TO: Mechanical Engineering Staff
FROM: David R. Smith
DATE: 9 November 2020
RE: Next task (due on *Canvas* by 11:59 pm, 24 November 2020)

Based on your design of the impeller shaft, the team has implemented some of your recommendations, including elimination of the key from the pulley and reversing it on the shaft to reduce the moment at the retaining ring. Nice work! While the senior engineers are reviewing the details of your impeller shaft design, we have a new assignment for you. We prefer to have all of our PumpCo pedestal pumps driven from the same motor, but our impeller team has a new design that would be more efficient if it could be driven at 3000 RPM instead of the usual 1800 RPM. This means that for the same input shaft power, we could potentially pump even more water and drown out the competition!

The project manager has sketched a layout (Figure 1). The front and back **housing walls** provide support to both the **drive shaft** and the **impeller shaft** via sealed rolling element **bearings**. The impeller shaft also extends at the back end through a **seal plate** into the **pumping cavity**, where it is connected to the **impeller**. Axial motion of each shaft is resisted by use of **retaining rings** outside each bearing. At the front end, the drive shaft is driven by a **pulley**, which is driven by a belt (not shown). The drive shaft turns a **drive gear**, which meshes with a **driven gear** on the impeller shaft.

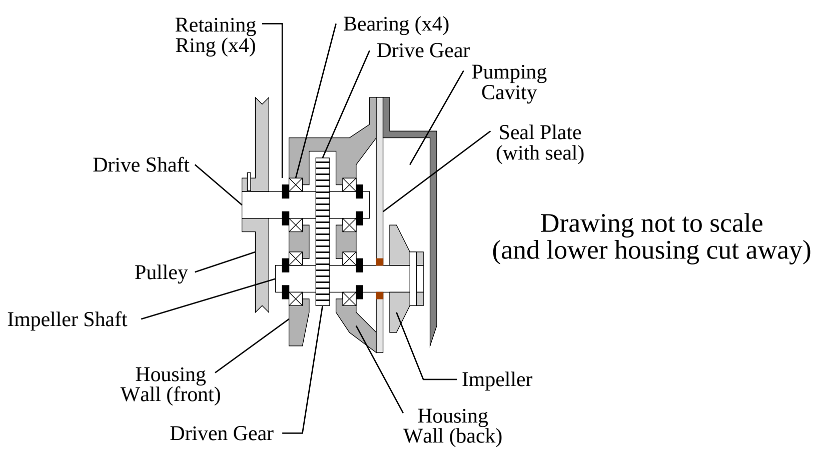

Figure 1: Geared Pump Layout

The dimensions and loading are shown in Figure 2 below. At the front end of the drive shaft, there is a pulley with an 8" pitch diameter, flipped around as recommended in your shaft design. As you reported from your design of the support system, the belt applies parallel vertical loads (y direction in the figure) of 150 N on one side of the pulley and 286.4 N on the other when pumping water at the rated power. The drive shaft turns a gear that meshes with another gear on the impeller shaft, spinning that shaft and the impeller. At the rear end of the impeller shaft, the impeller reacts an equal and opposite torque, as well as an axial load of 200 N, as shown.

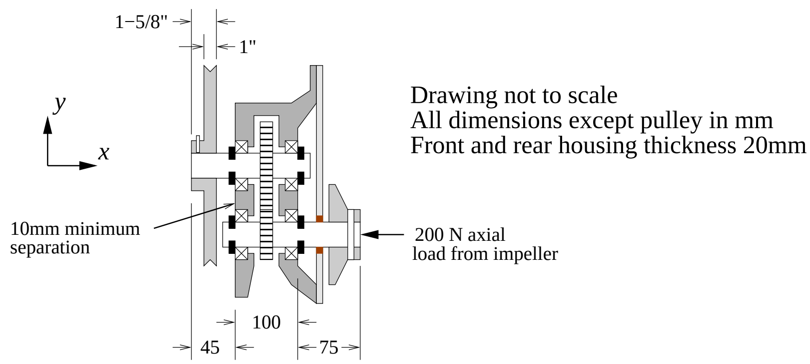

Figure 2: Dimensions

In this assignment, you must produce the **overall design layout** and perform the complete **design of the gears**. The specific requirements are given below. *As with DP2, you will also be required to type in summary data into a Canvas quiz.*

Assumptions and Requirements

Because this assignment is focused on gears, we'll skip many of the other details of shaft, bearing, and connection hardware design.

1. You may assume that we have found materials and suppliers for the shafts so that the drive shaft can be 5/8"–7/8" (15–22 mm if you choose metric gears) and that the impeller shaft can be 1/2"-3/4" (12–20 mm for metric gears). Your gear selections may allow any size in this range for the corresponding shaft.
2. You may also assume that the sealed ball bearings that match these shafts are sufficient for the loads.
3. The desired minimum factor of safety in the design of the gears is 1.5.
4. You must choose your gears from McMaster-Carr. They must be spur gears.

Design Assignment

1. Design the gear train kinematics, indicating the gear ratio as well as the number of teeth on each gear. You must leave room for the bearings in the housing walls, with a minimum of 10 mm between the outer diameters of any adjacent bearings.
2. Produce a layout view (front and side view), to scale, **representing the gears by only their pitch circles**. On your figure, include the following:
   a. The centerline distance between the shafts.
   b. The expected minimum distance between the outer diameters of the bearings.
   c. The total width of each gear, including any hub, along the axis of its corresponding shaft.

   Unlike the previous design problems, this is **not** a full technical drawing, just a front and side view of the figures above, but drawn to scale and with these layout dimensions shown.
3. On your layout, indicate how you would support and connect the gears. That is, where would you use any pins, keys, retaining rings, set screws, shoulders, etc.?

Design of the Final Drive Mesh

4. Determine the forces on the gear teeth (in all directions).
5. Determine the necessary face width for the gears. Justify your design, including the material properties used, the tooth bending stresses, and the surface contact stresses.
6. Provide the McMaster-Carr part numbers for the two gears you designed above.
7. Would you want to have these gears hardened? If not, why not? If so, what is the minimum hardness you would choose?

Last Minute Design Input

As you finish your design, another engineer asks why you didn't just replace the pulley on your original unit (as designed in DP2) with a smaller one.

8. Assuming that your original shaft design was sufficient for the 1800 RPM system, would this approach have worked? Justify your answer.