ME 345 – HTx   Spring 2022   Convection Take-Home Exam

For this take-home exam you are going to rework Example Problem 7.2 (from Lecture 22 presentation). Only you're going to take it much further. Your analysis will be for 10 of the heated plates (total plate length of 0.5 [m]). You will use the same temperatures and flow conditions as in the problem. I'm asking you to do two extra parts:

Part 1:

Make a plot of the local convection coefficient as a function of x down the plate (from 0.01 to 0.5 [m]). On this plot you should show two lines – one for the local laminar convection coefficient, and one for the local turbulent convection coefficient.

Also on this plot, make vertical lines representing the critical length where it may transition from laminar to turbulent flow. Show these (if they are in the x-range of the plot) for $Re_{x,c}$ of $1*10^5$, $5*10^5$, and $3*10^6$.

Part 2:

You're going to perform the analysis in the example problem, but for all 10 plates. And you're also going to do this three times (for $Re_{x,c}$ of $1*10^5$, $5*10^5$, and $3*10^6$). For each of these three conditions I would like you to calculate:

- Average convection coefficient for each plate [W/m^2K]
- Heat rate leaving the surface for each plate [W]
- Total heat rate leaving the entire surface (all 10 plates) [W]

Tips:

You can use whatever software you like. I used EES for my solution, and I put each of my variables for Part 2 in an array table. For my EES solution I also wrote 4 different sets of EES code: One for Part 1, then three for each of the conditions in Part 2. The three files for Part 2 are nearly the same, but I did change the Nusselt Number equation when it switched from laminar to turbulent.

You can use a solution path similar to the one shown in Example 7.2. Or you can use your plot from Part 1 to get to a very similar answer. Remember, if you integrate your local convection coefficient over the region of each plate you *should* get the average convection coefficient for each plate. You can use that average convection coefficient from each plate along with Newton's Law of Cooling to get the heat rate leaving each plate.