CH EN 3453 – HEAT TRANSFER – FALL 2014

HOMEWORK #12

Due Monday, December 8, 2014 at 4:00 PM

Help session Wednesday, December 3 at 4:30 PM in room MEB 2325.

Turn in to the CH EN 3453 basket at the main desk of the Chemical Engineering offices (MEB 3290)

1. (10 pts) Answer "YES" if you have done all the following:

(a) Checked the "Miscellaneous" tab of the course web site (www.chen3453.com) and:
- **(i)** Confirmed that your homework grades are correct
- **(ii)** Confirmed that your exam grades are correct
- **(iii)** Confirmed that you have received credit for turning in the draft sections of the project
- **(iv)** Emailed Kevin with any errors in his record

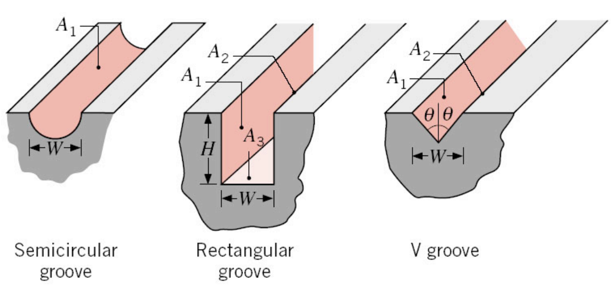
(b) Picked up all uncollected homework and draft project reports from the hallway behind the ICC

2. (10 pts) Answer the following questions concerning radiation exchange between surfaces.

(a) What is a view factor?
(b) What assumptions are associated with computing view factors between two surfaces?
(c) What is the reciprocity relation for view factors?
(d) What is the summation rule?

3.* (10 pts) Consider the following grooves, each of width W, that have been machined from a solid block of material.

(a) For each case obtain an expression for the view factor of the groove with respect to the surroundings outside the groove.
(b) For the V groove (right), obtain an expression for the view factor F_{12} where A_1 and A_2 are opposite surfaces.
(c) If $H = 2W$ in the rectangular groove, what is the view factor F_{12}?



4.* (10 pts) A circular ice rink 25 m in diameter is enclosed by a hemispherical dome 35 m in diameter. If the ice and dome surfaces may be approximated as blackbodies and are at 0 and 15°C, respectively, what is the net rate of radiative transfer from the dome to the rink?

5.* (10 pts) A very long electrical conductor 10 mm in diameter is concentric with a cooled cylindrical tube 50 mm in diameter whose surface is diffuse and gray with an emissivity of 0.9 and temperature of 27°C. The electrical conductor has a diffuse, gray surface with an emissivity of 0.6 and is dissipating 6.0 W per meter of length. Assuming that the space between the two surfaces is evacuated, calculate the surface temperature of the conductor.

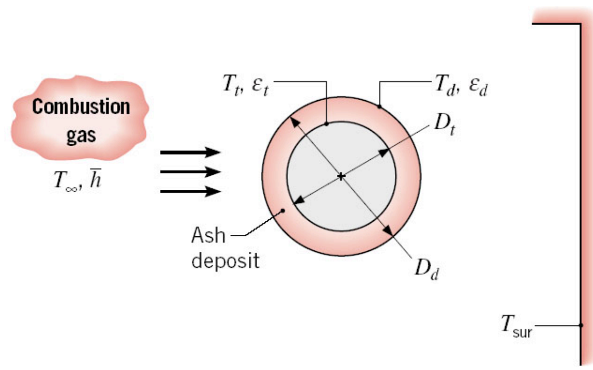
More problems on the other side…

* Solutions for these problems are available on the course website: www.chen3453.com

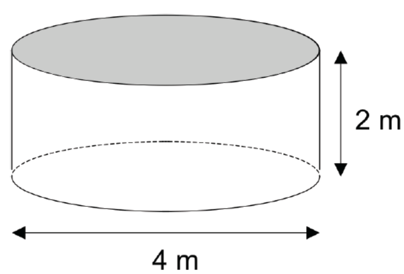
6.* (10 pts) Boiler tubes exposed to the products of coal combustion in a power plant are subject to fouling by the ash (mineral) content of the combustion gas. The ash forms a solid deposit on the tube outer surface, which reduces heat transfer to a pressurized water/steam mixture flowing inside the tubes. Consider a thin-walled boiler tube (D_t = 0.05 m) whose surface is maintained at T_t = 600 K by the boiling process. Combustion gases flowing over the tube at T_∞ = 1800 K provide a convection coefficient of h = 100 W/m^2·K, while radiation from the gas and boiler walls to the tube may be approximated as originating from large surroundings at T_{sur} = 1500 K.

(a) If the tube surface is diffuse and gray, with ε_t = 0.8, and there is *no* as deposit layer, what is the rate of heat transfer per unit length, q', to the boiler tube?

(b) If a deposit layer of diameter D_d = 0.06 m and thermal conductivity k = 1 W/m·K forms on the tube, what is the deposit surface temperature T_d? The deposit is diffuse and gray, with ε_d = 0.9, and T_t, T_∞, h and T_{sur} remain unchanged. What is the net rate of heat transfer per unit length, q', to the boiler tube?



7. (20 pts) For the cylindrical enclosure shown below, the circular base may be considered a *reradiating surface*. The vertical wall has an emissivity of 0.8 and the inner surface of that wall is kept at 280°C. If the top of the enclosure is open to the surroundings at 5°C, what is the net rate of radiant transfer to the surroundings.



8. (20 pts) Two parallel rectangles having emissivities of 0.6 and 0.9 are each 1.2 meters wide and 2.4 meters high. They are positioned 0.6 meters apart. The plate with ε = 0.6 is at 1000 K while the other is 420 K. The surroundings are at 290 K and may be assumed to absorb all energy that escapes the two plates.

(a) What is the total energy lost (Watts) from the hotter plate (radiosity)?
(b) What is the radiant energy exchange (Watts) between the two plates?

* Solutions for these problems are available on the course website: www.chen3453.com