Widgets Perfected Inc.

Project 3320 Term C-98

Professor R. L. Norton

1/6/98

In line-shaft driven production machinery, torsional deflections and vibrations of the shaft due to the time-varying torque of the various cams can cause synchronization problems between the various stations on the machine. We need to design a testing machine that will measure the torsional vibration effects of dynamic torque loading on a camshaft. This machine will accommodate two cams, each of which will drive its own spring-loaded translating roller follower on a slider mechanism at speeds up to 300 rpm.

These cams will be designed to give approximately opposite torque-time functions to one another. They can then be used singly or in pairs to investigate the effectiveness of the addition to a production machine of a torque-balancing cam that drives a dummy load. The cams will be split (see sample cam) to allow removal and installation without disassembling the shaft. Program Dynacam can be used to design the two cams and obtain the dynamic torque loads and forces on shaft and followers. Data on the primary cam program is as follows: mod sine rise 1” in 50 deg, dwell for 40 deg, cycloidal fall 1” in 50 deg, dwell for 40 deg, 345 poly rise 1” in 50 deg, dwell for 40 deg, 4-5-6-7 poly fall 1” in 50 deg, dwell for remainder. The secondary cam will be a mirror image of the primary cam to approximately balance the torque.

The camshaft in this test fixture must be designed to have torsional deflections that are large enough to be measured by 5000-count-per-revolution, optical shaft encoders attached at each end of the camshaft, but not so large as to fatigue-fail the shaft. At the same time, we want the camshaft to be stiff in bending and have a bending natural frequency at least 10 times its torsional natural frequency to minimize any coupling effects between bending and torsional modes. Stated another way: what should the shaft diameter be to give sufficient torsional deflections to be measurable under the designed loading conditions, but not to create undesirable bending deflections or vibrations?

Plain bearings must be used to avoid vibrations that would come from rolling element bearings. The test machine will be driven by a speed-controlled PM DC motor through a gear reduction unit of your design. Motor selection is also your responsibility.

What is required is a detailed design of a camshaft torsional vibration test machine including the cams, keys, follower trains, camshaft, bearings, couplings, gearbox, frame, and mounting hardware. Infinite life is desired. The dynamic loads on the cam and follower will depend on the mass of the follower train and the spring constant Once an estimate of the moving mass is available from your preliminary design, program Dynacam can be used to quickly calculate the dynamic forces at the cam-follower interface. The stresses in the various parts of the assembly can then be estimated based on the level of dynamic forces present.

See Chapter 9 in the text *Design of Machinery*, for information on using program Dynacam. Examples in that chapter are similar to this problem. Other analysis can best be done using a program such as *TKSolver* or *MathCad*, or with a spreadsheet. 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. will be made available as needed.

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 oral 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 its name (mandatory) by Monday 1/12. Anyone not in a group by that date must let me know and I will 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.

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| **Phase** | **Topics** | **Due** |
| 1 | Define the problem in detail. Sketch a design concept. Understand and bound the problem. Design the cam profile. | Friday 1/16 |
| 2 | Design a cam-follower train. Model the mechanism dynamically. Do calculations to determine its kinematics and kinetics, approximate forces, torques, power levels, etc. Determine the stresses in the follower links and estimate their static safety factors. | Friday 1/23 |
| 3 | Design the camshaft, keys, and flywheel for fatigue loading. Determine its deflections and natural frequencies in torsion and bending. | Friday 1/30 |
| 4 | Design a gearset of suitable ratio and size to transfer power from the motor to the camshaft. Determine its fatugue life in bending and surface fatigue. | Friday 2/6 |
| 5 | Design a suitable follower spring for the cam and determine the surface stresses and lubrication condition of the cam-follower interface. | Friday 2/13 |
| 6 | Design and specify the bearings and fasteners for the system. | Friday 2/20 |
|  | Final Project report due. | Thursday 2/26 |

Additional information will be provided as the project proceeds. The first hour of each section meeting will include a design review in which groups will be randomly selected to go to the board and explain their designs. I will EXPECT you ALL to be PREPARED to discuss the project every week. The second hour of each section meeting will be a quiz.