Civil Engineering - Fluid Mechanics I
Design Project
Fall 2001

In this course, in addition to learning the basics of fluid hydrostatics and fluid motions through lectures, labs, and homework exercises, you will learn through hands-on fabrication and testing of a positive displacement pump.

Background

One type of positive displacement pump uses a piston moving in a cylinder to "push" fluid along a pipe. As the piston is drawn out of the cylinder, a region of low pressure is developed. Fluid is admitted into the cylinder through a one-way "check" valve. As the piston moves back in to the cylinder, the inlet check valve closes, and an outlet check valve opens, allowing fluid to escape the cylinder.

A schematic of a single-acting piston pump is shown in Figure 1.

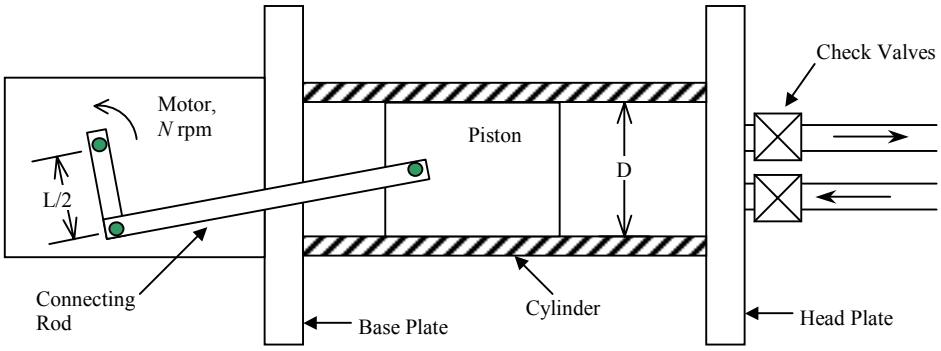

Figure 1: Horizontal single-acting piston pump (ref, Orlins & Constans, 2001)

A more complex pump moves fluid on both the in- and out-strokes of the piston, as shown in Figure 2.

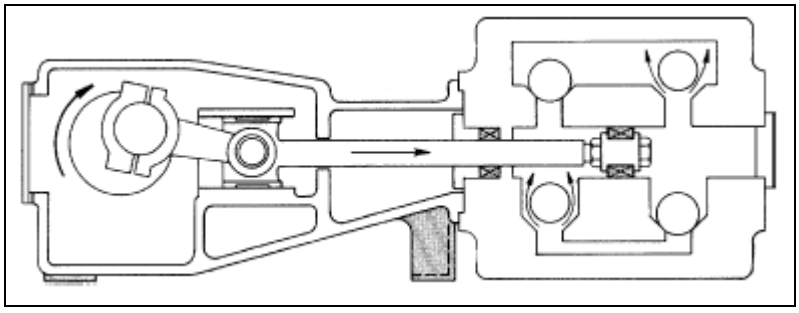

Figure 2: Horizontal double-acting piston pump. (ref: Hydraulic Institute, 2000)

Working with a group of your classmates, you will build (from scratch) a piston pump, using parts supplied to you. Your finished pump may look something like the one shown in Figure 3.

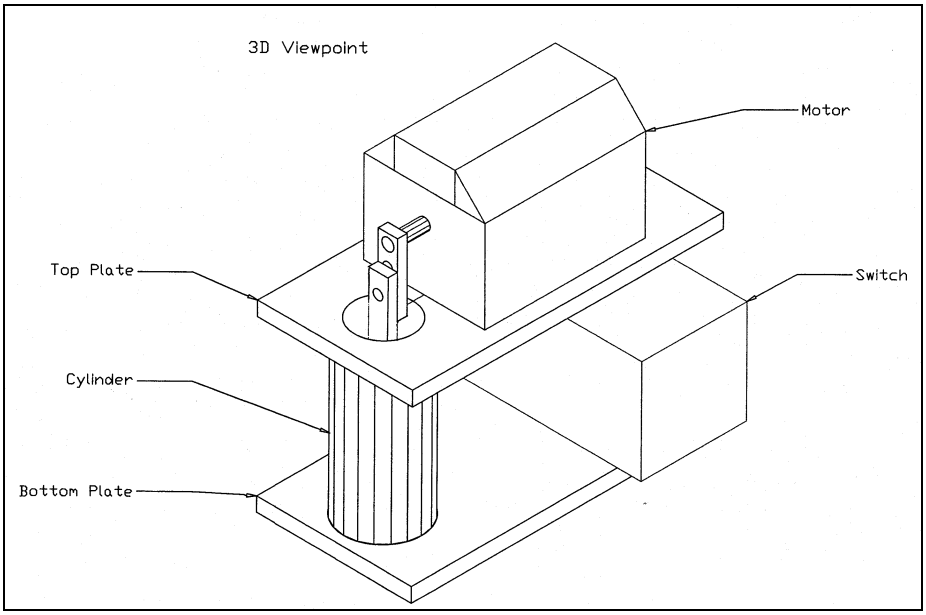

Figure 4: Schematic of completed pump (Orlins & Constans, 2001).

Educational Goals

In order to complete the positive displacement pump project successfully, you will need to understand and/or make use of the following topics and skills:

Fluid Mechanics
- (a) Introduction to turbomachinery
- (b) Control volumes, application of continuity
- (c) Head-discharge relationships for positive displacement pumps

Mechanical Design
- (d) Design of a linkage to perform a specific task

Prototyping Skills
- (e) Transfer of theoretical design into physical design
- (f) Fabrication of pump parts in the Rowan Machine Shop
- (g) Design testing / evaluation / improvement

Design Problem Statement

A positive displacement pump has a piston diameter of D, as shown schematically in Figure 1. The piston is attached to a slider-crank mechanism with a crank length of *L/2*. The total distance the piston moves in one direction is the "stroke length," *L*. The crank is attached to a variable speed motor, which rotates at speed N.

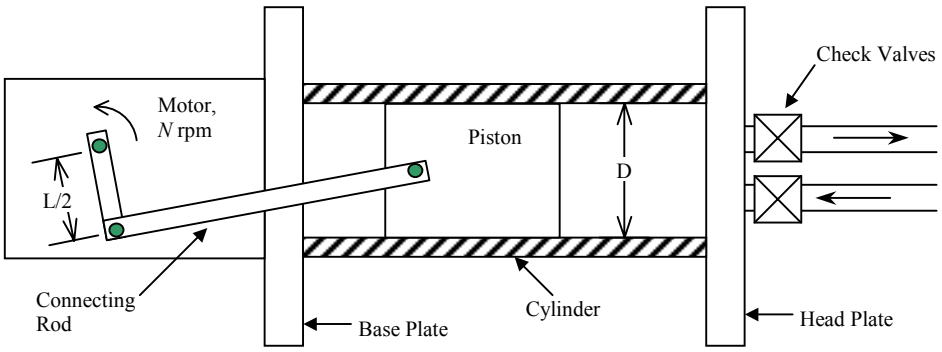

Figure 1 (repeated): Nomenclature and definition sketch for pump

1. Individual Exercise: **Due 27 September 2001**
    a. Calculate and plot the pump discharge as a function of cylinder diameter (D), piston stroke length (*L*), and motor speed (N). Use diameters of D = 0.5, 1.0, 1.5, and 2.0 inches; stroke lengths of 0.5, 1.0, and 1.5 inches; and motor speeds ranging from 0 to 200 rpm. Set up your plots showing discharge as a function of motor speed; this will result in a "family" of twelve curves for the different diameter / stroke combinations.

    b. Submit your nomination for a team of two other people to work with for the remainder of the project.

Group Project: (due 22 October 2001)

2. Design and build a positive displacement pump to provide 1 liter per minute of water.

3. Make engineering drawings of all the parts you made for your pump, including:
   a. Head plate
   b. Motor mounting plate
   c. Cylinder
   d. Piston
   e. Connecting rod
   f. Any additional parts you made

   Each drawing should include three views (orthographic projection) of the part and all dimensions. The drawings should be made on a computer. Make an assembly drawing, showing all the parts together. An example assembly drawing is shown in Figure 1.

4. Test your pump. Determine its maximum flow rate, Q_{max}, and maximum output head, H_{max}.

5. Complete a 1-page write-up of the pump project. Include a bill of materials needed to build a positive displacement pump (including fasteners). In the write-up, describe your design and characterize its performance. How would you improve your design?

Grading:

Your grade for this project will be counted as part of your laboratory grade. To receive a satisfactory grade for this project, you must:

a. Complete the individual homework assignment described above;
b. Participate actively in your group to design, build, test, revise, and document your pump;
c. Be prepared to answer any questions regarding the project that an instructor or interested individual might ask;
d. Provide both a self-evaluation and peer-evaluation.

References:

Hydraulic Institute, 2000. *Standards for Reciprocating and Power Pumps*.

Orlins, J.J., and Constans, E.W., 2001. "Hands-on Design and Manufacturing in an Undergraduate Fluid Mechanics Course," 2001 Annual ASEE Conference, Albuquerque, NM.