T_{air_4}	α_{air}	K_{air}	P_{r_air}
(K)	$\left(\frac{m^2}{s}\right)$	$\left(\frac{W}{m \cdot K} \cdot 10^{-3}\right)$	
100	$2.54 \cdot 10^{-6}$	9.34	0.786
150	$5.84 \cdot 10^{-6}$	13.8	0.758
200	$10.3 \cdot 10^{-6}$	18.1	0.737
250	$15.9 \cdot 10^{-6}$	22.3	0.720
300	$22.5 \cdot 10^{-6}$	26.3	0.707
350	$29.9 \cdot 10^{-6}$	30	0.700
400	$38.3 \cdot 10^{-6}$	33.8	0.690
450	$47.2 \cdot 10^{-6}$	37.3	0.686
500	$56.7 \cdot 10^{-6}$	40.7	0.684
550	$66.7 \cdot 10^{-6}$	43.9	0.683
600	$76.9 \cdot 10^{-6}$	46.9	0.685
650	$87.3 \cdot 10^{-6}$	49.7	0.690

T_{air_2}	C_{p_air}	k_{air}
$(°F)$	$\left(\frac{Btu}{lbm \cdot R}\right)$	
40	.240	1.401
100	.240	1.400
200	.241	1.397
300	.243	1.394
400	.245	1.389
500	.248	1.383
600	.250	1.377
700	.254	1.371
800	.257	1.365
900	.259	1.358
1000	.263	1.353
1500	.276	1.330
2000	.286	1.312

T_{air_3}	μ_{air}	ν_{air}
$(°F)$	$\left(lbf \cdot \frac{s}{ft^2}\right)$	$\left(\frac{ft^2}{s}\right)$
−40	$3.29 \cdot 10^{-7}$	$1.12 \cdot 10^{-4}$
−20	$3.34 \cdot 10^{-7}$	$1.19 \cdot 10^{-4}$
0	$3.38 \cdot 10^{-7}$	$1.26 \cdot 10^{-4}$
10	$3.44 \cdot 10^{-7}$	$1.31 \cdot 10^{-4}$
20	$3.50 \cdot 10^{-7}$	$1.36 \cdot 10^{-4}$
30	$3.58 \cdot 10^{-7}$	$1.42 \cdot 10^{-4}$
40	$3.60 \cdot 10^{-7}$	$1.46 \cdot 10^{-4}$
50	$3.68 \cdot 10^{-7}$	$1.52 \cdot 10^{-4}$
60	$3.75 \cdot 10^{-7}$	$1.58 \cdot 10^{-4}$
70	$3.82 \cdot 10^{-7}$	$1.64 \cdot 10^{-4}$
80	$3.86 \cdot 10^{-7}$	$1.69 \cdot 10^{-4}$
90	$3.90 \cdot 10^{-7}$	$1.74 \cdot 10^{-4}$
100	$3.94 \cdot 10^{-7}$	$1.79 \cdot 10^{-4}$
120	$4.02 \cdot 10^{-7}$	$1.89 \cdot 10^{-4}$
140	$4.13 \cdot 10^{-7}$	$2.01 \cdot 10^{-4}$
160	$4.22 \cdot 10^{-7}$	$2.12 \cdot 10^{-4}$
180	$4.34 \cdot 10^{-7}$	$2.25 \cdot 10^{-4}$
200	$4.49 \cdot 10^{-7}$	$2.4 \cdot 10^{-4}$
300	$4.97 \cdot 10^{-7}$	$3.06 \cdot 10^{-4}$
400	$5.24 \cdot 10^{-7}$	$3.65 \cdot 10^{-4}$
500	$5.8 \cdot 10^{-7}$	$4.51 \cdot 10^{-4}$
750	$6.81 \cdot 10^{-7}$	$6.68 \cdot 10^{-4}$
1000	$7.85 \cdot 10^{-7}$	$9.3 \cdot 10^{-4}$
1500	$9.5 \cdot 10^{-7}$	$15.1 \cdot 10^{-4}$

T_{air_1}	h_{air}
(R)	$\left(\frac{Btu}{lbm}\right)$
540	129.06
560	133.86
580	138.66
600	143.47
620	148.28
640	153.09
660	157.92
680	162.73
700	167.56
720	172.39
740	177.23
760	182.08
780	186.94
800	191.69
820	196.69
840	201.56
860	206.46
880	211.35
900	216.26
920	221.18
940	226.11
960	231.06
980	236.02
1000	240.98
1040	250.95
1080	260.97
1120	271.03
1160	281.14
1200	291.3

T_{ss}	K_{ss}	C_{pss}
(K)	$\left(\frac{W}{m \cdot K}\right)$	$\left(\frac{J}{kg \cdot K}\right)$
100	9.2	272
200	12.6	402
300	14.9	477
400	16.6	515
600	19.8	557
800	22.6	582

$$C_{pair}(x) := \text{linterp}(T_{air\_2}, C_{p\_air}, x)$$

$$k_{air}(x) := \text{linterp}(T_{air\_2}, k_{air}, x)$$

$$h_{air}(x) := \text{linterp}(T_{air\_1}, h_{air}, x)$$

$$\mu_{air}(x) := \text{linterp}(T_{air\_3}, \mu_{air}, x)$$

$$\nu_{air}(x) := \text{linterp}(T_{air\_3}, \nu_{air}, x)$$

$$\alpha_{air}(x) := \text{linterp}(T_{air\_4}, \alpha_{air}, x)$$

$$K_{air}(x) := \text{linterp}(T_{air\_4}, K_{air}, x) \qquad K_{ss}(x) := \text{linterp}(T_{ss}, K_{ss}, x)$$

$$P_{r\_air}(x) := \text{linterp}(T_{air\_4}, P_{r\_air}, x)$$

$$Re_V(Velocity, D_h, T_{air}) := \frac{(Velocity \cdot D_h)}{\nu_{air}(T_{air})}$$

$$Re_m(Mdot, D_h, T_{air}) := \frac{4 \cdot Mdot}{\pi \cdot \mu_{air}(T_{air}) \cdot D_h}$$

$$\rho_{air}(Temperature, Pressure) := \frac{Pressure \cdot M_{bar\_air}}{Temperature \cdot R_u}$$

$$M_{bar\_air} \equiv 28.97 \ \frac{lb}{mol}$$

$$R_u \equiv (1.545 \cdot 10^3) \ \frac{(ft \cdot lbf)}{R \cdot mol}$$

$$K_{air\_p}(T, P) := \rho_{air}(T, P) \cdot C_{pair}(T) \cdot \alpha_{air}(T)$$

Below are the heat transfer calculations for a circular pipe

$$Nu_{Di}(Re_D, P_r, n) := 0.023 \cdot Re_D^{\ 5} \cdot P_r^{\ n}$$

n = 0.3 for cooling
= 0.4 for heating

$$Nu_{Di}(f, Re_D, P_r) := \frac{\left(\frac{f}{8}\right) \cdot (Re_D - 1000) \cdot P_r}{1 + 12.7 \cdot \left(\frac{f}{8}\right)^{\frac{1}{2}} \cdot \left(P_r^{\frac{2}{3}} - 1\right)}$$

$0.5 < P_r < 2000$

$3000 < Re_D < 5 \cdot 10^6$

$$Nu_{Do}(Re_D, P_r) := 0.3 + \frac{0.62 \cdot Re_D^{\frac{1}{2}} \cdot P_r^{\frac{1}{3}}}{\left(1 + \left(\frac{0.4}{P_r}\right)^{\frac{2}{3}}\right)^{\frac{1}{4}}} \cdot \left(1 + \left(\frac{Re_D}{282000}\right)^{\frac{5}{8}}\right)^{\frac{4}{5}}$$

All Re_D

$P_r > 0.2$

$$Nu_{DI}(T_{fi}, T_{fo}, m_{rate}, D_i, n) := Nu_{Di}\left(Re_m\left(m_{rate}, D_i, \frac{T_{fo}+T_{fi}}{2}\right), P_{r\_air}\left(\frac{T_{fi}+T_{fo}}{2}\right), n\right)$$

$$Nu_{DO}(T_{so}, T_{inf}, D_o, V_{inf}) := Nu_{Do}\left(Re_V\left(V_{inf}, D_o, \frac{T_{inf}+T_{so}}{2}\right), P_{r\_air}\left(\frac{T_{inf}+T_{so}}{2}\right)\right)$$

$$h_i(n, P_{avg}, T_{fi}, T_{fo}, m_{rate}, D_i) := \frac{Nu_{DI}(T_{fi}, T_{fo}, m_{rate}, D_i, n) \cdot K_{air\_p}\left(\frac{T_{fi}+T_{fo}}{2}, P_{avg}\right)}{D_i}$$

$$h_o(T_{so}, T_{inf}, m_{rate}, D_o, V_{inf}) := \frac{Nu_{DO}(T_{so}, T_{inf}, D_o, V_{inf}) \cdot K_{air}\left(\frac{T_{inf}+T_{so}}{2}\right)}{D_o}$$

$$\Delta T_{lm}(T_{fi}, T_{fo}, T_{si}) := \frac{T_{fi}-T_{fo}}{\ln\left(\frac{T_{si}-T_{fi}}{T_{si}-T_{fo}}\right)}$$

$Tempsolve(n, P_{avg}, m_{rate}, T_{fi}, T_{fo}, T_{inf}, D_i, D_o, L, V_{inf}, Error) :=$

$T_{inf\_calc} \leftarrow T_{inf} + Error + 5\ K$

$T_{error} \leftarrow |T_{inf\_calc} - T_{inf}|$

while $T_{error} > Error$

$h_1 \leftarrow h_{air}(T_{fi})$

$h_2 \leftarrow h_{air}(T_{fo})$

$Q \leftarrow m_{rate} \cdot (h_1 - h_2)$

$h_{int} \leftarrow h_i(n, P_{avg}, T_{fi}, T_{fo}, m_{rate}, D_i)$

$$T_{si} \leftarrow \frac{T_{fi} - T_{fo} \cdot e^{\frac{(T_{fi}-T_{fo}) \cdot h_{int} \cdot \pi \cdot D_i \cdot L}{Q}}}{1 - e^{\frac{(T_{fi}-T_{fo}) \cdot h_{int} \cdot \pi \cdot D_i \cdot L}{Q}}}$$

$$T_{so} \leftarrow T_{si} - \frac{Q \cdot \ln\left(\frac{D_o}{D_i}\right)}{2 \cdot \pi \cdot L \cdot K_{ss}(T_{si})}$$

$h_{ext} \leftarrow h_o(T_{so}, T_{inf}, m_{rate}, D_o, V_{inf})$

$$T_{inf\_calc} \leftarrow T_{si} - \frac{Q}{h_{ext} \cdot \pi \cdot D_o \cdot L}$$

if $T_{inf\_calc} > T_{inf}$

  $T_{fo\_new} \leftarrow T_{fo} - 0.001\ K$

else if $T_{inf\_calc} < T_{inf}$

  $T_{fo\_new} \leftarrow T_{fo} + 0.001\ K$

$T_{fo} \leftarrow T_{fo\_new}$

$T_{error} \leftarrow |T_{inf\_calc} - T_{inf}|$

return $\begin{bmatrix} T_{fo} \\ T_{inf\_calc} \\ T_{inf} \\ T_{si} \\ T_{so} \end{bmatrix}$

$$Tempsolve\left(0.3, 80\ psi, 0.135\ \frac{lbm}{s}, 320\ °C, 300\ °C, 90\ °F, 0.402\ in, 0.5\ in, 1.5\ ft, 10\ mph, 0.5\ K\right) = \begin{bmatrix} 588.091 \\ 304.882 \\ 305.372 \\ 588.09 \\ 586.831 \end{bmatrix} K$$

$$Tempsolve\left(0.3, 80\ psi, 30\ \frac{lbm}{s}, 340\ °C, 300\ °C, 20\ °F, 10\ in, 10.2\ in, 100\ ft, 20\ mph, 0.5\ K\right) = \begin{bmatrix} 598.608 \\ 266.005 \\ 266.483 \\ 598.607 \\ 597.518 \end{bmatrix} K$$

$$Tempsolve\left(0.3, 20\ psi, 5\ \frac{lbm}{s}, 700\ K, 10\ °C, 35\ °F, 6.1\ in, 6.625\ in, 50\ ft, 30\ mph, 0.05\ K\right) = \begin{bmatrix} 652.174 \\ 274.774 \\ 274.817 \\ 652.173 \\ 647.329 \end{bmatrix} K$$