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Carbon Monoxide, Oxygen and Argon Mixtures at High Temperatures

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ABSTRACT. Carbon monoxide is one of the harmful gases which generated in combustion. One of the ways to avoid the generation of carbon monoxide is to use a surface which is catalysis to CO and O to form CO_2.

In order to deal with this method of suppressing CO details about the properties of different percentages of carbon monoxide, oxygen and argon mixtures at high temperatures should be known.

The present paper gives some useful data for carbon monoxide, oxygen and argon mixtures at temperatures ranging between 4000°K up to 10,000°K. The presented data are in the form of tables and curves.

Nomenclature

R_o	Universal gas constant
D_{12}	Diffusion coefficient (m^2/sec)
G_{ik}	Defined as in equation 2
K	Thermal conductivity
M	Molecular or atomic weight
T	Absolute temp. in K
T_{12}^*	Reduced temperature
P	Pressure in bars
$\varkappa$	Mole fraction
C_p	Specific heat at constant pressure
σ	Collision diameter
$\Omega(2,2)^*$	Collision integral

μ Coefficient of viscosity
$\Omega(1,1)^*$ Collision integral

Introduction

Pollution due to exhaust of combustion of gases has been recognised to be serious problem. Carbon monoxide is an important candidate in most of the combustion processes.

Most of the data published for the transport properties of simple and gas mixtures are at low temperatures. These data are not enough when dealing with combustion processes or when subjected to a very high temperatures.

This study is a part of research project related to heat transfer of hydrocarbons in simulated combustion systems. The data for simple combinations are available (Nasser *et al.* 1980, 1981). The present study is for CO/O/Ar combinations. Argon has been chosen for all these data since it is a monoatomic molecule and its ionization temperature is higher than the range of dissociation temperatures.

This paper presents a useful data at different percentages of carbon monoxide, oxygen and argon mixtures. These data are the viscosity, thermal conductivity and diffusion. These data are presented in both forms of curves and tables.

Calculation Procedure

A computer programme has been developed to compute the viscosity and thermal conductivity of different mole fractions of carbon monoxide, oxygen diluted in argon mixtures. The diffusion of carbon monoxide and oxygen in argon have also computed at atmospheric pressures. The range of temperature is between 4000°K and 10,000°K.

Viscosity Coefficient

Wilkie (1950) has given the following mixture rule to calculate the coefficient of viscosity of a mixture of gases containing ν components.

$$\mu = \sum_{i=1}^{\nu} \mu_i \left[1 + \sum_{\substack{k=1 \\ k \neq i}}^{\nu} G_{ik} \frac{\varkappa_k}{\varkappa_i} \right]^{-1} \qquad (1)$$

where μ_i is the coefficient of viscosity of species i, $\varkappa_i$ is the mole fraction of species i and

$$G_{ik} = \frac{[1+(\mu_i/\mu_k)^{1/2}(M_k/M_i)^{1/4}]^2}{2^{3/2}\,[1+(M_i/M_k)]} \tag{2}$$

Using the Chapman-Enskog theory the pure gas coefficient of viscosity may be calculated as

$$\mu_i = 266.93 \times 10^{-8} \frac{(M_i\ T)^{1/2}}{\sigma^2\ \Omega(2,2)^*} \tag{3}$$

where μ_i is the coefficient of viscosity of species i (Kg/m. sec)

σ = Collision diameter (Angstroms)

$\Omega(2,2)^*$ Collision integral which is tabulated in Hirschfelder *et al.* (1964).

Thermal Conductivity

Mason and Saxena (1958) have shown that the thermal conductivity of a mixture is given by:

$$K = \sum_{i=1}^{v} K_i \left(1.065 \sum_{\substack{k=1 \\ k\neq i}}^{v} G_{ik} \frac{\varkappa_k}{\varkappa_i} \right)^{-1} \tag{4}$$

where the thermal conductivity of species i is also given by the Chapman - Enskog result

$$K_i = \frac{15}{4} \frac{R_o}{M_i} \mu_i \tag{5}$$

Expression may be applied to poly atomic gases providing that the pure gas thermal conductivities K_i's are multiplied by a correction factor of

$0.115 + (0.354\ C_{pi} \frac{M_i}{R_o})$ before use in expression.

Binary Diffusion Coefficient

The approximate expression given by Hirschfelder, *et al.* (1964) and based on

Lennard-Jones potential model is used in the present work. The diffusion of CO in Ar and O in Argon is computed as:

$$D_{12} = D_{21} = 2.628 \times 10^{-7} \frac{[T^3(M_1+M_2)/2M_1M_2]}{P\ \sigma_{12}^2\ \Omega(1,1)^*(T_{12^*})} \quad (6)$$

where $D_{12} = D_{21}$ = diffusion coefficient m^2/sec.

P = pressure (bar).

$\sigma_{12} = 1/2\ (\sigma_1+\sigma_2)$ = mean collision diameter (Angstroms)

$\Omega(1,1)^*$ is the collision integral tabulated in Chapman and Cowling (1952) as a function of the reduced temperature T_{12^*}.

$$T_{12^*} = \frac{T}{(\varepsilon_{12}/K)}$$

and $\varepsilon_{12} = \sqrt{\varepsilon_1 \cdot \varepsilon_2}$ is the mean depth of the potential well of the Lennard-Jones potentials for the two gases 1,2.

A computer programme based on these equations and expressions have been constructed for carbon monoxide, oxygen and argon mixture at different mole fractions and at different subjected temperatures which ranges between 4000°K and 10,000°K.

Input Data

Data for carbon monoxide, oxygen and argon have been estimated and fed to the computer. The following are the data used for the different gases.

	Carbon Monoxide	Oxygen Atom	Argon
ε	3.59°A	0.877°A	3.418°A
$\frac{\varepsilon}{K}$	110 K	59000 K	124 K
M	28	16	38.95

Output Results

The output results from the computer have been printed forming tables then

fed to a graph plotter forming curves for viscosity, thermal conductivity and diffusion against temperatures. Figs. 1-3 show the output from the graph plotter while tables 1-12 are the print out results from the computer.

References

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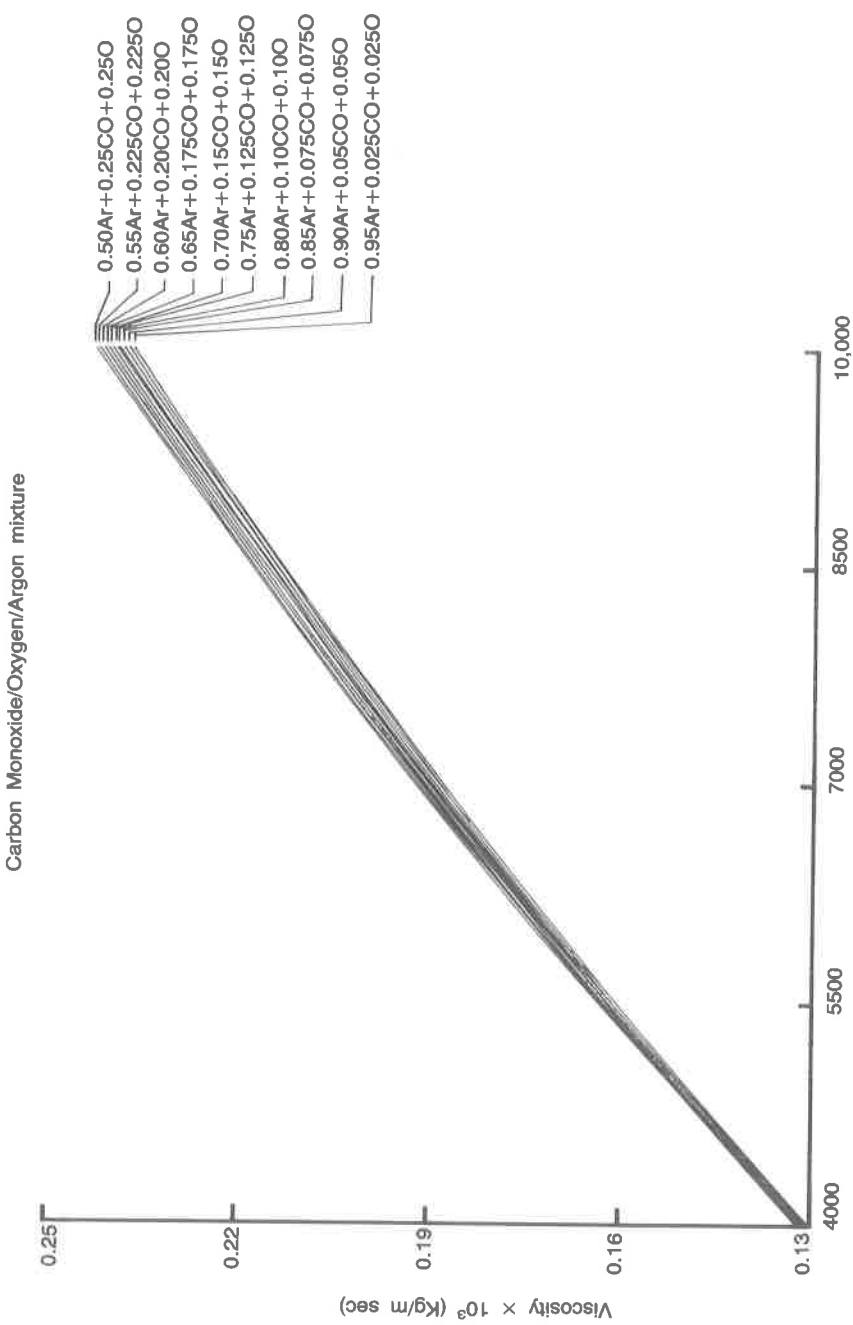

Fig. 1. The variation of viscosity of mixtures of Carbon Monoxide/Oxygen/Argon with absolute temperatures.

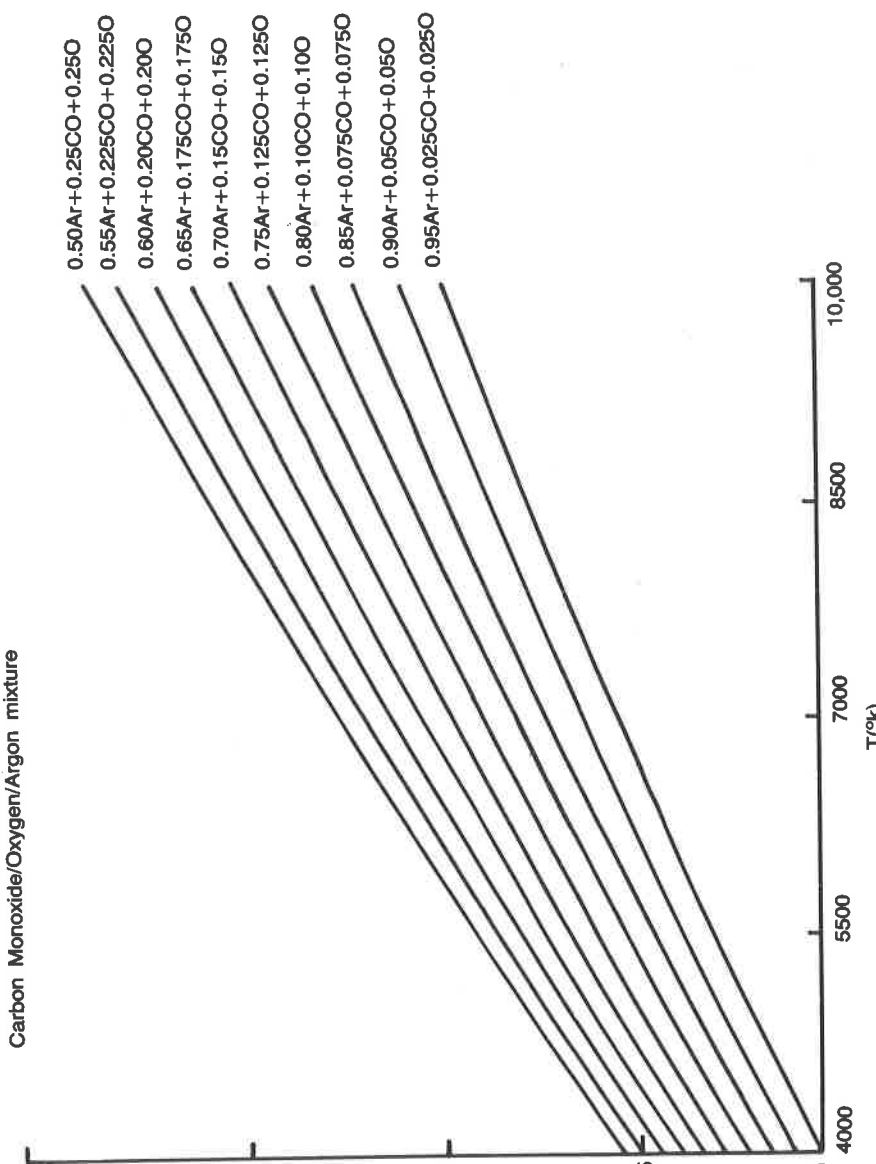

Fig. 2. The variation of thermal conductivity of mixtures of Carbon Monoxide/Oxygen/Argon with the absolute temperature.

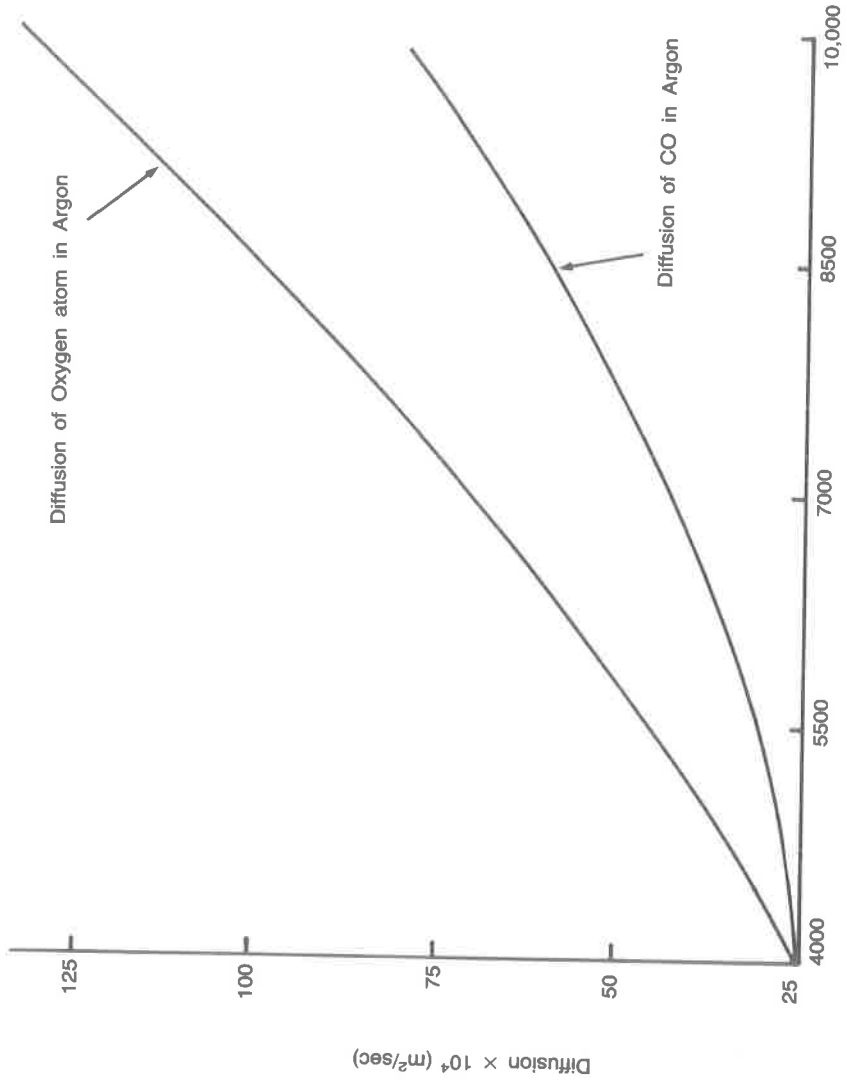

Fig. 3. The variation of the diffusion of oxygen atom and carbon monoxide in Argon.

Table 1. Variation of viscosity and thermal conductivity of a mixture of 0.025 CO + 0.025 0 in Argon. against absolute temperature

AR / CO / O = .95/ .025/.25

T	U	K	T	U	K
4000	.1305E−03	.1103E+00	7100	.1889E−03	.1597E+00
4100	.1326E−03	.1121E+00	7200	.1906E−03	.1612E+00
4200	.1347E−03	.1139E+00	7300	.1923E−03	.1626E+00
4300	.1367E−03	.1156E+00	7400	.1641E−03	.1597E+00
4400	.1388E−03	.1173E+00	7500	.1957E−03	.1655E+00
4500	.1408E−03	.1190E+00	7600	.1974E−03	.1669E+00
4600	.1428E−03	.1207E+00	7700	.1991E−03	.1684E+00
4700	.1448E−03	.1224E+00	7800	.2008E−03	.1698E+00
4800	.1467E−03	.1241E+00	7900	.2024E−03	.1712E+00
4900	.1487E−03	.1257E+00	8000	.2041E−03	.1726E+00
5000	.1507E−03	.1274E+00	8100	.2057E−03	.1740E+00
5100	.1526E−03	.1290E+00	8200	.2074E−03	.1754E+00
5200	.1545E−03	.1306E+00	8300	.2090E−03	.1768E+00
5300	.1564E−03	.1322E+00	8400	.2106E−03	.1781E+00
5400	.1583E−03	.1338E+00	8500	.2123E−03	.1795E+00
5500	.1602E−03	.1354E+00	8600	.2139E−03	.1809E+00
5600	.1621E−03	.1370E+00	8700	.2155E−03	.1823E+00
5700	.1639E−03	.1386E+00	8800	.2171E−03	.1836E+00
5800	.1658E−03	.1402E+00	8900	.2187E−03	.1850E+00
5900	.1676E−03	.1417E+00	9000	.2203E−03	.1863E+00
6000	.1695E−03	.1433E+00	9100	.2219E−03	.1877E+00
6100	.1713E−03	.1448E+00	9200	.2234E−03	.1890E+00
6200	.1731E−03	.1463E+00	9300	.2250E−03	.1903E+00
6300	.1749E−03	.1479E+00	9400	.2266E−03	.1917E+00
6400	.1767E−03	.1494E+00	9500	.2281E−03	.1930E+00
6500	.1784E−03	.1509E+00	9600	.2297E−03	.1943E+00
6600	.1802E−03	.1524E+00	9700	.2312E−03	.1956E+00
6700	.1820E−03	.1539E+00	9800	.2328E−03	.1969E+00
6800	.1837E−03	.1553E+00	9900	.2343E−03	.1982E+00
6900	.1855E−03	.1568E+00	10000	.2358E−03	.1995E+00
7000	.1872E−03	.1583E+00			

Table 2. Variation of viscosity and thermal conductivity of a mixture of 0.05 CO + 0.05 0 in Argon against absolute temperature

AR / CO / O = .90/ .05/.05

T	U	K	T	U	K
4000	.1308E−03	.1163E+00	7100	.1894E−03	.1683E+00
4100	.1329E−03	.1181E+00	7200	.1911E−03	.1699E+00
4200	.1350E−03	.1200E+00	7300	.1928E−03	.1714E+00
4300	.1370E−03	.1218E+00	7400	.1945E−03	.1729E+00
4400	.1391E−03	.1236E+00	7500	.1962E−03	.1744E+00
4500	.1411E−03	.1254E+00	7600	.1979E−03	.1759E+00
4600	.1431E−03	.1272E+00	7700	.1996E−03	.1774E+00
4700	.1451E−03	.1290E+00	7800	.2013E−03	.1789E+00
4800	.1471E−03	.1307E+00	7900	.2029E−03	.1804E+00
4900	.1490E−03	.1325E+00	8000	.2046E−03	.1819E+00
5000	.1510E−03	.1342E+00	8100	.2063E−03	.1834E+00
5100	.1529E−03	.1359E+00	8200	.2079E−03	.1849E+00
5200	.1548E−03	.1376E+00	8300	.2096E−03	.1864E+00
5300	.1568E−03	.1393E+00	8400	.2112E−03	.1878E+00
5400	.1587E−03	.1410E+00	8500	.2128E−03	.1893E+00
5500	.1606E−03	.1427E+00	8600	.2145E−03	.1907E+00
5600	.1624E−03	.1444E+00	8700	.2161E−03	.1922E+00
5700	.1643E−03	.1460E+00	8800	.2177E−03	.1936E+00
5800	.1662E−03	.1477E+00	8900	.2193E−03	.1951E+00
5900	.1680E−03	.1493E+00	9000	.2209E−03	.1965E+00
6000	.1698E−03	.1509E+00	9100	.2225E−03	.1979E+00
6100	.1717E−03	.1526E+00	9200	.2241E−03	.1994E+00
6200	.1735E−03	.1542E+00	9300	.2257E−03	.2008E+00
6300	.1753E−03	.1558E+00	9400	.2273E−03	.2022E+00
6400	.1771E−03	.1574E+00	9500	.2288E−03	.2036E+00
6500	.1788E−03	.1590E+00	9600	.2304E−03	.2050E+00
6600	.1806E−03	.1605E+00	9700	.2320E−03	.2064E+00
6700	.1824E−03	.1621E+00	9800	.2335E−03	.2078E+00
6800	.1841E−03	.1637E+00	9900	.2351E−03	.2092E+00
6900	.1859E−03	.1652E+00	10000	.2366E−03	.2106E+00
7000	.1876E−03	.1668E+00			

Table 3. Variation of viscosity and thermal conductivity of a mixture of 0.075 CO + 0.075 0 in Argon against absolute temperature

AR / CO / O = .85/ .075/.075

T	U	K	T	U	K
4000	.1310E−03	.1220E+00	7100	.1897E−03	.1683E+00
4100	.1331E−03	.1239E+00	7200	.1915E−03	.1782E+00
4200	.1352E−03	.1259E+00	7300	.1932E−03	.1798E+00
4300	.1373E−03	.1278E+00	7400	.1949E−03	.1815E+00
4400	.1393E−03	.1297E+00	7500	.1966E−03	.1830E+00
4500	.1414E−03	.1316E+00	7600	.1983E−03	.1846E+00
4600	.1434E−03	.1334E+00	7700	.2000E−03	.1862E+00
4700	.1454E−03	.1353E+00	7800	.2017E−03	.1878E+00
4800	.1473E−03	.1371E+00	7900	.2034E−03	.1894E+00
4900	.1493E−03	.1389E+00	8000	.2051E−03	.1910E+00
5000	.1513E−03	.1408E+00	8100	.2067E−03	.1925E+00
5100	.1532E−03	.1426E+00	8200	.2084E−03	.1941E+00
5200	.1551E−03	.1444E+00	8300	.2100E−03	.1956E+00
5300	.1570E−03	.1461E+00	8400	.2117E−03	.1972E+00
5400	.1590E−03	.1479E+00	8500	.2133E−03	.1987E+00
5500	.1608E−03	.1497E+00	8600	.2150E−03	.2003E+00
5600	.1627E−03	.1514E+00	8700	.2166E−03	.2018E+00
5700	.1646E−03	.1532E+00	8800	.2182E−03	.2033E+00
5800	.1665E−03	.1549E+00	8900	.2198E−03	.2048E+00
5900	.1683E−03	.1566E+00	9000	.2215E−03	.2063E+00
6000	.1701E−03	.1583E+00	9100	.2231E−03	.2079E+00
6100	.1720E−03	.1600E+00	9200	.2247E−03	.2094E+00
6200	.1738E−03	.1617E+00	9300	.2263E−03	.2109E+00
6300	.1756E−03	.1634E+00	9400	.2278E−03	.2124E+00
6400	.1774E−03	.1651E+00	9500	.2294E−03	.2139E+00
6500	.1792E−03	.1668E+00	9600	.2310E−03	.2153E+00
6600	.1810E−03	.1684E+00	9700	.2326E−03	.2168E+00
6700	.1827E−03	.1701E+00	9800	.2342E−03	.2183E+00
6800	.1845E−03	.1717E+00	9900	.2357E−03	.2198E+00
6900	.1862E−03	.1734E+00	10000	.2373E−03	.2213E+00
7000	.1880E−03	.1750E+00			

Table 4. Variation of viscosity and thermal conductivity of a mixture of 0.1 CO + 0.1 0 in Argon against absolute temperature

AR / CO / O = .80/ .10/.10

T	U	K	T	U	K
4000	.1313E−03	.1275E+00	7100	.1900E−03	.1846E+00
4100	.1334E−03	.1295E+00	7200	.1918E−03	.1863E+00
4200	.1354E−03	.1316E+00	7300	.1935E−03	.1880E+00
4300	.1375E−03	.1336E+00	7400	.1952E−03	.1897E+00
4400	.1395E−03	.1355E+00	7500	.1969E−03	.1914E+00
4500	.1416E−03	.1375E+00	7600	.1987E−03	.1930E+00
4600	.1436E−03	.1395E+00	7700	.2004E−03	.1947E+00
4700	.1456E−03	.1414E+00	7800	.2021E−03	.1964E+00
4800	.1476E−03	.1433E+00	7900	.2037E−03	.1980E+00
4900	.1495E−03	.1452E+00	8000	.2054E−03	.1997E+00
5000	.1515E−03	.1471E+00	8100	.2071E−03	.2013E+00
5100	.1534E−03	.1490E+00	8200	.2088E−03	.2029E+00
5200	.1554E−03	.1509E+00	8300	.2104E−03	.2046E+00
5300	.1573E−03	.1527E+00	8400	.2121E−03	.2062E+00
5400	.1592E−03	.1546E+00	8500	.2138E−03	.2078E+00
5500	.1611E−03	.1564E+00	8600	.2154E−03	.2094E+00
5600	.1630E−03	.1583E+00	8700	.2170E−03	.2111E+00
5700	.1648E−03	.1601E+00	8800	.2187E−03	.2127E+00
5800	.1667E−03	.1619E+00	8900	.2203E−03	.2143E+00
5900	.1686E−03	.1637E+00	9000	.2219E−03	.2159E+00
6000	.1704E−03	.1655E+00	9100	.2235E−03	.2174E+00
6100	.1722E−03	.1673E+00	9200	.2252E−03	.2190E+00
6200	.1741E−03	.1691E+00	9300	.2268E−03	.2206E+00
6300	.1759E−03	.1708E+00	9400	.2284E−03	.2222E+00
6400	.1777E−03	.1726E+00	9500	.2300E−03	.2238E+00
6500	.1795E−03	.1743E+00	9600	.2316E−03	.2253E+00
6600	.1812E−03	.1761E+00	9700	.2331E−03	.2269E+00
6700	.1830E−03	.1778E+00	9800	.2347E−03	.2285E+00
6800	.1848E−03	.1795E+00	9900	.2363E−03	.2300E+00
6900	.1866E−03	.1812E+00	10000	.2379E−03	.2316E+00
7000	.1883E−03	.1829E+00			

Table 5. Variation of viscosity and thermal conductivity of a mixture of 0.125 CO + 0.125 0 in Argon against absolute temperature

AR / CO / O = .75/ .125/.125

T	U	K	T	U	K
4000	.1314E−03	.1329E+00	7100	.1903E−03	.1924E+00
4100	.1335E−03	.1350E+00	7200	.1921E−03	.1942E+00
4200	.1356E−03	.1371E+00	7300	.1938E−03	.1959E+00
4300	.1377E−03	.1391E+00	7400	.1955E−03	.1977E+00
4400	.1397E−03	.1412E+00	7500	.1972E−03	.1994E+00
4500	.1417E−03	.1432E+00	7600	.1990E−03	.2012E+00
4600	.1438E−03	.1453E+00	7700	.2007E−03	.2029E+00
4700	.1458E−03	.1473E+00	7800	.2024E−03	.2046E+00
4800	.1477E−03	.1493E+00	7900	.2041E−03	.2064E+00
4900	.1497E−03	.1513E+00	8000	.2058E−03	.2081E+00
5000	.1517E−03	.1533E+00	8100	.2074E−03	.2098E+00
5100	.1536E−03	.1552E+00	8200	.2091E−03	.2115E+00
5200	.1556E−03	.1572E+00	8300	.2108E−03	.2132E+00
5300	.1572E−03	.1591E+00	8400	.2125E−03	.2149E+00
5400	.1594E−03	.1611E+00	8500	.2141E−03	.2166E+00
5500	.1613E−03	.1630E+00	8600	.2158E−03	.2183E+00
5600	.1632E−03	.1649E+00	8700	.2174E−03	.2200E+00
5700	.1650E−03	.1668E+00	8800	.2191E−03	.2217E+00
5800	.1669E−03	.1687E+00	8900	.2207E−03	.2234E+00
5900	.1688E−03	.1705E+00	9000	.2223E−03	.2250E+00
6000	.1706E−03	.1724E+00	9100	.2240E−03	.2267E+00
6100	.1725E−03	.1743E+00	9200	.2256E−03	.2284E≠00
6200	.1743E−03	.1761E+00	9300	.2272E−03	.2300E+00
6300	.1761E−03	.1780E+00	9400	.2288E−03	.2317E+00
6400	.1779E−03	.1798E+00	9500	.2304E−03	.2333E+00
6500	.1797E−03	.1816E+00	9600	.2320E−03	.2350E+00
6600	.1815E−03	.1834E+00	9700	.2336E−03	.2336E+00
6700	.1833E−03	.1852E+00	9800	.2352E−03	.2383E+00
6800	.1850E−03	.1870E+00	9900	.2368E−03	.2399E+00
6900	.1868E−03	.1888E+00	10000	.2384E−03	.2415E+00
7000	.1886E−03	.1906E+00			

Table 6. Variation of viscosity and thermal conductivity of a mixture of 0.15 CO + 0.15 0 in Argon against absolute temperatures

AR / CO / O = .70/ .15/.15

T	U	K	T	U	K
4000	.1316E−03	.1380E+00	7100	.1905E−03	.1999E+00
4100	.1337E−03	.1402E+00	7200	.1923E−03	.2017E+00
4200	.1358E−03	.1424E+00	7300	.1940E−03	.2035E+00
4300	.1378E−03	.1445E+00	7400	.1957E−03	.2054E+00
4400	.1399E−03	.1467E+00	7500	.1975E−03	.2072E+00
4500	.1419E−03	.1488E+00	7600	.1992E−03	.2090E+00
4600	.1439E−03	.1509E+00	7700	.2009E−03	.2108E+00
4700	.1459E−03	.1530E+00	7800	.2026E−03	.2126E+00
4800	.1479E−03	.1551E+00	7900	.2043E−03	.2144E+00
4900	.1499E−03	.1571E+00	8000	.2060E−03	.2162E+00
5000	.1518E−03	.1592E+00	8100	.2077E−03	.2180E+00
5100	.1538E−03	.1612E+00	8200	.2094E−03	.2198E+00
5200	.1557E−03	.1633E+00	8300	.2111E−03	.2216E+00
5300	.1576E−03	.1653E+00	8400	.2128E−03	.2234E+00
5400	.1595E−03	.1673E+00	8500	.2144E−03	.2251E+00
5500	.1614E−03	.1693E+00	8600	.2161E−03	.2269E+00
5600	.1633E−03	.1713E+00	8700	.2177E−03	.2287E+00
5700	.1652E−03	.1732E+00	8800	.2194E−03	.2304E+00
5800	.1671E−03	.1752E+00	8900	.2210E−03	.2322E+00
5900	.1689E−03	.1771E+00	9000	.2227E−03	.2339E+00
6000	.1708E−03	.1791E+00	9100	.2243E−03	.2357E+00
6100	.1726E−03	.1810E+00	9200	.2260E−03	.2374E+00
6200	.1745E−03	.1829E+00	9300	.2276E−03	.2391E+00
6300	.1763E−03	.1849E+00	9400	.2292E−03	.2409E+00
6400	.1781E−03	.1868E+00	9500	.2308E−03	.2426E+00
6500	.1799E−03	.1887E+00	9600	.2324E−03	.2443E+00
6600	.1817E−03	.1905E+00	9700	.2341E−03	.2460E+00
6700	.1835E−03	.1924E+00	9800	.2357E−03	.2478E+00
6800	.1852E−03	.1943E+00	9900	.2373E−03	.2495E+00
6900	.1870E−03	.1962E+00	10000	.2389E−03	.2512E+00
7000	.1888E−03	.1980E+00			

Table 7. Variation of viscosity and thermal conductivity of a mixture of 0.175 CO + 0.175 0 in Argon against absolute temperatures

AR / CO / O = .65/ .175/.175

T	U	K	T	U	K
4000	.1317E−03	.1430E+00	7100	.1907E−03	.2071E+00
4100	.1338E−03	.1453E+00	7200	.1924E−03	.2090E+00
4200	.1359E−03	.1475E+00	7300	.1942E−03	.2009E+00
4300	.1379E−03	.1498E+00	7400	.1959E−03	.2128E+00
4400	.1400E−03	.1520E+00	7500	.1977E−03	.2147E+00
4500	.1420E−03	.1542E+00	7600	.1994E−03	.2166E+00
4600	.1440E−03	.1564E+00	7700	.2011E−03	.2185E+00
4700	.1460E−03	.1585E+00	7800	.2028E−03	.2204E+00
4800	.1480E−03	.1607E+00	7900	.2045E−03	.2223E+00
4900	.1500E−03	.1628E+00	8000	.2062E−03	.2241E+00
5000	.1519E−03	.1649E+00	8100	.2079E−03	.2260E+00
5100	.1539E−03	.1670E+00	8200	.2096E−03	.2278E+00
5200	.1558E−03	.1691E+00	8300	.2113E−03	.2297E+00
5300	.1577E−03	.1712E+00	8400	.2130E−03	.2315E+00
5400	.1597E−03	.1733E+00	8500	.2147E−03	.2334E+00
5500	.1616E−03	.1754E+00	8600	.2164E−03	.2352E+00
5600	.1635E−03	.1774E+00	8700	.2180E−03	.2370E+00
5700	.1653E−03	.1795E+00	8800	.2197E−03	.2389E+00
5800	.1672E−03	.1815E+00	8900	.2213E−03	.2407E+00
5900	.1691E−03	.1835E+00	9000	.2230E−03	.2425E+00
6000	.1709E−03	.1855E+00	9100	.2246E−03	.2443E+00
6100	.1728E−03	.1876E+00	9200	.2263E−03	.2461E+00
6200	.1746E−03	.1895E+00	9300	.2279E−03	.2480E+00
6300	.1764E−03	.1915E+00	9400	.2295E−03	.2498E+00
6400	.1782E−03	.1935E+00	9500	.2312E−03	.2516E+00
6500	.1800E−03	.1955E+00	9600	.2328E−03	.2534E+00
6600	.1818E−03	.1974E+00	9700	.2344E−03	.2552E+00
6700	.1836E−03	.1994E+00	9800	.2360E−03	.2569E+00
6800	.1854E−03	.2013E+00	9900	.2377E−03	.2587E+00
6900	.1872E−03	.2033E+00	10000	.2393E−03	.2605E+00
7000	.1889E−03	.2052E+00			

Table 8. Variation of viscosity and thermal conductivity of a mixture of 0.2 CO + 0.2 0 in Argon against absolute temperatures

AR / CO / O = .60/ .20/.20

T	U	K	T	U	K
4000	.1318E−03	.1479E+00	7100	.1908E−03	.2141E+00
4100	.1339E−03	.1502E+00	7200	.1926E−03	.2161E+00
4200	.1360E−03	.1525E+00	7300	.1943E−03	.2181E+00
4300	.1380E−03	.1548E+00	7400	.1961E−03	.2200E+00
4400	.1401E−03	.1571E+00	7500	.1978E−03	.2220E+00
4500	.1421E−03	.1594E+00	7600	.1996E−03	.2240E+00
4600	.1441E−03	.1616E+00	7700	.2013E−03	.2259E+00
4700	.1461E−03	.1639E+00	7800	.2030E−03	.2279E+00
4800	.1481E−03	.1661E+00	7900	.2047E−03	.2298E+00
4900	.1501E−03	.1683E+00	8000	.2064E−03	.2317E+00
5000	.1520E−03	.1705E+00	8100	.2081E−03	.2337E+00
5100	.1540E−03	.1727E+00	8200	.2098E−03	.2356E+00
5200	.1559E−03	.1748E+00	8300	.2115E−03	.2375E+00
5300	.1578E−03	.1770E+00	8400	.2132E−03	.2394E+00
5400	.1598E−03	.1791E+00	8500	.2149E−03	.2413E+00
5500	.1617E−03	.1813E+00	8600	.2166E−03	.2433E+00
5600	.1635E−03	.1834E+00	8700	.2182E−03	.2452E+00
5700	.1654E−03	.1855E+00	8800	.2199E−03	.2471E+00
5800	.1673E−03	.1876E+00	8900	.2216E−03	.2489E+00
5900	.1692E−03	.1897E+00	9000	.2232E−03	.2508E+00
6000	.1710E−03	.1918E+00	9100	.2249E−03	.2527E+00
6100	.1729E−03	.1939E+00	9200	.2265E−03	.2546E+00
6200	.1747E−03	.1959E+00	9300	.2282E−03	.2565E+00
6300	.1765E−03	.1980E+00	9400	.2298E−03	.2584E+00
6400	.1783E−03	.2000E+00	9500	.2315E−03	.2602E+00
6500	.1801E−03	.2021E+00	9600	.2331E−03	.2621E+00
6600	.1819E−03	.2041E+00	9700	.2347E−03	.2640E+00
6700	.1837E−03	.2061E+00	9800	.2364E−03	.2658E+00
6800	.1855E−03	.2081E+00	9900	.2380E−03	.2677E+00
6900	.1873E−03	.2101E+00	10000	.2396E−03	.2695E+00
7000	.1891E−03	.2121E+00			

Table 9. Variation of viscosity and thermal conductivity of a mixture of 0.225 CO + 0.225 0 in Argon against absolute temperatures

AR / CO / O = .55/ .225/.225

T	U	K	T	U	K
4000	.1319E−03	.1525E+00	7100	.1909E−03	.2209E+00
4100	.1340E−03	.1549E+00	7200	.1927E−03	.2229E+00
4200	.1360E−03	.1573E+00	7300	.1945E−03	.2250E+00
4300	.1381E−03	.1597E+00	7400	.1962E−03	.2270E+00
4400	.1401E−03	.1621E+00	7500	.1979E−03	.2290E+00
4500	.1422E−03	.1644E+00	7600	.1997E−03	.2311E+00
4600	.1442E−03	.1667E+00	7700	.2014E−03	.2331E+00
4700	.1462E−03	.1690E+00	7800	.2031E−03	.2351E+00
4800	.1482E−03	.1713E+00	7900	.2049E−03	.2371E+00
4900	.1501E−03	.1736E+00	8000	.2066E−03	.2391E+00
5000	.1521E−03	.1579E+00	8100	.2083E−03	.2411E+00
5100	.1540E−03	.1781E+00	8200	.2100E−03	.2431E+00
5200	.1560E−03	.1803E+00	8300	.2117E−03	.2451E+00
5300	.1579E−03	.1826E+00	8400	.2134E−03	.2471E+00
5400	.1598E−03	.1848E+00	8500	.2151E−03	.2491E+00
5500	.1617E−03	.1870E+00	8600	.2168E−03	.2510E+00
5600	.1636E−03	.1892E+00	8700	.2184E−03	.2530E+00
5700	.1655E−03	.1914E+00	8800	.2201E−03	.2550E+00
5800	.1674E−03	.1935E+00	8900	.2218E−03	.2569E+00
5900	.1692E−03	.1957E+00	9000	.2234E−03	.2589E+00
6000	.1711E−03	.1978E+00	9100	.2251E−03	.2608E+00
6100	.1729E−03	.2000E+00	9200	.2268E−03	.2628E+00
6200	.1748E−03	.2021E+00	9300	.2284E−03	.2647E+00
6300	.1766E−03	.2042E+00	9400	.2301E−03	.2667E+00
6400	.1784E−03	.2063E+00	9500	.2317E−03	.2686E+00
6500	.1802E−03	.2084E+00	9600	.2334E−03	.2706E+00
6600	.1820E−03	.2105E+00	9700	.2350E−03	.2725E+00
6700	.1838E−03	.2126E+00	9800	.2366E−03	.2744E+00
6800	.1856E−03	.2147E+00	9900	.2383E−03	.2764E+00
6900	.1874E−03	.2168E+00	10000	.2399E−03	.2783E+00
7000	.1892E−03	.2188E+00			

Table 10. Variation of viscosity and thermal conductivity of a mixture of 0.25 CO + 0.25 0 in Argon against absolute temperatures

AR / CO / O = .50/ .25/.25

T	U	K	T	U	K
4000	.1319E−03	.1571E+00	7100	.1910E−03	.2274E+00
4100	.1340E−03	.1595E+00	7200	.1928E−03	.2296E+00
4200	.1361E−03	.1620E+00	7300	.1945E−03	.2317E+00
4300	.1381E−03	.1644E+00	7400	.1963E−03	.2338E+00
4400	.1402E−03	.1669E+00	7500	.1980E−03	.2359E+00
4500	.1422E−03	.1693E+00	7600	.1998E−03	.2380E+00
4600	.1442E−03	.1717E+00	7700	.2015E−03	.2400E+00
4700	.1462E−03	.1740E+00	7800	.2032E−03	.2421E+00
4800	.1482E−03	.1764E+00	7900	.2050E−03	.2442E+00
4900	.1502E−03	.1787E+00	8000	.2067E−03	.2463E+00
5000	.1521E−03	.1811E+00	8100	.2084E−03	.2483E+00
5100	.1541E−03	.1834E+00	8200	.2101E−03	.2504E+00
5200	.1560E−03	.1857E+00	8300	.2118E−03	.2524E+00
5300	.1579E−03	.1880E+00	8400	.2135E−03	.2545E+00
5400	.1599E−03	.1903E+00	8500	.2152E−03	.2565E+00
5500	.1618E−03	.1925E+00	8600	.2169E−03	.2586E+00
5600	.1637E−03	.1948E+00	8700	.2186E−03	.2606E+00
5700	.1655E−03	.1970E+00	8800	.2203E−03	.2626E+00
5800	.1674E−03	.1993E+00	8900	.2219E−03	.2647E+00
5900	.1693E−03	.2015E+00	9000	.2236E−03	.2667E+00
6000	.1711E−03	.2037E+00	9100	.2253E−03	.2687E+00
6100	.1730E−03	.2059E+00	9200	.2270E−03	.2707E+00
6200	.1748E−03	.2081E+00	9300	.2286E−03	.2727E+00
6300	.1766E−03	.2103E+00	9400	.2303E−03	.2748E+00
6400	.1785E−03	.2124E+00	9500	.2319E−03	.2768E+00
6500	.1803E−03	.2146E+00	9600	.2336E−03	.2788E+00
6600	.1821E−03	.2168E+00	9700	.2352E−03	.2808E+00
6700	.1839E−03	.2189E+00	9800	.2369E−03	.2828E+00
6800	.1857E−03	.2211E+00	9900	.2385E−03	.2848E+00
6900	.1857E−03	.2232E+00	10000	.2402E−03	.2868E+00
7000	.1892E−03	.2253E+00			

Table 11. Variation of diffusion of oxygen atom in Argon against absolute temperatures

Diffusion of O in AR

T	D	T	D
4000	.2512E−02	7100	.7228E−02
4100	.2633E−02	7200	.7340E−02
4200	.2757E−02	7300	.7484E−02
4300	.2884E−02	7400	.7702E−02
4400	.3012E−02	7500	.7964E−02
4500	.3143E−02	7600	.8216E−02
4600	.3275E−02	7700	.8421E−02
4700	.3409E−02	7800	.8602E−02
4800	.3546E−02	7900	.8785E−02
4900	.3686E−02	8000	.8982E−02
5000	.3827E−02	8100	.9186E−02
5100	.3972E−02	8200	.9390E−02
5200	.4119E−02	8300	.9594E−02
5300	.4266E−02	8400	.9798E−02
5400	.4414E−02	8500	.1000E−01
5500	.2565E−02	8600	.1021E−01
5600	.4720E−02	8700	.1042E−01
5700	.4865E−02	8800	.1063E−01
5800	.5024E−02	8900	.1085E−01
5900	.5186E−02	9000	.1106E−01
6000	.5350E−02	9100	.1128E−01
6100	.5517E−02	9200	.1150E−01
6200	.5686E−02	9300	.1171E−01
6300	.5857E−02	9400	.1194E−01
6400	.6028E−02	9500	.1216E−01
6500	.6198E−02	9600	.1238E−01
6600	.6368E−02	9700	.1261E−01
6700	.6542E−02	9800	.1284E−01
6800	.6728E−02	9900	.1306E−01
6900	.6921E−02	10000	.1329E−01
7000	.7095E−02		

Table 12. Variation of diffusion of carbon monoxide in Argon against absolute temperature

Diffusion of CO in AR

T	D	T	D
4000	.1554E−02	7100	.4017E−02
4100	.1619E−02	7200	.4111E−02
4200	.1685E−02	7300	.4206E−02
4300	.1752E−02	7400	.4302E−02
4400	.1819E−02	7500	.4398E−02
4500	.1888E−02	7600	.4496E−02
4600	.1958E−02	7700	.4594E−02
4700	.2029E−02	7800	.4693E−02
4800	.2101E−02	7900	.4793E−02
4900	.2174E−02	8000	.4894E−02
5000	.2248E−02	8100	.4996E−02
5100	.2323E−02	8200	.5098E−02
5200	.2399E−02	8300	.5202E−02
5300	.4276E−02	8400	.5306E−02
5400	.2554E−02	8500	.5411E−02
5500	.2633E−02	8600	.5517E−02
5600	.2712E−02	8700	.5623E−02
5700	.2793E−02	8800	.5731E−02
5800	.2875E−02	8900	.5839E−02
5900	.2957E−02	9000	.5948E−02
6000	.3041E−02	9100	.6058E−02
6100	.3125E−02	9200	.6168E−02
6200	.3210E−02	9300	.6279E−02
6300	.3296E−02	9400	.6392E−02
6400	.3383E−02	9500	.6504E−02
6500	.3471E−02	9600	.6618E−02
6600	.3560E−02	9700	.6732E−02
6700	.3650E−02	9800	.6848E−02
6800	.3740E−02	9900	.6963E−02
6900	.3832E−02	10000	.7080E−02
7000	.3924E−02		

خواص خليط أول أكسيد الكربون وأوكسيجين وأرجون عند درجات الحرارة العالية

عـادل ناصـر

قسم العلوم الهندسية والفيزياء ـ جامعة الخليج العربي ـ ص . ب : ٢٦٦٧١ المنامة ـ البحرين

أول أكسيـد الكربـون أحد الغـازات الضارة والنـاتجـة عن الاحـتراق غـير الكـامل وقـد يحدث هـذا مثلاً في الـتربينات الغـازيـة التي تـولـد الكهـربـاء أو المحـركـات النفـاثـه أو آلات الاحـتراق الـداخـلي . وأحـد الـطرق التي يمكن استخدامها للحد من وجود غاز أول أكسيد الكربون هو استخدام أسطح تساعد على اتحاد ذرة الأوكسيجين مع أول أكسيد الكربون عـلى السطح مكـونه غـاز ثاني أكسيد الكربون .

وأول ما يصادف الباحث في معالجة مثل هذه الحالة هو معرفة تفـاصيل عن خواص خليط أول أكسيد الكربون والأوكسيجين ولقد أضفنا غـاز الأرجون حتى يمكن معالجته معملياً ومقارنة النتائج العملية بالنتائج النظريـة . ولقد استخـدمنا في هذا البحث نسب مختلفة من أول أكسيد الكربون والأوكسيجين والأرجون وتم عمل الحسابات المطلوبه عند درجات الحرارة العالية .

ولقد أختير غاز الأرجون لأنه غاز أحادي الجزيء درجـة حرارة تـأينه عـالية ولا يؤثر في التفاعل .

ولقد تمت برمجة المعادلات الحـاكمه لحسـاب اللزوجة والتـوصيل الحـراري والنفاذيه لنسب مختلفة من خليط أول أكسيد الكـربون والأوكسيجين والأرجـون عند درجات حرارة عالية تتراوح بين ٤٠٠٠ إلى ١٠,٠٠٠ درجة مطلقه وقدمت النتـائج عـلى هيئة منحنيـات وجداول عـلى حسب دقـة الحسـابـات المـطلوبـة .

وأظهـرت النتائـج أن لزوجـة الخليط تتغير بنسبـة حوالي ٩٠ ٪ عنـد تغير درجـة

الحرارة من ٤٠٠٠ إلى ١٠,٠٠٠ درجة مطلقة أما التوصيل الحراري فتغيره شبه خطي مع درجة الحرارة ولقد تم حساب النفاذيه لكل من ذرة الهيدروجين وأول أكسيد الكربون في الأرجون ولقد بينت النتائج أن نفاذيه ذرة الأوكسيجين حوالي ٤٠ ٪ أكبر من أول أكسيد الكربون في الأرجون عند درجة حرارة ٨٠٠٠ درجة مطلقة.

أما الجداول فقد قدمت لكل خليط وكان مدى تغير درجة الحرارة عبارة عن ١٠٠° م وبالدقه المناسبة لاستخدامها في التطبيقات المختلفة.