. (1). In addition, some workers (Saksena & Saxena, 1965) have used experimental values of λ_{mix} for gaseous mixtures around the middle composition to calculate the Wassiljewa coefficients and thus got the good agreement between calculated and experimental values of λ_{mix}. In both the approaches, the experimental values of λ_{mix} are required beforehand, without which the theoretical

evaluation of thermal conductivities is not possible. On the other hand several empirical formulae for A_{ij} have also been proposed. Best estimates of A_{ij} for both polar and non-polar gases may be made from the empirical equation of Lindsay and Bromley (1950) in terms of viscosity η. Sutherland's constant S and the molecular weight M of the pure gases

$$A_{ij} = \tfrac{1}{4}\left[1 + \left\{\frac{\eta_i}{\eta_j}\left(\frac{M_j}{M_i}\right)^{3/4}\frac{T+S_i}{T+S_j}\right\}^{1/2}\right]^2\left(\frac{T+S_{ij}}{T+S_i}\right), \qquad ...(2)$$

where $S_{ij} = (S_i S_j)^{1/2}$ if both the components i and j are non-polar and $S_{ij} = 0.73 (S_i S_j)^{1/2}$ if one or both the components is polar. Although Lindsay-Bromley method does not require the knowledge of experimental λ_{mix} values, yet in experimental viscosity data of the pure components are needed for the evaluation of A_{ij}.

In the present paper, the authors are suggesting a new method which enables the calculation of thermal conductivities of binary gas mixtures at all compositions and temperatures.

In this method, the experimental thermal conductivity values are not needed for the calculation of A_{ij}. Unlike the Lindsay-Bromley method which has been widely used, the present approach avoids the use of experimental viscosity data of pure components. In addition, the proposed equation is simpler for binary monoatomic gas mixture and $(M_j/M_i)^{3/4}$ term is reduced to $(M_i/M_j)^{1/4}$. In spite of unadjustment of Wassiljewa coefficients for best experimental fit, the present method yields the results of almost same accuracy as obtained by the other traditional methods. Thermal conductivities of following pairs have been calculated and compared utilizing the present approach : Kr + Ar ; Kr + Ne ; Kr + He; Ar + Ne ; Ne + He ; Ar + He ; and Ne + He at 18 °C and $CH_4 + SO_2$; $N_2O + SO_2$; $CO_2 + SO_2$; Ar + SO_2 ; $NH_3 + N_2O$; and $H_2 + O_2$ at 50 and 100 °C.

THEORETICAL

Eucken has given the first approximation to the thermal conductivity of a pure gas component, which related thermal conductivity to the viscosity of the gas in the following way

$$\lambda_1 = \frac{15R}{4M}\left(\frac{4C_V}{15R} + \frac{3}{5}\right)\eta_1 \qquad ...(3)$$

where λ_1 and η_1 are the coefficients of thermal conductivity and viscosity respectively, each to the first approximation, C_V the molar heat capacity at constant volume, R the molar gas constant and M and molecular weight of the gas. This is applicable to polyatomic gases where the molecules have rotational and vibrational energies in addition to the kinetic energy of translation and these energies may be exchanged in collision. For binary monoatomic gas mixtures C_V and R terms for one component can be taken approximately equal to those for the other component and the following form is applicable to monoatomic gases only :

$$\lambda_1 = \frac{15R}{4M}\eta_1. \qquad ...(4)$$

From eqn. (3), the relation for binary polyatomic gas mixture is

$$\frac{[\eta_i]_1}{[\eta_j]_1} = \frac{M_i\left[\frac{4}{15}\,C_{V_j} + \frac{3}{5}\,R_j\right][\lambda_i]_1}{M_j\left[\frac{4}{15}\,C_{V_i} + \frac{3}{5}\,R_i\right][\eta_j]_1} \qquad \ldots(5)$$

and the following relation is obtained for binary polyatomic gas mixture

$$\frac{[\eta_i]_1}{[\eta_j]_1} = \frac{M_i}{M_j}\,\frac{[\lambda_i]_1}{[\lambda_j]_1} \qquad \ldots(6)$$

The approximation

$$\frac{[\eta_i]_1}{[\eta_j]_1} \approx \frac{\eta_i}{\eta_j} \text{ and } \frac{[\lambda_i]_1}{[\lambda_j]_1} \approx \frac{\lambda_i}{\lambda_j} \qquad \ldots(7)$$

can be taken here for purposes of calculation.

From eqns. (2), (5), and (7) Wassiljewa coefficients A_{ij} and A_{ji} for binary polyatomic gas mixtures are given by

$$A_{ij} = \tfrac{1}{4}\left[1 + \left\{\frac{\lambda_i}{\lambda_j}\left(\frac{M_i}{M_j}\right)^{1/4}\frac{\frac{4}{15}\,C_{V_j} + \frac{3}{5}\,R_i}{\frac{4}{15}\,C_{V_i} + \frac{3}{5}\,R_i}\,\frac{T+S_i}{T+S_j}\right\}^{\frac{1}{2}}\right]^2 \frac{T+S_{ij}}{T+S_i} \qquad \ldots(8)$$

and

$$A_{ji} = \tfrac{1}{4}\left[1 + \left\{\frac{\lambda_j}{\lambda_i}\left(\frac{M_j}{M_i}\right)^{1/4}\frac{\frac{4}{15}\,C_{V_i} + \frac{3}{5}\,R_i}{\frac{4}{15}\,C_{V_j} + \frac{3}{5}\,R_j}\,\frac{T+S_j}{T+S_i}\right\}^{\frac{1}{2}}\right]^2 \frac{T+S_{ij}}{T+S_j} \qquad \ldots(9)$$

Similarly from eqns. (2), (6), and (7), Wassiljewa coefficients for binary monoatomic gas mixtures can be written as

$$A_{ij} = \tfrac{1}{4}\left[1 + \left\{\frac{\lambda_i}{\lambda_j}\left(\frac{M_i}{M_j}\right)^{1/4}\frac{T+S_i}{T+S_j}\right\}^{1/2}\right]^2 \frac{T+S_{ij}}{T+S_i} \qquad \ldots(10)$$

and

$$A_{ji} = \tfrac{1}{4}\left[1 + \left\{\frac{\lambda_j}{\lambda_i}\left(\frac{M_j}{M_i}\right)^{1/4}\frac{T+S_j}{T+S_i}\right\}^{1/2}\right]^2 \frac{T+S_{ij}}{T+S_j}, \qquad \ldots(11)$$

where all the terms have the same significances as explained earlier. For the mixture of one monoatomic and the other polyatomic gases, Wassiljewa coefficients can also be derived from eqns. (2), (3), (4), and (7).

Method of Calculation

For each system Wasiljewa coefficient A_{ij} and A_{ji} have been calculated from eqns. (8),(9),(10) and (11) To calculate molar heat capacity at constant volume C_V terms,we

first calculate molar heat capacity at constant pressure C_p terms is calculated from the well-known relation.

$$C_p = \alpha + \beta T + \gamma T^2 + \delta T^3, \qquad \ldots(12)$$

where α, β, γ, and δ are constants depending upon the nature of the gas. These constants are taken from the sources (Spencer *et al.*, 1934, 1942, 1945; Bryant, 1973). These C_P terms are then converted into C_V terms. The experimental values of the coefficients of thermal conductivity of pure components and those of mixtures at varying compositions are taken from the literature (Gray & Holland, 1969; Maczek & Gray, 1970; Thornton, 1961; Thornton & Baker, 1962). The values of Sutherland's constants and molar gas constants have been taken from the reference (Chapman & Cowling, 1970). These A_{ij} values are substituted in Wassiljewa eqn. (1) for getting the thermal conductivities of the binary gas mixtures at different compositions. The percentage deviations from the experimental values are also calculated and compared with those obtained by Lindsay-Bromley equation.

Results and Discussion

Calculated values of thermal conductivity of six binary monoatomic gas mixtures : Kr + Ar ; Kr + Ne ; Kr + He; Ar + Ne ; Ar + He; and Ne + He at 18 °C, using eqns. (10), (11), and (1) are presented in Table I. For comparison,

Table I

Thermal conductivities λ (10^{-7} *cal* cm^{-1} sec^{-1} $°K^{-1}$) *of binary monoatomic gas mixtures at* 18 °C

System $i+j$	mole fraction X_i	Exptl. (λ)	Wassiljewa + Lindsay - Bromley		Wassiljewa + The Present method	
			(λ)	% dev.	(λ)	% dev.
Kr + Ar	0.865	233	241.491	+3.64	241.288	+3.56
	0.777	242	256.193	+5.86	255.881	+5.74
	0.673	256	274.320	+7.16	273.893	+6.99
	0.546	277	297.648	+7.45	297.148	+7.27
	0.443	302	317.608	+5.17	317.090	+5.00
	0.330	326	340.670	+4.50	340.177	+4.35
	0.228	348	362.615	+4.20	362.210	+4.08
	0.109	387	389.683	+0.69	389.353	+0.61
Mean absolute deviation (%)				+4.83		+4.70
Kr + Ne	0.889	257	274.998	+7.00	274.665	+6.87
	0.797	305	325.781	+6.81	325.158	+6.57
	0.647	400	420.797	+5.20	419.753	+4.94
	0.533	482	505.526	+4.88	504.216	+4.61
	0.438	568	586.465	+3.25	585.000	+2.99
	0.339	650	683.120	+5.10	681.556	+4.85
	0.229	780	808.878	+3.70	807.412	+3.51
	0.111	960	971.672	+1.22	970.679	+1.11
	0.065	1030	1044.946	+1.45	1044.222	+1.38
Mean absolute deviation (%)				+4.29		+4.09

(*Continued*)

TABLE I — (*Continued*)

System $i + j$	mole fraction (X_i)	Exptl. (λ)	Wassiljewa + Lindsay - Bromley		Wassiljewa + The Present method	
			(λ)	% dev.	(λ)	% dev.
Kr + He	0.891	343	337.747	—1.53	338.742	—1.24
	0.797	480	456.246	—4.95	458.148	—4.55
	0.698	642	602.576	—6.14	605.474	—5.69
	0.600	825	775.340	—6.02	779.314	—5.54
	0.439	1210	1144.374	—5.42	1150.089	—4.95
	0.353	1530	1404.042	—8.23	1410.568	—7.81
	0.272	1850	1797.190	—2.85	1803.706	—2.50
	0.151	2500	2317.513	—7.30	2324.071	—7.04
	0.069	3050	2899.396	—4.94	2903.923	—4.90
Mean absolute deviation (%)				—5.26		—4.91
Ar + Ne	0.900	470	465.667	—0.92	465.394	—0.98
	0.803	520	517.458	—0.49	516.936	—0.59
	0.726	570	561.415	—1.51	560.722	—1.63
	0.638	620	615.749	—0.69	614.160	—0.94
	0.541	680	678.896	—0.17	677.793	—0.32
	0.436	760	754.048	—0.78	752.952	—0.93
	0.328	840	839.184	—0.10	836.065	—0.47
	0.221	930	932.443	+0.26	931.469	+0.16
	0.157	990	993.164	+0.31	992.298	+0.23
Mean absolute deviation (%)				—0.45		—0.61
Ar + He	0.914	540	524.264	—2.91	529.296	—1.98
	0.844	630	645.572	+2.47	631.177	+0.19
	0.782	730	724.159	—0.80	729.690	—0.04
	0.720	830	829.960	0.00	837.105	+0.98
	0.645	960	971.691	+1.22	980.753	+2.16
	0.574	1110	1122.052	+1.09	1132.881	+2.06
	0.520	1270	1248.797	—1.67	1260.880	—0.72
	0.438	1510	1465.617	—2.94	1479.342	—2.03
	0.299	2040	1919.690	—5.90	1935.013	—5.15
	0.208	2410	2297.343	—4.67	2312.117	—4.89
	0.061	3300	3112.494	—5.68	3120.494	—5.44
Mean absolute deviation (%)				—1.80		—1.36
Ne + He	0.894	1330	1330.172	+0.01	1332.586	+0.19
	0.783	1530	1523.363	—0.43	1528.071	—0.13
	0.655	1790	1767.888	—1.23	1774.845	—0.85
	0.565	1990	1955.672	—1.72	1963.831	—1.31
	0.393	2370	2357.285	—0.54	2366.447	—0.15
	0.250	2840	2742.191	—3.44	2750.403	—3.15
	0.158	3100	3019.232	—2.61	3025.646	—2.40
Mean absolute deviation (%)				—1.42		—1.11

the experimental values of λ_{mix} for these pairs as well as the theoretically calculated values obtained from Lindsay-Bromley eqn. (2) are also enlisted. Percentage deviations and mean absolute deviation for each pair are shown in the Table. Similarly

eqns. (8), (9), and (1) are used to evaluate the thermal conductivities of four polyatomic gas mixtures (one polar component) : $CH_4 + SO_2$; $N_2O + SO_2$; $CO_2 + SO_2$, and $NH_3 + N_2O$; one monoatomic and other polyatomic polar ($Ar + SO_2$), and one pair containing both diatomic and non-polar ($H_2 + O_2$) at 50° and 100 °C. These values in conjunction with experimental and theoretical Lindsay-Bromley values are enlisted in Table II. Percentage deviations and mean absolute deviations from ex-

TABLE II

Thermal conductivities λ (*Cal* km^{-1} sec^{-1} $°K^{-1}$) *of binary gas mixtures.*

System $i + j$	Mole fraction (X_i)	Exptl. (λ)	Wassiljewa + Lindsay - Bromley		Wassiljewa + The Present method	
			(λ)	% dev.	(λ)	% dev.
		At 50 °C				
$CH_4 + SO_2$	0.1030	2.98	3.051	+ 2.39	3.021	+ 1.39
	0.2005	3.48	3.584	+ 2.99	3.529	+ 1.23
	0.2980	3.98	4.141	+ 4.04	4.066	+ 2.15
	0.4010	4.575	4.757	+ 3.99	4.665	+ 1.98
	0.4995	5.205	5.375	+ 3.26	5.273	+ 1.31
	0.6020	5.87	6.046	+ 3.01	5.943	+ 1.25
	0.7025	6.52	6.736	+ 3.31	6.640	+ 1.84
	0.8005	7.304	7.435	+ 1.80	7.444	+ 1.91
	0.8995	8.045	8.169	+ 1.55	8.123	+ 0.97
Mean absolute deviation (%)				+ 2.93		+ 1.56
		At 100 °C				
$CH_4 + SO_2$	0.1030	3.65	3.729	+ 2.16	3.683	+ 0.90
	0.2005	4.195	4.380	+ 4.41	4.296	+ 2.40
	0.2980	4.81	5.059	+ 5.17	4.942	+ 2.75
	0.4010	5.85	5.807	+ 4.07	5.665	+ 1.53
	0.4995	6.305	6.553	+ 3.94	6.397	+ 1.47
	0.6020	7.05	7.363	+ 4.44	7.204	+ 2.19
	0.7025	7.835	8.189	+ 4.52	8.042	+ 2.65
	0.8005	8.80	9.026	+ 2.57	8.907	+ 1.21
	0.8995	9.745	9.900	+ 1.59	9.829	+ 0.86
Mean absolute deviation (%)				+ 3.65		+ 1.77
		At 50 °C				
$N_2O + SO_2$	0.101	2.72	2.760	+ 1.48	2.752	+ 1.16
	0.199	2.925	2.994	+ 2.35	3.979	+ 1.85
	0.301	3.125	3.230	+ 3.37	3.211	+ 2.76
	0.402	3.355	3.456	+ 3.02	3.435	+ 2.39
	0.507	3.65	3.681	+ 3.27	3.660	+ 2.67
	0.601	3.75	3.873	+ 3.28	3.853	+ 2.75
	0.702	3.95	4.066	+ 2.93	4.049	+ 2.51
	0.800	4.175	4.238	+ 1.51	4.226	+ 1.23
	0.9025	4.36	4.400	+ 0.91	4.394	+ 0.78
Mean absolute deviation (%)				+ 2.46		+ 2.01

(Continued)

TABLE II — (*Continued*)

System $i + j$	mole fraction (X_i)	Exptl. (λ)	Wassiljewa + Lindsay - Bromley		Wassiljewa + The Present method	
			(λ)	% dev.	(λ)	% dev.
		At 100 °C				
$N_2O + SO_2$	0.101	3.335	3.369	+ 1.02	3.349	+ 0.43
	0.199	3.59	3.652	+ 1.72	3.618	+ 0.77
	0.301	3.815	3.937	+ 3.19	3.892	+ 2.02
	0.402	4.095	4.208	+ 2.76	4.157	+ 1.53
	0.507	4.34	4.477	+ 3.15	4.425	+ 1.97
	0.601	4.58	4.705	+ 2.72	4.656	+ 1.67
	0.702	4.805	4.933	+ 2.67	4.892	+ 1.82
	0.800	5.025	5.138	+ 2.24	5.108	+ 1.64
	0.9025	5.27	5.330	+ 1.13	5.314	+ 0.83
Mean absolute deviation (%)				+ 2.29		+ 1.41
		At 50 °C				
$CO_2 + SO_2$	0.100	2.70	2.745	+ 1.65	2.736	+ 1.33
	0.2195	2.935	3.012	+ 2.62	2.995	+ 2.06
	0.303	3.12	3.192	+ 2.31	3.172	+ 1.67
	0.400	3.30	3.394	+ 2.84	3.371	+ 2.16
	0.501	3.50	3.593	+ 2.67	3.570	+ 2.01
	0.6025	3.665	3.782	+ 3.19	3.760	+ 2.60
	0.699	3.845	3.947	+ 2.66	3.929	+ 2.19
	0.801	4.02	4.106	+ 2.14	4.093	+ 1.81
	0.9015	4.20	4.243	+ 1.02	4.236	+ 0.85
Mean absolute deviation (%)				+ 2.34		+ 1.85
		At 100 °C				
$CO_2 + SO_2$	0.100	3.31	3.348	+ 1.16	3.332	+ 0.66
	0.2195	3.575	3.670	+ 2.66	3.640	+ 1.82
	0.303	3.785	3.887	+ 1.69	3.850	+ 1.72
	0.400	4.01	4.130	+ 2.98	4.088	+ 1.95
	0.501	4.26	4.370	+ 2.58	4.328	+ 1.59
	0.6025	4.47	4.597	+ 2.84	4.557	+ 1.95
	0.699	4.685	4.797	+ 2.39	4.763	+ 1.68
	0.801	4.90	4.983	+ 2.70	4.966	+ 1.34
	0.9015	5.10	5.158	+ 1.15	5.145	+ 0.88
Mean absolute deviation (%)				+ 2.24		+1.51
		At 50 °C				
$Ar + SO_2$	0.102	2.66	2.713	+ 1.98	2.704	+ 1.65
	0.200	2.825	3.908	+ 2.94	2.892	+ 2.38
	0.3015	2.98	3.115	+ 4.52	3.092	+ 3.78
	0.4005	3.17	3.319	+ 4.72	3.293	+ 3.87
	0.501	3.37	3.529	+ 4.73	3.500	+ 3.85
	0.601	3.56	3.738	+ 5.01	3.708	+ 4.15
	0.6985	3.785	3.939	+ 4.07	3.910	+ 3.31
	0.7995	4.02	4.140	+ 2.98	4.116	+ 2.40
	0.9005	4.25	4.327	+ 1.82	4.314	+ 1.50
Mean absolute deviation (%)				+ 3.64		+ 2.99

TABLE II — (*Continued*)

System $i + j$	mole fraction (X_i)	Exptl. (λ)	Wassijlewa + Lindsay - Bromley		Wassiljewa + The Present method	
			(λ)	% dev.	(λ)	% dev.
		At 100 °C				
$Ar + SO_2$	0.102	3.25	3.275	+ 0.76	3.273	+ 0.72
	0.200	3.405	3.475	+ 2.05	3.472	+ 1.96
	0.3015	3.57	3.685	+ 3.23	3.681	+ 3.11
	0.4005	3.77	3.892	+ 3.25	3.888	+ 3.12
	0.501	3.96	4.103	+ 3.61	4.098	+ 3.47
	0.601	4.155	4.311	+ 3.75	4.305	+ 2.92
	0.6985	4.365	4.509	+ 3.29	4.504	+ 3.18
	0.7995	4.575	4.705	+ 2.83	4.701	+ 2.75
	0.9005	4.795	4.886	+ 1.90	4.884	+ 1.85
Mean absolute deviation (%)				+ 2.74		+ 2.56
		At 50 °C				
$NH_3 + N_2O$	0.0905	4.795	4.793	— 0.04	4.822	+ 0.57
	0.202	5.085	5.099	+ 0.27	5.151	+ 1.30
	0.301	5.315	5.349	+ 0.65	5.418	+ 1.93
	0.401	5.525	5.586	+ 1.11	5.661	+ 2.46
	0.4805	5.715	5.761	+ 0.80	5.835	+ 1.09
	0.5985	5.93	5.994	+ 1.07	6.060	+ 2.19
	0.700	6.11	6.166	+ 0.92	6.219	+ 1.79
	0.799	6.245	6.306	+ 0.98	6.343	+ 1.57
	0.873	6.365	6.390	+ 0.40	6.414	+ 0.77
Mean absolute deviation (%)				+ 0.68		+ 1.63
		At 100 °C				
$NH_3 + N_2O$	0.0905	5.775	5.802	+ 0.46	5.839	+ 1.12
	0.202	6.175	6.172	— 0.05	6.245	+ 1.13
	0.301	6.46	6.484	+ 0.38	6.577	+ 1.81
	0.401	6.77	6.782	+ 0.18	6.884	+ 1.69
	0.4805	6.985	7.005	+ 0.28	7.108	+ 1.77
	0.5985	7.26	7.308	+ 0.66	7.404	+ 1.98
	0.700	7.47	7.541	+ 0.95	7.622	+ 2.03
	0.799	7.685	7.739	+ 0.71	7.798	+ 1.48
	0.873	7.82	7.867	+ 0.16	7.906	+ 1.11
Mean absolute deviation (%)				+ 0.47		+ 1.57
		At 50 °C				
$H_2 + O_2$	0.1143	9.08	9.12	+ 0.5	9.125	+ 0.49
	0.2262	11.53	11.70	+ 1.4	11.706	+ 1.52
	0.3944	15.79	16.25	+ 2.9	16.267	+ 3.02
	0.5033	19.43	19.76	+ 1.7	19.771	+ 1.76
	0.6092	22.92	23.70	+ 3.4	23.710	+ 3.45
	0.7168	27.91	28.38	+ 1.7	28.382	+ 1.69
	0.8320	33.77	34.36	+ 1.8	34.340	+ 1.69
	0.8783	36.58	37.12	+ 1.5	37.082	+ 1.37
Mean absolute deviation (%)				+ 1.86		+ 1.87

(*Continued*)

		At 100 °C				
$H_2 + O_2$	0.1143	10.19	10.26	+ 0.6	10.279	+ 0.87
	0.2262	13.01	13.10	+ 0.7	13.141	+ 1.01
	0.3944	17.80	18.13	+ 1.9	18.202	+ 22.26
	0.5033	21.91	22.01	+ 0.5	22.093	+ 0.84
	0.6092	25.80	26.39	+ 2.3	26.467	+ 2.58
	0.7168	31.37	31.59	+ 0.7	31.658	+ 0.92
	0.8320	37.70	38.25	+ 1.4	38.283	+ 1.55
	0.8783	40.72	41.32	+ 1.5	41.333	+ 1.51
Mean absolute deviation (%)				+ 1.20		+ 1.44

perimental values for the present method and Lindsay-Bromley method are shown. For the calculation of thermal conductivity of binary gas mixture, the experimental values of thermal conductivities of pure gases are taken from the sources (Gray *et al.*, 1969; Maczek & Gray, 1970; Thornton, 1961; Thornton & Baker, 1962).

The Wassiljewa coefficient A_{ij} and A_{ji} for binary monoatomic gas mixtures, obtained from present procedure are recorded in Table III and compared with Lindsay-Bromley values. For polyatomic gas mixtures, the presently calculated values of A_{ij} and A_{ji} at two different temperatures 50 and 100 °C with Lindsay-Bromley values (Gray *et al.*, 1969; Maczek & Gray, 1970) are presented in Table IV. For monoatomic gas mixtures, Lindsay-Bromley values of Wassiljewa coefficients at 18 °C are not available in literature and the values reported have been calculated by us.

Thornton (1961) calculated the thermal conductivities of Kr + Ar; Kr + Ne; and Kr + He and Thornton and Baker (1962) those of Ar + Ne; Ar + He; and Ne + He at 18 °C by using L-J (6:12) Potential. Their calculated values show the mean absolute deviations from — 8.07 to + 1.45. Lindsay-Bromley method affords mean absolute deviations from — 5.26 to + 4.83 whereas in the present method the mean absolute deviations are found to be — 4.91 to +4.70. The mean absolute deviations due to Lindsay-Bromley method and the present method for binary monoatomic gas mixtures are given in Table III. Thus the calculated thermal conductivities of Thornton (1961) and Thornton and Baker (1962) are less than the experimental values while

TABLE III

Wassiljewa coefficients A_{ij} for thermal conductivities of binary monoatomic gas mixtures at 18 °C

System $i + j$	Lindsay - Bromley method			The Present Method		
	A_{ij}	A_{ji}	% dev.	A_{ij}	A_{ji}	% dev.
Kr + Ar	0.8074	1.2520	+ 4.83	0.8030	1.2620	+ 4.70
Kr + Ne	0.5404	1.9770	+ 4.29	0.5384	1.9890	+ 4.09
Kr + He	0.4262	3.2626	— 5.26	0.4277	3.2361	— 4.91
Ar + Ne	0.6610	1.5387	— 0.45	0.6582	1.5470	— 0.61
Ar + He	0.5019	2.4840	— 1.80	0.5065	2.4390	—1.36
Ne + He	0.7163	1.4990	— 1.42	0.7233	1.4790	— 1.11

TABLE IV

Wassiljewa coefficients A_{ij} for thermal conductivities of binary gas mixtures

System $i + j$	Temp. (°C)	Lindsay - Bromley method			The Present Method		
		A_{ij}	A_{ji}	% dev.	A_{ij}	A_{ji}	% dev.
$CH_4 + SO_2$	50	1.38	0.55	+ 2.93	1.4602	0.5302	+ 1.56
	100	1.35	0.57	+ 3.65	1.4492	0.5459	+ 1.77
$N_2O + SO_2$	50	1.08	0.69	+ 2.46	1.1213	0.6665	+ 2.01
	100	1.06	0.71	+ 2.29	1.1293	0.6772	+ 1.41
$CO_2 + SO_2$	50	1.07	0.69	+ 2.34	1.1082	0.6729	+ 1.85
	100	1.06	0.71	+ 2.24	1.1198	0.6818	+ 1.51
$Ar + SO_2$	50	1.37	0.54	+ 3.64	1.4086	0.5395	+ 2.99
	100	1.35	0.57	+ 2.74	1.3577	0.5687	+ 2.56
$NH_3 + N_2O$	50	1.04	0.73	+ 0.68	0.9482	0.7822	+ 1.63
	100	1.06	0.74	+ 0.47	0.9707	0.7815	+ 1.57
$H_2 + O_2$	50	1.972	0.578	+ 1.86	1.9679	0.5780	+ 1.87
	100	1.983	0.580	+ 1.20	1.9683	0.5804	+ 1.44

Lindsay-Bromley method and our method render higher values than their calculated values.

For other gaseous mixtures i.e., $CH_4 + SO_2$; $N_2O + SO_2$; $CO_2 + SO_2$; $Ar + SO_2$; $NH_3 + N_2O$ and $H_2 + O_2$, the calculated values of thermal conductivities by Lindsay-Bromley method and our method are higher than the experimental values (Gray *et al.*, 1969; Maczek & Gray, 1970). The mean absolute deviations due to Lindsay-Bromley and the present method range from + 0.68 to + 3.64 and + 1.56 to + 2.99 respectively at 50 °C and from + 0.47 to + 3.65 and + 1.41 to + 2.56 respectively at 100 °C. The respective values of mean absolute deviations are shown in Table IV.

CONCLUSION

In order to avoid the adjustment procedure and the forehand use of the experimental thermal conductivity values of mixtures and viscosity of pure components for the evaluation of Wassiljewa coefficients, an alternative method has been adopted which is applicable to various binary gas mixtures at all compositions and different temperatures. The sign and the magnitude of mean deviations are of the same order as obtained by Lindsay-Bromley method. The overall agreement is very good.

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