Widgets Perfected Inc.

Project 3320 Term B-2011

Professor Robert L. Norton

10/25/11

Our client (a Fortune 100 company) manufactures consumer products in very high quantities. These products are assembled on automated machines that run continuously at rates up to 10 assemblies per second. In addition to these high speeds, the product requires very high precision with tolerances of +/- 0.001 inch on most assembled parts.

The task assigned to us is to design one station of the assembly machine and ensure that it will both perform the assigned tasks and will last at least 20 years of 24 hour/day, 7 day/week (24/7) operation. The station assigned to us has the function of "stapling" the collection of parts together to complete the assembly. The stapling (clip) operation is accomplished by cam-driven tooling that places and crimps the staple (clip) around the parts. The crimp tooling and the cams already have been designed.

The tooling is carried on a 500-mm-dia dial of 16-mm-thick solid steel that weighs 239 N. There are 20 sets of tools mounted to the top surface of the dial, equispaced around its circumference on a 416-mm bolt circle. The combined tooling mass moment of inertia is 59.07 in-lb-sec^2. The dial is supported on a vertical shaft that is driven by a servomotor through a gear reduction unit. The shaft is supported in bearings attached to the machine's bed plate. The bed plate is 50-mm-thick steel and its top surface is 30 inches above the floor. The top surface of the dial is 40 inches above the floor. The actuating cams surround the dial shaft and are stationary. Each set of tooling has cam followers that ride along the cams and execute the programmed motions to feed and crimp the staples within the tooling assemblies. The attached figures show the general configuration of the assembly and the combined torque-time functions of the combined cams. The maximum pressure angles on the cams are 25.

What is required is a detailed design of a dial drive system that will rotate the dial assembly described above at up to a rate of 10 product cycles per second (30 rpm). Deflections at the tooling radius of dial cannot be greater than 0.001 inch in any direction. You will design the drive system for this station, consisting of the shaft, bearings, gear train, coupling, and mounting hardware including fasteners. Either plain or rolling element bearings may be used. The dial will be driven by a servomotor through a gear reduction unit of your design. For control system purposes it is desired that one revolution of the servomotor occur per product cycle. You must determine the power required to size the servomotor and also select a commercial coupling to connect the gearbox output to the shaft. Please ask the Chief Engineer for any information needed that is not included in this document.

Note that it is **required** that a computer be used to solve this problem and *TKSolver* is recommended for the stress and design calculations. A *TKSolver* file (Student.TK) is supplied on the book’s CD-ROM for use as a starter file. Please use it! Catalog information on motors, bearings, springs, etc. is available from the web.

We will attack this design project in six phases as defined below. Each phase will be allowed approximately one week of effort beginning in week 2 of the course but you are expected to start on this project IMMEDIATELY if not sooner! This will be a group project. Weekly design reviews and written progress reports are required from each group. You will arrange your own groups of 3 or 4 students. I need a list of your group members and the group name by the first Friday of the term. Anyone not in a group by that date must let the TA know and he will then put you in a group.

Five weekly progress reports will be required in a format defined in the P*rogress Report Specifications* handout supplied. A final *Project Report* will also be expected whose format will adhere to the separate *Project Report Specifications* handout supplied.

|  |  |  |
| --- | --- | --- |
| **Phase** | **Topics** | **Due** |
| 1 | Define the problem in detail. Sketch one or more design concepts. Understand and bound the problem. Calculate input torque and power. Define the coupling and servomotor requirements. | Friday 11/4 |
| 2 | Model the mechanism dynamically. Do further calculations to better estimate its kinetics, approximate forces, torques, power levels, etc. Determine the static stresses and deflections in the parts and estimate their static safety factors. | Friday 11/11 |
| 3 | Design the shaft and keys for fatigue loading. Determine the deflections and natural frequencies in torsion and bending. | Friday 11/18 |
| 4 | Design a reverted gearbox of 20:1 ratio and size it to transfer power from the motor to the dial. Determine its gear life in bending and surface fatigue. | Friday 12/2 |
| 5 | Design the motor mount for the system and recalculate the torsional natural frequency including its stiffness. Design and specify the coupling and bearings for the system | Friday 12/9 |
| 6 | Size and spec the socket capscrews to attach the dial to the shaft. | Friday 12/15 |
|  | Final Project report due. | Friday 12/15 |

Additional information will be provided as needed. Each weekly section meeting will include a design review in which I will go over your progress and give you feedback. Please come prepared.

