ME 510 Fall 2001

HW #1

Due Tuesday Sept. 9th by 5:00 p.m.

1. Locate on the world wide web or from any other source, either; a high quality photograph illustrating a principle of compressible fluid mechanics, or a link to a web site with information and visualization of compressible flow phenomena (check the examples on the course web page). Email a copy of either the URL or the picture to Dr. Maynes prior to class on Wednesday 9/12. Go to the course web page and peruse the photographs and links listed there, you may choose to initiate your search there. (http://www.et.byu.edu/~maynesrd/classes/me510/me510.html)

2. Read chapter 2 in Saad.

3. A natural gas reservoir is to be suplied from a pipeline at a steady rate of w_1 lbm/hr. The fuel demand from the reservoir, w_2, varies approximately as follows with a 24 hour period:

$$w_2 = A + B\cos(\omega t)$$

where ωt is a dimensionless time measured from the time of peak demand (approximately 6 a.m.).

   a. Determine the maximum, minimum, and average values of w_2 for a 24 hour period in terms of A and B.
   b. Determine the required value of w_1 in terms of A and B so that the reservoir does not empty.
   c. Let the mass in the reservoir, $m=m_0$ at t=0 and determine m in the tank as a function of time in terms of m_0, A, and B.
   d. If A=5000 lbm/hr, B=2000 lbm/hr and ρ=0.044 lbm/ft^3 in the reservoir, determine the absolute minimum reservoir capacity in cubic feet to meet the demand without interruption. At what time of day must the reservoir be full to permit such operation?
   e. Determine the minimum reservoir capacity, in cubic feet, required to permit maintaining at least a three day reserve at all times.

4. In the manufacture of paper pulp the cellulose fibers of wood chips are freed from the lignin binder by heating in alkaline solutions under pressure in large cylindrical tanks called digesters (shown in Figure 1). At the end of the "cooking" period a small port in one end of the digester is opened and the slurry of wood softened wood chips is allowed to blow against an impact plate to complete breakup of the chips and separation of the fibers.

   a. Estimate the velocity of the discharging stream and the force on the impact plate for the conditions shown in the figure.
   b. How long will it take for the take to drain?

   Frictional effects inside the digester, and the small kinetic energy of the fluid inside of the tank may be neglected.

5. 2.5 in Saad

6. 2.8 in Saad

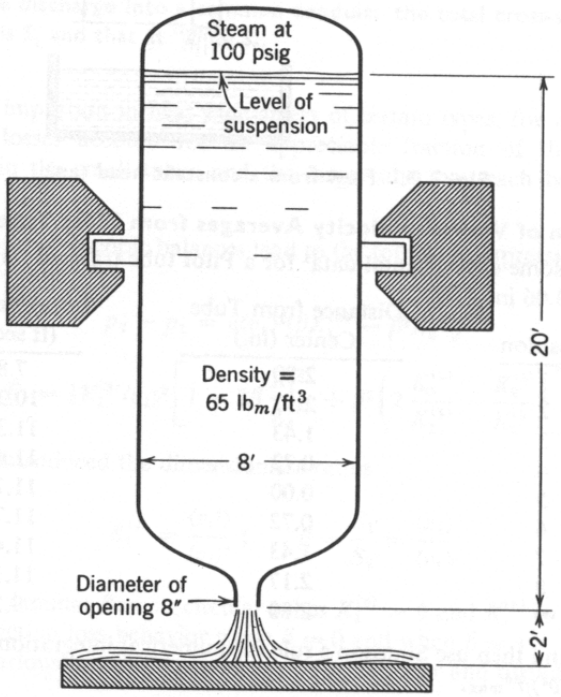

Figure 1. Schematic of digester for separation of cellulose fibers (problem 4).