# ME 345 – HTx Fall 2023 Week 2 Homework

## Problem 1:

The wall of an industrial furnace is constructed from fireclay brick that is 0.15 [m] thick, with a thermal conductivity of 1.7 [W/m-K]. During steady-state operation the temperatures were found to be Tinside = 1400 K, and Toutside = 1250 K. If the wall has dimensions of 1.2 [m] wide and 0.5 [m] tall, calculate the following:

1. Heat rate of loss through the wall [W]
2. Heat flux through the wall [W/m2]



## Problem 2:

For the sheet of extruded solid insulation (3 m x 3 m x 25 mm) and conditions shown below calculate the following:

1. Heat rate of loss through the insulation [W]
2. Heat flux through the insulation [W/m2]
3. Comparing this to the problem above, which wall would be a better insulator?



## Problem 3:

You’re going to explore heat transfer through the shaft of a power generation gas turbine. Details are shown in the figure below. Find the following:

1. Compare the ratio of the heat rate [W] through the shaft over the power output [W].
2. Make a plot showing the ratio above as a function of shaft length. Explore lengths between 0.005 to 1 [m]
3. Discuss the implications and feasibility of operating this turbine with a shaft length of 0.05 [m]



## Problem 4:

You’re going to boil water in a pan, and have the option of using either an aluminum pan or copper pan (both of same dimensions). Assuming 1D steady-state conditions through the bottom of the pan calculate the following:

1. Temperature at the bottom of the pan (T1) in [°C] for aluminum pan
2. Temperature at the bottom of the pan (T1) in [°C] for copper pan
3. How does T1 relate to the temperature of the top surface of the burner?



## Problem 5:

Let’s do a calculation comparing convection heat transfer between really cold air and your hand, and pretty cold water and your hand. Assume the surface temperature of your hand remains at 30 °C for both cases. The conditions for each case are shown in the table below. Calculate the following:

1. Heat flux [W/m2] from your hand to the cold water (low velocity, like in a slow-moving stream)
2. Heat flux [W/m2] from your hand to the very cold air (modest velocity, like a winter breeze)
3. What implications does this have for things like staying warm in the winter?
4. Estimate the surface area of your body and calculate the heat rate [W] for each case. How does this compare to your typical 100 [W] heat rate loss in a comfortable environment?

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| **Convection in mildly cold water*** Twater = 10 °C
* Velocity = 0.2 m/s
* h = 900 W/m2-K
 | **Convection in much colder, faster air*** Tair = -5 °C
* Velocity = 35 km/hr
* h = 40 W/m2-K
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