MECH 325
Assignment for Module #2: Flex Drives and Bearings

Report and Poster Due at Start of Class on October 11, 2012

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-1000. 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 300 rpm.

Like the original machine, the ClumpBuster-1000 only runs clockwise. After operating for 5 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 40 lbf, 36" diameter, 24" long drum gets a batch load of 200 lbf of beans, which are initially clumped together; this causes a jolting load for about 2 hours. The load evens out after that and runs for an additional 3 hours. The plant only has on average two batches every day that clump and must be separated with this special machine. The desired life of the retrofitted machine is at least 10 years.

The motor, not visible since it is inside the triangular chassis and near the floor, has an output shaft parallel to the drum shaft and directly underneath it, i.e., they are both at an angle of approximately 60° from vertical. Between the motor shaft and the drum shaft, there used to be a 50:1 reduction multi-stage gear box, tuned to the motor, which must now be replaced in the design by a flexible or chain drive of some kind that delivers the desired output speed of 300 rpm. The drum shaft bearings are also in need of a redesign to accommodate the changed operating parameters. The centre-to-centre distance of the original shafts can be adjusted.

Figure 1: Polishing Pan Tumbler

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 rigidity than 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 bushings / bearings) and maintenance cost (as described in the "Further Notes and Simplifications" section). Thus, the performance metric is:

Performance = Total Cost [US$]

There is a 1 HP motor driving this unit. Start-up acceleration is not an issue, but speed variations under load are to be minimized. A 10″ long shaft is available to place bearings and drive components in the triangular chassis. The nominal shaft diameter is 1″ but it can be locally increased or decreased if desired.

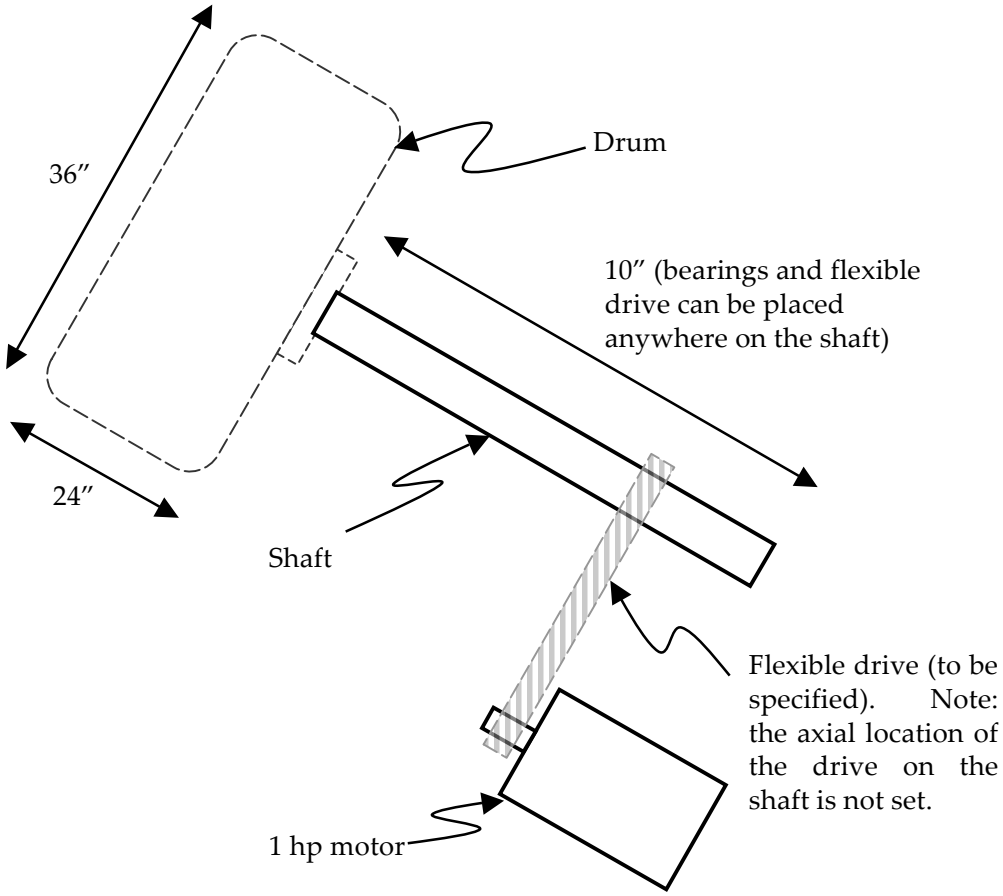

Figure 2: Tumbler Schematic

Operational factors:

- Medium shock loading at driven side
- Overall reliability of 0.95
- Overall design factor of at least 1.5
- Operation is 10 hrs per day, 300 days per year

Further Notes and Simplifications

- For determining shaft reaction forces, assume that the load can be modelled as a point mass at the centre of the drum; assume imbalance and jolting are accounted for in the shock loading correction
- Belts may be sized using speed, power, and service factor (do not worry about analyzing the load characteristics)
- You do not need to design or specify mounting hardware for bushings, bearings or flexible drives; 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 10-year life. The total cost includes the initial purchase price for all flexible drive components (belt, chain, pulley, sprocket, etc.) and bushing/bearing components. If components need to be replaced during the 10-year period

due to insufficient life, the replacement parts must be included in the "maintenance cost". In addition, add $100 for each component that must be removed in any maintenance operation (even if it is put back in operation as is). In other words, if a bearing must be temporarily removed from a shaft to replace a belt, that labour cost must be added as well.

- To simplify the process, specify parts from the following catalogues if possible (using SKF and Timken sites is also permitted) and use prices in US$:
  - Gates (belts and roller chain): pdf file on Vista
  - Manhattan Supply Company: http://www1.mscdirect.com
  - McMaster-Carr: www.mcmaster.com
  - Reid Supply: www.reidsupply.com
  - W.W. Grainger: http://www.grainger.com

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** providing your detailed, **final** calculations. Your calculations must be presented in equation form, with parameters suitably referenced. Matlab m-code and Excel spreadsheets are supplementary, but **not a substitute**. 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):

- drivetrain geometry (diameters, pitch, centre-to-centre distance, etc.)
- bearing geometry (catalogue number, types, sizes of bearings, spacing, inner and outer bore, etc.)
- drivetrain and bearing life
- drivetrain and bearing component cost (main components only)
- calculations of component life leading to incurred maintenance costs.

Poster

When you hand in your report, it will be time to display your poster in class for other teams to review.

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

- the total cost of your design,
- the total maintenance cost, and
- the overall, combined performance metric (see page 1).

Remember to bring your poster to class and do not be late!

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 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 it must be received by Dr. Van der Loos vdl@mech.ubc.ca 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.