Constant Properties of n-Heptane, O_2 and N_2 @1000K

[a]Mariovane Donini,

[a]*Grupo de Mecânica de Fluidos Reativos*
Instituto Nacional de Pesquisas Espaciais - INPE
Cachoeira Paulista - SP, Brazil

From [1] on Table B.3 for n-Heptane (C_7H_{16}):

$$
\begin{aligned}
k_{C_7H_{16}} = (&-4.606147 \times 10^{-2} + 5.95652224 \times 10^{-4}T - 2.98893153 \times 10^{-6}T^2 \\
&+ 8.44612876 \times 10^{-9} * T^3 - 1.22927 \times 10^{-11}T^4 + 9.0127 \times 10^{-15}T^5 \\
&- 2.62961 \times 10^{-18} * T^6)[W/mK]
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
\mu_{C_7H_{16}} = (&1.540087 + 1.095157 \times 10^{-2}T + 1.800664 \times 10^{-5}T^2 \\
&- 1.36379 \times 10^{-8}T^3)[Ns/m^2] \times 10^6
\end{aligned} \tag{2}
$$

$$
\begin{aligned}
\rho_{C_7H_{16}} = &5.10490319 \times 10^{-6}T^3 - 0.00453356654T^2 \\
&+ 1.3537197365T - 135.5452328229
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
cp_{C_7H_{16}} = (&-7.40308 \times 10^2 + 1.0893537 \times 10^1T - 1.265124 \times 10^{-2}T^2 \\
&+ 9.843763 \times 10^{-6}T^3 - 4.3228296 \times 10^{-9}T^4 + 7.863665 \times 10^{-13}T^5)[J/kgK] \times 10^6
\end{aligned} \tag{4}
$$

From NIST webbook for n-Heptane (C_7H_{16}) at $1atm$:

$$\rho_{C_7H_{16}} = 0,000015878T^2 - 0,0214227788T + 9,2184793364[kg/m^3]$$

$$cp_{C_7H_{16}} = 0,0037638842T + 0,6385320938[kJ/kgK]$$

$$\mu_{C_7H_{16}} = 1,88414068667895.10^{-8}T + 6,16915491028679.10^{-7}[Pas]$$

$$k_{C_7H_{16}} = 0,0001099183T - 0,02319995272[W/mK]$$

$$\rho_{C_7H_{16}} = 3,6737005364[kg/m^3]$$

$$cp_{C_7H_{16}} = 4,4024162938[kJ/kgK]$$

$$\nu_{C_7H_{16}} = 5,29665.10^{-6}[m^2/s]$$

$$k_{C_7H_{16}} = 0,0867183473[W/mK]$$

From [1] on Table C.2 for N_2:

$$\rho_{N_2} = 0,3368[kg/m^3]$$

$$cp_{N_2} = 1,167[kJ/kgK]$$

$$\nu_{N_2} = 118,7.10^{-6}[m^2/s]$$

$$k_{N_2} = 64,7.10^{-3}[W/mK]$$

From [1] on Table C.2 for O_2:

$$\rho_{O_2} = 0,3848[kg/m^3]$$

$$cp_{O_2} = 1,090[kJ/kgK]$$

$$\nu_{O_2} = 124.10^{-6}[m^2/s]$$

$$k_{O_2} = 71.10^{-3}[W/mK]$$

Thermophisycal mixture properties at T=1000K:

$X_{C_7H_{16}} = 0,25, \quad X_{O_2} = 0,25, \quad X_{N_2} = 0,50$

Then

$$\rho_{total} = 0,25 \times 3,6737005364 + 0,25 \times 0,3848 + 0,5 \times 0,3368 [kg/m^3]$$

$$\boxed{\rho_{total} = 1,1950251341 [kg/m^3]}$$

$$cp_{total} = 0,25 \times 4,4024162938 + 0,25 \times 1,090 + 0,5 \times 1,167 [kJ/kgK]$$

$$\boxed{cp_{total} = 1,9373540735E + 03 [J/kgK]}$$

$$\nu_{total} = 0,25 \times 5,29665E - 05 + 0,25 \times 1,24E - 04 + 0,5 \times 1,19E - 04 [m^2/s]$$

$$\boxed{\nu_{total} = 9,30492E - 05 [m^2/s]}$$

$$k_{total} = 0,25 \times 8,6718E - 02 + 0,25 \times 7,11E - 02 + 0,5 \times 6,47E - 02 [W/mK]$$

$$\boxed{k_{total} = 7,3404587E - 02 [W/mK]}$$

1. Dimensional Analysis

$$\mathrm{a}_0 = 10^{-3} m$$

$$\alpha = \frac{k}{cp\rho} = \frac{7,3404 \times 10^{-2}}{1,9373 \times 10^3 \times 1,1950} \frac{J}{smK} \frac{kgK}{J} \frac{m^3}{kg}$$

$$\boxed{\alpha = 3,17 \times 10^{-5} \frac{m^2}{s}} \tag{5}$$

$$\mathrm{v}_c = \frac{\alpha}{\mathrm{a}_0} \tag{6}$$

$$\mathrm{v}_c = \frac{3,17 \times 10^{-5}}{10^{-3}} \frac{m^2}{s} \frac{1}{m}$$

$$\boxed{\mathrm{v}_c = 3,17 \times 10^{-2} \frac{m}{s}} \tag{7}$$

$$Pr = \frac{\nu}{\alpha} = \frac{9,30492 \times 10^{-5}}{3,17 \times 10^{-5}} \Rightarrow \boxed{Pr = 2,9353} \tag{8}$$

$$Fr = \frac{\mathrm{v}_c}{\sqrt{g\mathrm{a}_0}} = \frac{3,17 \times 10^{-2}}{\sqrt{9,8066 \times 10^{-3}}} \Rightarrow \boxed{Fr = 0,3201} \tag{9}$$

[1] Stephen R Turns et al. *An introduction to combustion*, volume 287. McGraw-hill New York, 1996.