MECH 325
Assignment for Module #2:
Flex Drives

Report and Poster due at start of class on October 13, 2016

Scenario

The purpose of this assignment is to design a flexible drive train and bearing set for a candy polishing machine. The SugarCoater-1000 (see Figure 1) was modified by a plant engineer to break up clumps of jellybeans, creating the ClumpBuster-2000. To do this, the drum was outfitted with a newly-patented, movable, adaptive, inside paddle arrangement and a special inner surface finish, and its speed was increased from the nominal speed of 30 rpm to 120 rpm. Like the original machine, the ClumpBuster-2000 only runs in one direction.

After operating for 6 hours, the jellybeans have become separated, look smooth and shiny, and are then removed and packed in small bags, ready for shipment to dentists' offices worldwide. The 100 lbf, 24" diameter, 30" long drum gets a batch load of 50 lbf of jelly beans, which are initially clumped together; this causes a jolting load for about 2 hours. The load evens out after that and runs smoothly for an additional 2 hours. The plant only has on average 4 batches every day that must be separated with this special machine. The desired life of the retrofitted machine is at least 4 years. They expect to have figured out the cause of the clumping by then and can retire this machine.

The motor, not visible since it is inside the roughly trapezoidal-shaped compartment and near the floor, is a smooth-running DC motor. It has an output shaft parallel to the drum shaft and directly underneath it, i.e., they are both at an angle of approximately 30° from horizontal. Between the motor shaft and the drum shaft, there used to be a 40:1 reduction multi-stage gear box, tuned to the motor, which must now be replaced in the design by a flexible drive of some kind that delivers the desired output speed. The centre-to-centre distance between motor and output shafts have been increased, and the new design will accommodate separation distances from 10" to 30". The drum shaft bearings are also in need of redesign to accommodate the changed operating parameters.

The designer would like to improve the smoothness of operation of the drum, minimize the plant's ambient noise and provide easy maintenance at lower cost. Using gears is not an option. In addition, the drivetrain must be integrated with the bearings of the drum, which are also to be redesigned for higher loading the previous version. See Figure 2 for a schematic of the new design.

The metric used to evaluate the design is the total cost based on **component cost** (flexible drive) and **maintenance cost** (as described in the "Further Notes and Simplifications" section). Thus, the performance metric is:

Performance = Total Cost [US$]

Figure 1: Polishing Pan Tumbler

There is a 1.0 HP motor driving this unit. Start-up acceleration is not an issue, but large speed variations under load are undesirable. A 12″ long shaft is available to place bearings and drive components in the trapezoidal-compartment. The nominal shaft diameter is 1.5″ but it can be locally decreased if desired (to as small as 1″) in order to accommodate components.

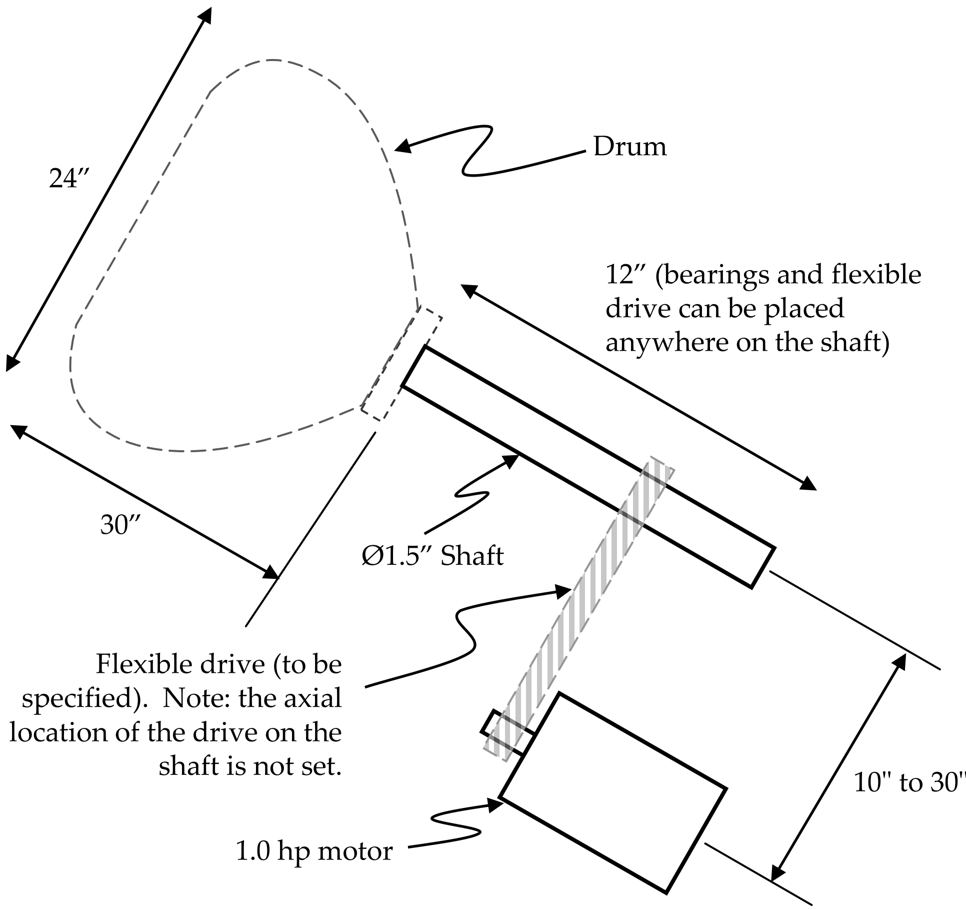

Figure 2: Tumbler Schematic

Operational factors:

- Overall safety factor of 2.5
- Operation is 16 hrs per day, 250 days per year

Further Notes and Simplifications

- For determining shaft reaction forces, assume that the load can be modeled as a point mass at the center of the drum (i.e. on the shaft axis, 27″ from the right-side end of the shaft). Assume imbalance and jolting are accounted for in a shock loading correction.
- Drive elements may be sized using steady-state speed, power, and service factor (do not worry about analyzing the load characteristics).
- You do not need to design or specify the bearings and/or bushings and their related mounting hardware. However, you need to consider their location in relation to the flexible drive system. You may assume that any components you specify will be appropriately mounted. Likewise, you do not need to account for the cost of the mounting hardware.
- You must supply a total cost for your design over its lifespan. The total cost includes the purchase price for all flexible drive components (belt, chain, pulley, sprocket, etc).
- If components need to be replaced during the lifespan, the replacement parts must be included in the parts cost along with $200 for each maintenance visit (to account for labour).

- To simplify the process, specify parts from the following catalogues and use prices in US$:
    - Gates or Goodyear (belts and roller chain)
    - Manhattan Supply Company: http://www1.mscdirect.com
    - McMaster-Carr: www.mcmaster.com
    - Reid Supply: www.reidsupply.com
    - W.W. Granger: http://www.grainger.com
- You may use pulleys and sprockets larger than those available in one of the above catalogues, assume a cost proportional to diameter, based on the cost of the largest pulley available of the type you are seeking.
- For roller chain, add the following additional costs (over the lifespan) for lubrication:
    - No cost for manual lubrication
    - $200 for drip feed lubrication
    - $400 for oil bath lubrication
    - $1200 for oil stream lubrication

Reporting Requirements

There are two required documents for this assignment: a report for formal marking (80% of mark) and a poster for class review (10%). Your notes from an in-class review discussion will be handed in and marked as well (10%).

Report

The team report will be handed in at the beginning of class on the due date. It will be convenient for you to have a copy of your report in class (either in hardcopy or on a laptop).

Your report shall consist of:

- A **title page** with the assignment number, your group number, and names and student numbers for all team members.
- A **summary** of your approach to the problem, your assumptions and methods, your final design, and the design and performance information requested below. Point-form writing, tables, and figures are all encouraged. **The summary must not exceed 2 pages and text should be computer-generated.**
- An **appendix** outlining your detailed calculations. The appendix can be hand-written or computer-generated and **must not exceed 10 pages**.

The report must contain the following design and performance information in the summary (supporting calculations must also be provided, either directly in the summary or in the appendix):

- a sketch and description of your chosen drive, including key specifications of the flexible drive (type, diameters, pitch, centre-to-centre distance, etc.) and bearing locations.
- Drivetrain life
- drivetrain component cost

When you hand in your report, please give the instructor a piece of paper with:

- **the parts cost**
- **the maintenance cost**

Then receive TWO blank evaluation sheets per team, and hang up your poster at the requested location.

Poster

Your poster should contain a sketch or drawing of your proposed solution along with a summary of key assumptions, values, and calculations. It should clearly specify:

- the parts cost
- the maintenance cost
- the total cost
- life of your design.

The poster is limited to 11″×17″ (you may tape two 8.5″×11″ sheets of paper together if you wish). **All poster text must be in 18 pt or larger font.** This is to limit your content to only the most important points, as well as to ensure others can read your poster from a distance.

After hanging the poster, you will have time to review all of the other teams' posters in a "gallery walk". During this time you will note down any errors, omissions, unrealistic assumptions, and so on that other teams have made. In addition, you should be looking for unsupported decisions other teams have made (e.g., specifying a particular critical dimension without explaining how that value was determined). Part of your mark on this assignment (10%) will depend on your critical analysis of other teams' designs as noted on the review sheets you submit at the end of the gallery walk.

Note: your mark on the poster is based primarily on *content*, not appearance or presentation (provided your poster is neat and legible). Likewise, your critique of other teams' work should be based on *their* content. In other words, rather than spending a great deal of time generating a "pretty" poster, you should focus on providing a clear description of your design with sufficient support and justification. It is perfect acceptable to neatly generate all drawings, sketches, and equations by hand.

A class discussion of the designs will follow the gallery showing.

Addendum

After reviewing other teams' designs, if your team feels that your report could be improved substantially due to oversights, you may submit a 1-page, 12-pt font addendum with clarifications and/or amplifications. This can be handed in as a hardcopy to the Mech Office (CEME 2054) or emailed as a PDF file but must be received by Prof. Mikkelsen within 24 hours of the end of the class. This is not intended as an opportunity for you to completely change your design. Any extra points gain in the addendum will be worth ½ of their value had they been provided in the original report.