You are asked to quench cylindrical bars of a Ni based alloy from 1200 ^{o}C to 300 ^{o}C in a furnace by forcing Ar gas over them at 150 ^{o}C. Use a lumped capacitance method (is that valid?) to predict the cooling behavior of the parts, which are L = 0.2 m long and d = 0.02 m in diameter. Assume that the gas flow is perpendicular to the axis of the cylinders, that the properties of the metal can be approximated as those of pure Ni, and that the gas properties can be evaluated at 450 ^{o}C. It is suggested that increasing the gas pressure will increase the heat transfer rate. Assuming that only density is affected by the pressure, evaluate this theory by plotting the cooling curves (T vs. t) for the cases of P = 1 atm, P = 3 atm, and P = 5 atm. In each case, how long does it take to reduce the temperature of the part to 300 ^{o}C? The velocity of the argon in each case is V_{Ar} = 4 m/s.

Cylinders in cross flow:

$$Nu_D = C\, Re_D^m\, Pr^{1/3} \qquad 0.6 < Pr$$

Re_D	C	m
0.4 – 4	0.989	0.330
4 – 40	0.911	0.385
40 – 4000	0.683	0.466
4000 – 40,000	0.193	0.618
40,000 – 400,000	0.027	0.805

(correlation referenced in Incropera and DeWitt, *Fundamentals of Heat and Mass Transfer*, 3rd ed., Wiley, 1990)