Department of Material Science and Engineering
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Exercise 11: TMT4208

Hand out: 12.04.2021
Seminar: 19.04.2021
Hand in: 23.04.2021

Task 1: Radiation heat gain.

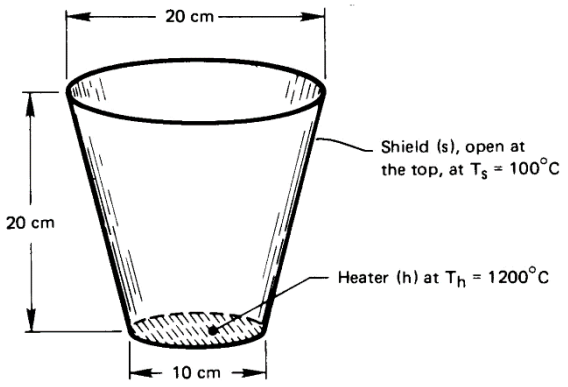
A physics experiment uses liquid nitrogen as a coolant. Saturated liquid nitrogen at 80 K flows through 6.35 mm O.D. stainless steel line ($\varepsilon_l = 0.2$) inside a vacuum chamber. The chamber walls are at $T_c = 230$ K and are at some distance from the line.

a) Determine the heat gain of the line per unit length [W/m].
b) If a second stainless steel tube, 12.7 mm in diameter, is placed around the line to act as radiation shield, to what rate is the heat gain reduced ?
c) Find the temperature of the shield.

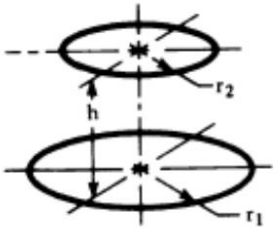
Task 2: Heat transfer from heater

A heater (h) as shown in the Figure to the right radiates to the partially conical shield (s) that surrounds it. The heater and the shield are both black.

a) What is the view factor F_{hs} from the heater to the shield?
b) Calculate the net heat transfer from the heater to the shield.
c) Calculate the heat transferred out of the shield through the open top when the temperature outside the shield is 27°C



Hint: Imagine a plane (i) laid across the open top of the shield



Let $R_1 = r_1/h$, $R_2 = r_2/h$, and $X = 1 + \left(1 + R_2^2\right) / R_1^2$. Then:

$$F_{1\text{-}2} = \frac{1}{2}\left[X - \sqrt{X^2 - 4(R_2/R_1)^2}\right]$$

Task 3: Heat transfer from a tapping stream

A jet of liquid metal at 2000°C pours from a crucible. It is 3 mm in diameter. A long cylindrical radiation shield, 5 cm diameter, surrounds the jet through an angle of 330°, but there is a 30° slit in it. The jet and the shield radiate as black bodies. They sit in a room at 30°C, and the shield has a temperature of 700°C.

a) Calculate the net heat transfer per unit length of the jet [kW/m] from the jet to the room without the radiation shield.
b) Calculate the net heat transfer per unit length of the jet [kW/m] from the jet to the room through the slit
c) Calculate the net heat transfer per unit length of the jet [kW/m] from the jet to the shield
d) Calculate the net heat transfer per unit length of the jet [kW/m] from the inside of the shield to the room.