Widgets Perfected Inc.

Project 3320 Term C-99

Professor R. L. Norton

1/14/99

Our client (a Fortune 100 company) manufactures consumer products in very high quantities. These products contain molded plastic parts and assemblies, some of which are made in “two-shot” injection molding machines. A two-shot part requires a rotating die and two sets of cavities per part in that die. The first portion of the finished part is molded of material A with the die in position 1. The die is then opened and rotated 180 degrees to position 2 with the molded part still in its cavity. The die closes again, placing portion I of the part against the second cavity. Material B is then injected into portion I, creating portion II of the part. The die opens again and the finished assembly is ejected. A sample part is provided for your examination.

Our task is to design the die-rotating mechanism to be fastened into the molding machine and to which any number of different dies can be bolted. The largest die to be accommodated is 910 mm high by 790 mm wide by 326 mm long along the axis of rotation. Assume this to be a block of solid steel. The die will bolt to a round turntable of your design that is driven by a servomotor to accomplish the required rotation. It must rotate 180 degrees in 0.8 sec. It will then remain stationary for a variable length of time (depending on the molding cycle of the part) after which it will again rotate 180 degrees in 0.8 sec. The cycle will then repeat. The molding machine will operate 24 hours a day, 7 days a week, 50 weeks a year. No failure of this mechanism is allowed for a period of at least 10 years.

When the die is hung on the turntable it must not deflect more than 0.001 inch (0.025 mm) in either the vertical or axial directions at any point on the die face. Vibrations of the die should be minimized on stopping to avoid delays in mold closing. The length of the assembly in the axial direction should be kept as short as is practical. The opening/closing motion of the die will be a maximum of 25 mm. A hydraulic cylinder will provide the axial motion. The last 1 mm of axial motion on die closing compresses an overtravel spring which reduces the impact at closing.

The rotation will be driven by a servomotor through a gear reduction unit of your design. Either plain or rolling element bearings may be used. Motor torque/power specification is also your responsibility as is specification of the size and power needed from the hydraulic cylinder to obtain the axial motion in the time specified.

What is required is a detailed design of a mold rotation machine including the turntable, shaft, keys, gear train, bearings, couplings, frame, and mounting hardware (fasteners). The dynamic will depend on the mass of the system. Once an estimate of the moving mass is available from your preliminary design, program Dynacam can be used to calculate the dynamic forces due to servomotor rotation. The stresses and deflections in the various parts of the assembly can then be estimated based on the level of dynamic forces present.

See Chapter 8 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 the group name (mandatory) by the first Monday of the term. Anyone not in a group by that date must let me know and I 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 power, torque, gear ratio, cycle life. Define all kinematics. Design the servo profile. | Friday 1/22 |
| 2 | Design a turntable and support system. 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 1/29 |
| 3 | Design the shaft and keys for fatigue loading. Determine its deflections and natural frequencies in torsion and bending. | Friday 2/5 |
| 4 | Design a gearset of suitable ratio and size to transfer power from the motor to the die. Determine its life in bending and surface fatigue. | Friday 2/12 |
| 5 | Design a suitable overtravel spring for the turntable’s axial motion. | Friday 2/19 |
| 6 | Design and specify the bearings and fasteners for the system. | Friday 2/26 |
|  | Final Project report due. | Thursday 3/4 |

Additional information will be provided as the project proceeds. 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.