# THERMAL CONDUCTIVITY OF POLYETHYL SILOXANE LIQUIDS AT HIGH PRESSURES

V. G. Nemzer and V. V. Pugach

UDC 536.22

The thermal conductivities of three polyethyl siloxane liquids have been investigated experimentally at pressures up to 200 mN/m² in the temperature interval from 20 to 200°C. Equations are proposed for calculations.

We have previously [1-3] published the results of investigations of the thermophysical properties of polyethyl siloxane (PES) liquids at atmospheric pressure.

We now report the results of an experimental study of the thermal conductivity of PES-2, PES-4, and PES-5 at pressures up to 200 mN/m² in the temperature interval from 20 to 200°C. We measured the thermal conductivity on an arrangement in which the measurement cell was fabricated by the method of coaxial cylinders with plane closed ends [4, 5]. The technique used to process the experimental data is described in [6]. The maximum relative error of the thermal-conductivity measurements was ±1.6%.

The values of the density $\rho_4^{20}$, viscosity $\nu_{20}$, refractive index $n_D^{20}$, and molecular mass M, measured by standard techniques, are given in Table 1. Measurements of the thermal conductivity were derived by the method of isotherms in steps of 20 mN/m². The values of the thermal conductivity of the investigated PES liquids, smoothed with respect to the pressure, are given in Table 2.

An analysis of the experimental data shows that the thermal conductivity of polyethyl siloxanes increases with the pressure; the rate of increase is higher for higher temperatures.

The enhancement of the pressure effect with increasing temperature differs from one PES to the next and depends on their molecular structure as well as on the forces of intermolecular interaction. As the pressure is increased from 0.098 to 200 mN/m² at a fixed temperature of 20°C, the thermal conductivities of PES-2, PES-4, and PES-5 increase by 22, 19, and 16%, respectively; the corresponding increases at 200°C are 55, 45, and 40% (see Table 2 and Fig. 1).

In the investigated temperature range the thermal-conductivity isobars of PES are practically straight lines, while the isotherms have a rather large curvature. Their curvature increases with the temperature (see Fig. 1).

As a result of processing of the experimental data we have derived an interpolation equation for the thermal conductivity of the investigated polyethyl siloxanes:

$$\lambda_{p,t} = \lambda_{p,20} - \left( \frac{\partial \lambda}{\partial t} \right)_p^{\text{av}} (t - 20), \tag{1}$$

where $\lambda_{p,20}$ is the thermal conductivity at pressure p and a temperature of 20°C;

TABLE 1. Characteristics of Polyethyl Siloxane Liquids

| Polymer | $\rho_4^{20}$ | $\rho_{30}$, kg/m$^3$ | $n_D^{20}$ | $\nu_{20}\cdot 10^6$, m$^2$/sec | $M$ | $n$ | $\lambda_{20}$, W/m·°K | $C\cdot 10^2$ | $B$ |
|---|---|---|---|---|---|---|---|---|---|
| PES-2 | 0,9214 | 913,4 | 1,4398 | 10,80 | 392 | 2 | 0,1330 | 3,12 | 102,46 |
| PES-4 | 0,9656 | 957,8 | 1,4425 | 51,52 | 626 | 4 | 0,1420 | 2,8 | 118,72 |
| PES-5 | 0,9980 | 991,0 | 1,4468 | 268,8 | 1607 | 14 | 0,1570 | 2,64 | 120,87 |

---

Academician M. D. Millionshchikov Georgian Petroleum Institute. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 33, No. 3, pp. 464-466, September, 1977. Original article submitted September 30, 1976.

0022-0841/77/3303-1061$07.50

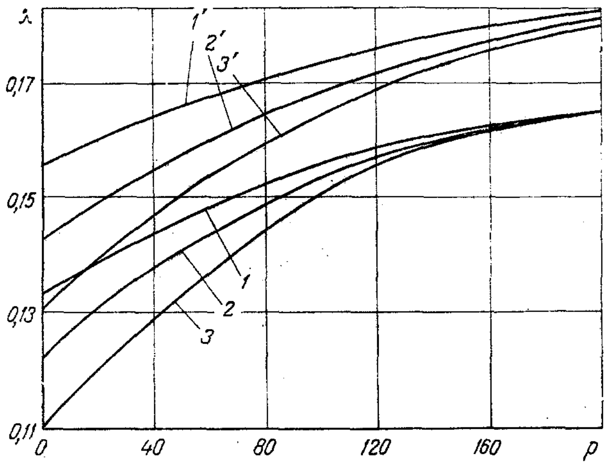

Fig. 1. Thermal conductivity λ, W/m•°K, versus pressure p, mN/m², for PES-2 (1-3) and PES-5 (1'-3'). 1) Isotherm 24.1, 2) 105.5, 3) 194.7 °C; 1') 31.2, 2') 114.7, 3') 198.8°C.

TABLE 2. Thermal Conductivities of Polyethyl Siloxane Liquids

| t, °C | Pressure, mN/m² | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0,098 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
| PES-2 | | | | | | | | | | | |
| 24,1 | 0,1325 | 0,1390 | 0,1445 | 0,1491 | 0,1524 | 0,1551 | 0,1587 | 0,1613 | 0,1620 | 0,1642 | 0,1651 |
| 49,8 | 0,1289 | 0,1364 | 0,1422 | 0,1476 | 0,1510 | 0,1498 | 0,1579 | 0,1612 | 0,1624 | 0,1639 | 0,1650 |
| 81,3 | 0,1247 | 0,1323 | 0,1402 | 0,1451 | 0,1494 | 0,1536 | 0,1573 | 0,1608 | 0,1623 | 0,1634 | 0,1650 |
| 105,5 | 0,1211 | 0,1304 | 0,1374 | 0,1436 | 0,1488 | 0,1545 | 0,1576 | 0,1594 | 0,1616 | 0,1641 | 0,1650 |
| 137,3 | 0,1166 | 0,1278 | 0,1346 | 0,1423 | 0,1472 | 0,1528 | 0,1569 | 0,1590 | 0,1610 | 0,1632 | 0,1650 |
| 171,0 | 0,1123 | 0,1230 | 0,1311 | 0,1389 | 0,1462 | 0,1518 | 0,1562 | 0,1589 | 0,1611 | 0,1628 | 0,1650 |
| 194,7 | 0,1110 | 0,1206 | 0,1289 | 0,1369 | 0,1445 | 0,1510 | 0,1562 | 0,1589 | 0,1610 | 0,1630 | 0,1650 |
| PES-4 | | | | | | | | | | | |
| 28,4 | 0,1410 | 0,1463 | 0,1503 | 0,1534 | 0,1572 | 0,1592 | 0,1617 | 0,1634 | 0,1650 | 0,1663 | 0,16856 |
| 60,5 | 0,1362 | 0,1413 | 0,1469 | 0,1513 | 0,1550 | 0,1574 | 0,1613 | 0,1637 | 0,1650 | 0,1672 | 0,1684 |
| 91,4 | 0,1317 | 0,1387 | 0,1439 | 0,1492 | 0,1524 | 0,1570 | 0,1604 | 0,1632 | 0,1648 | 0,1666 | 0,1684 |
| 119,7 | 0,1284 | 0,1352 | 0,1417 | 0,1463 | 0,1511 | 0,1557 | 0,1600 | 0,1626 | 0,1643 | 0,1666 | 0,1682 |
| 129,9 | 0,1273 | 0,1342 | 0,1407 | 0,1463 | 0,1510 | 0,1554 | 0,1600 | 0,1627 | 0,1647 | 0,1677 | 0,1682 |
| 168,1 | 0,1213 | 0,1304 | 0,1367 | 0,1434 | 0,1493 | 0,1542 | 0,1590 | 0,1623 | 0,1639 | 0,1662 | 0,168 |
| 198,3 | 0,1178 | 0,1269 | 0,1337 | 0,1415 | 0,1473 | 0,1536 | 0,1581 | 0,1610 | 0,1639 | 0,1662 | 0,168 |
| PES-5 | | | | | | | | | | | |
| 31,2 | 0,1551 | 0,1600 | 0,1637 | 0,1681 | 0,1703 | 0,1734 | 0,1751 | 0,1783 | 0,1798 | 0,1818 | 0,1822 |
| 51,7 | 0,1521 | 0,1574 | 0,1619 | 0,1663 | 0,1682 | 0,1720 | 0,1750 | 0,1764 | 0,1784 | 0,1804 | 0,1820 |
| 89,8 | 0,1462 | 0,1534 | 0,1569 | 0,1624 | 0,1663 | 0,1701 | 0,1737 | 0,1761 | 0,1779 | 0,1800 | 0,1818 |
| 114,7 | 0,1425 | 0,1498 | 0,1549 | 0,1603 | 0,1648 | 0,1689 | 0,1719 | 0,1754 | 0,1771 | 0,1793 | 0,1814 |
| 131,6 | 0,1402 | 0,1469 | 0,1538 | 0,1587 | 0,1642 | 0,1679 | 0,1717 | 0,1751 | 0,1769 | 0,1793 | 0,1810 |
| 167,4 | 0,1349 | 0,1431 | 0,1498 | 0,1562 | 0,1616 | 0,1663 | 0,1708 | 0,1740 | 0,1765 | 0,1790 | 0,1806 |
| 196,8 | 0,1303 | 0,1390 | 0,1465 | 0,1539 | 0,1595 | 0,1651 | 0,1693 | 0,1732 | 0,1761 | 6,1787 | 0,1803 |

$$\lambda_{p,20}=\lambda_{20}+C\ln\left(1+\frac{P}{B}\right), \tag{2}$$

where $\lambda_{20}$ is the thermal conductivity at atmospheric pressure and 20°C.

The values of $\lambda_{20}$ along with the constants C and B are given in Table 1 for the investigated polymers.

The dependence of $(\partial\lambda/\partial t)_p^{av}$ on the pressure p is described by the following equations for PES-2, PES-4, and PES-5, respectively:

$$\left(\frac{\partial\lambda}{\partial t}\right)_p^{av}=0.358\cdot10^{-8}p^2-0.139\cdot10^{-5}p+0.134\cdot10^{-3},$$

$$\left(\frac{\partial\lambda}{\partial t}\right)_p^{av}=0.324\cdot10^{-8}p^2-0.134\cdot10^{-5}p+0.139\cdot10^{-3}; \tag{3}$$

$$\left(\frac{\partial\lambda}{dt}\right)_p^{av} = 0.287\cdot10^{-8}p^2 - 0.129\cdot10^{-5}p + 0.151\cdot10^{-3}.$$

The deviations of the experimental data from the values calculated according to Eq. (1) do not exceed the experimental error limits.

## LITERATURE CITED

1. V. G. Nemzer and Yu. L. Rastorguev, Plast. Massy, No. 7 (1969).
2. V. G. Nemzer and Yu. L. Rastorguev, Plast. Massy, No. 1 (1969).
3. V. G. Nemzer and Yu. L. Rastorguev, Neft' i Gaz, No. 6 (1975).
4. Yu. L. Rastorguev and V. V. Pugach, Teploênergetika, No. 4 (1970).
5. Yu. L. Rastorguev and V. V. Pugach, Inzh.-Fiz. Zh., 19, No. 2 (1970).
6. Yu. L. Rastorguev, Author's Abstract of Doctoral Dissertation, Azerb. Inst. Neorg. Khim. im. M. A. Azizbekova, Baku (1971).

---

# THERMOPHYSICAL AND RHEOLOGICAL PROPERTIES OF CERTAIN BIOLOGICAL FLUIDS

V. S. Mikhalev, L. N. Novichenok, and Yu. M. Pikus

UDC 536.22+532.135

The dependence of the thermophysical properties of blood on its physicochemical composition and rheological properties is determined. Measurements are carried out by the probe technique.

The biological activity of the organism of man and animals is contingent upon the movement of various biological fluids in it. The most important such fluid is the blood. Knowledge of its thermophysical properties is not only of practical importance in connection with the design of heat exchangers needed for artificial circulation apparatus, it also has purely scientific implications insofar as those properties characterize the nature of the physiological thermal regulation system. The role of the blood in the thermal regulation system of the living organism is immense, because the poor heat conduction of the tissues renders heat conduction via heat transfer in the organism of little consequence in comparison with the convective heat transfer effected by the blood flow. Yet the thermophysical properties of the blood itself have been studied very little to date.

Research on the thermophysical properties of blood has been directed along the following lines:

1) determination of the influence of physicochemical composition and rheological properties of blood on its thermophysical characteristics;

2) determination of the variations of measurable quantities with age.

The thermophysical properties of blood have been studied experimentally by means of a relative probing technique [1] based on the comparison of thermograms for the investigated medium and a standard medium. This technique has been used with great effectiveness in determining the thermophysical characteristics of disperse materials [2]. Blood, of course, comprises a dispersoid of definite constituents (erythrocytes, leukocytes, and lymphocytes) in the plasma. The virtue of this technique is that it permits all the thermophysical coefficients of the medium to be calculated from one brief test with the use of simple experimental equipment.

The theoretical foundation of the method is the solution of the heat-conduction problem for heating of a finite cylinder (the probe) in an unbounded medium. The solution of this problem is described in [3] and represents complex functional dependences, which are exceedingly difficult to use for the derivation of analytical expressions describing the thermo-

---

Gerontology Sector, Minsk Medical Institute, Academy of Sciences of the Belorussian SSR. A. V. Lykov Institute of Heat and Mass Transfer, Academy of Sciences of the Belorussian SSR, Minsk. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 33, No. 3, pp. 467-472, September, 1977. Original article submitted December 2, 1975.

0022-0841/77/3303-1063$07.50