MSE 3380
Mechanical Components Design for Mechatronic Systems

Design Project

Dept. of Mechanical & Materials Engineering	Instructor: Prof. Aaron Price
Faculty of Engineering	Interim Report Due: 5:00 PM on March 22nd
Western University	Final Report Due: 5:00 PM on April 5th

Your task: A tool manufacturer has commissioned your group of FOUR to aid in the design of the drive system for a new single-speed electric drill as shown in Fig. 1. This specialized tool will be marketed toward mining equipment operators for heavy-duty applications. In order to be competitive, a two-year warranty will be provided as part of the standard warranty package, which covers failure of the mechanical components.

1 Scope

This term your group will be responsible for the specification of:

1. Gear dimensions and materials
2. Shaft dimensions and materials
3. Bearings and seals
4. Connections of components to shafts (fits, keys, etc.)

The following considerations would normally also be important, but are outside of the scope of the project this term due to time constraints and are therefore **not required**:

5. Shaft deflection analysis at the location of bearings and gears
6. Determination of critical speeds
7. Fastener selection for assembly
8. Specification of interior housing dimensions

2 Performance Specification and Constraints

2.1 Motor Performance Specification

In order to control costs, the motor employed in the design has already been specified to a model currently manufactured in-house with the following characteristics:

1. Nominal operating voltage: **40 VDC**
2. Body length: 73.025 mm

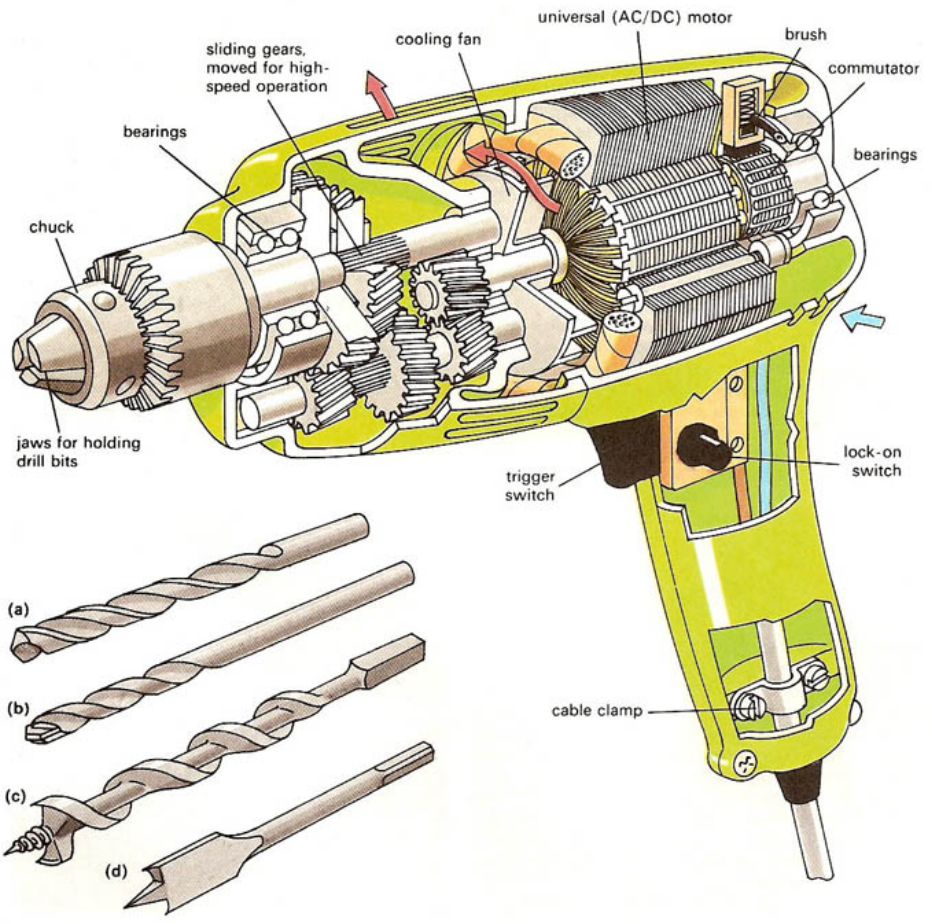

Figure 1: Mechanical components of a multiple (selectable) speed drill model. For this project, only a single-speed drill is desired. Source: David Darling

3. Overall length: 88.90 mm
4. Diameter: 46.831 mm
5. Mass: 443.67 g
6. Torque Constant: 8.474 N · mm/A
7. Voltage Constant: 1125 rpm/V
8. No-load current: 2.6 A
9. Armature resistance: 0.072 Ω

2.2 Design Constraints and Assumptions

1. Required drill output torque: 55 N · m
2. Required drill output speed: 575 rpm

3. Duty requirement: 8 hours a day, 5 days a week, for 50 weeks in the year
4. Based on your past experience, you can assume a gearing efficiency of 90%
5. The gearbox should be a two-stage reduction using spur gears and/or helical gears (an artificial constraint to keep the scope of your project tenable)
6. The input pinion of the gearbox will be integral to the rotor of the electric motor
7. **For this fictional system, we will neglect any limits on the current the battery is able to provide, and also assume that the associated heat generated is adequately dissipated by the cooling fan mounted on the rotor.**

3 Deliverables

This project consists of two phases and a design report is required at the end of each phase.

3.1 Phase 1 Report: Specifications, Initial Design

Due: 5:00 PM on March 22nd submitted as a PDF via OWL. The report must be prepared in accordance with the general instructions provided on the course website. **MAXIMUM 15 PAGES**, double- spaced with 12-pt font using Times New Roman typeface.
In this phase, your group will determine the performance specifications, specify the required gear ratios, determine the dimensions and materials of the gears and design an initial layout of the gearbox while considering how the gearbox will be assembled. In this phase, you are to complete stress calculations for the **GEARS ONLY**. Detailed shaft and bearing calculations will be performed in the next report.
In order to be cost-effective, your will prescribe standard gears available from an industrial supplier. For this project, we will select products from Boston Gear; the catalogue is provided on OWL. All calculations are to be submitted as a MATLAB file. We will evaluate your calculations using input values and checking the output. Each group will submit a report consisting of:

1. Determination of the performance specifications
2. Specification of gear ratios and reduction stages
3. Estimation of the torque within the shafts
4. The forces on the pinions and gears and their dimensions
5. Contact stress and contact safety factors for the gears
6. Bending stress and bending safety factors for the gears
7. 2D assembly drawing (scaled appropriately) of the entire general gearbox layout. In this assembly drawing, you should show your general shaft layouts with features (shoulders, keyways, etc.). The assembly drawing **MUST SHOW A CROSS-SECTION** of the assembly.
8. CAD model of the entire gearbox submitted as a zip file. Make sure you use *Pack and Go* to include all required parts in your submission (this will be submitted separately from your report).

3.2 Phase 2 Report: Final Design

Due: 5:00 PM on April 5th submitted via OWL. Report to be submitted as a PDF, the supplementary (SolidWorks and MATLAB) files should be submitted as a zip file. In this phase, your group will complete the design of the shafts, gear and bearing mounting connections, bearings and housing. A summary of the analysis from the Phase 1 report must also be included in this report since it may have evolved from the previous iteration. Calculations are to be submitted as a MATLAB file. The report consists of:

1. Summary of the analysis from the Phase 1 Report (indicate where updates were made)
2. Free body diagrams for shafts
3. Calculation of all torques and forces acting on shafts
4. Shear, moment and torque diagrams for shafts
5. Fully corrected endurance limit for shaft material
6. Fatigue safety factors for shafts (be sure to include stress concentration factors)
7. Bearing specification (manufacturer/model number) configuration and life calculation. Specify a recommended lubrication strategy.

Drawings of:

8. Assembly with parts (incl. shafts, gears, and housing, etc.) indicated and bill of material.
9. Fully dimensioned shaft and gear drawings (one drawing per part).
10. CAD model of entire gearbox submitted as a zip file. Use Pack and Go to include all required parts in your submission. (NOTE: this will be submitted separately from report).

The report must be prepared in accordance with the general instructions to be provided on the course website. **MAXIMUM 20 PAGES**, double-spaced with 12-pt font.

4 Questions and Clarifications

All questions regarding the project should be directed via email to Mr. Ben Holness (fholness@uwo.ca).