ME 6103 Engineering Optimization

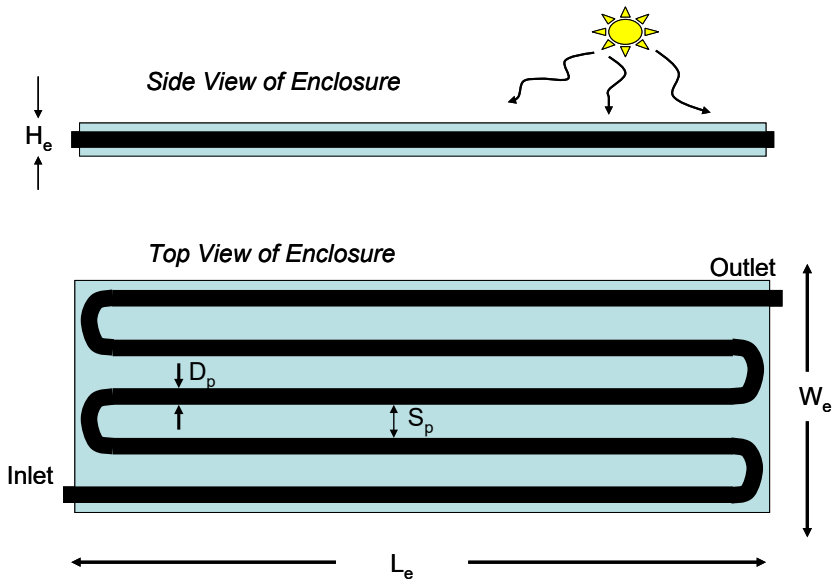
Spring 2025, Dr. Carolyn Conner Seepersad

Assignment 3: Multiobjective Optimization

Due: On Canvas by March 10, 2025

As an environmentally conscious designer, you have been asked to design a solar energy collection device for heating a swimming pool. As shown in the figure on the next page, the device works by arranging black pipes in an enclosure and exposing the pipes to direct sunlight. Your objective is to design an enclosure that is easy to transport and requires a minimum of pumping pressure. It should increase the temperature of the water by 3K per pass.

a. Present and explain your analysis model. Consider the assumptions and limitations described on Page 2.
b. Formulate the problem as a multiobjective optimization problem.
c. Devise a method for obtaining the Pareto curve. Show a graph of objective 1 vs. objective 2 and indicate the Pareto curve.
d. Apply a weighted sum technique to identify at least 5 Pareto solutions. Explain the trends you observe in the solutions.
e. Apply 1 additional technique from class (e.g., compromise programming) to identify at least 3 Pareto solutions. Explain the trends you observe in the solutions.
f. How do your answers to parts (d) and (e) compare? Why are they similar/different?



You may make the following assumptions:

- The ease of transport may be measured by the total volume of the enclosure.
- The pumping pressure may be measured by the total head loss in the pipe (including joints), but you may ignore any changes in height or velocity across the enclosure. Here's a link to a website that explains head loss in a pipe.
- The friction factor in the pipes assumes a constant value of 0.04.
- Flow conditions are turbulent, steady-state, and fully developed.
- The device is designed to operate on a sunny day with an incident solar heat flux of 1000 W per square meter of *pipe* surface area exposed directly to sunlight (i.e., do not count the under side of the pipes or the spacing between pipes). You may ignore the effects of radiation.
- The flowrate of water through the device is 0.2 kg/s.
- The inlet temperature of the water is 300K.
- Pipes are available with continuously variable circular diameters ranging from 2 to 12 cm.

Consider the following restrictions in your design:

- The maximum length of the enclosure, L_e, is 1.5 m.
- The minimum spacing between parallel pipes, S_p, is equal to the pipe diameter, D_p, to maintain consistent exposure to sunlight in the morning and evening.
- The enclosure must be tall enough to fully enclose the pipes (i.e., H_e must be slightly larger than the pipe diameter).
- The number of loops in the pipe may be adjusted.