ME363 PROJECT

Due: October 25, 2007

FACE MILLING PROCESS SIMULATION ASSIGNMENT

As a manufacturing engineer working for a major automotive company you are responsible for developing efficient process plans for producing automotive components. Your present task is to develop a process plan for an automotive engine block made of Aluminum that requires a face milling operation. The initial dimension of the cast workpieces is 18 inch long and 6 inch wide. You are going to use a face milling process to remove a total of 0.10 inches in depth of cut to create the final size and surface finish required for these engine blocks. The cutting tool available for the operation is 8 inches in diameter with uncoated carbide inserts**(CARBIDE(K68-L))**. The geometry of the face mill cutter is as follows: 6 teeth, 15 lead angle, -2 degree radial rake angle, and 5 degree axial rake angle. The spindle speed is fixed at 600 rpm. Your goal is to minimize the number of steps, i.e., the number of stations in the transfer line, to generate the final dimension without incurring any chatter. Each station would cost about $600,000 and an operating cost of $40/hour. The depth of cut for the final finishing pass should not be less than 0.030 inches or greater than 0.060 inches with the feed of 0.003 inch/tooth to maintain good surface quality.

Use the Integrated Dynamic Machining Simulation (IDMS) program (follow instructions on the next page) to determine the minimum number of tool passes required to produce the step feature within the required tolerance and without **breaking the cutting tool.** Assume that only the feed per tooth and axial depth of cut can be varied to achieve the above objectives. For productivity reasons the lowest allowable feed rate per pass of the cutting tool is 0.003 inch feed per tooth while the upper limit is governed by the strength of the cutting tool (0.010 inches/tooth). For the finishing cut, the feed and depth of cut were chosen to be 0.003 inch/tooth and 0.030 inches, respectively. The feed per tooth and the axial depth of cut for each roughing pass should be selected so as to maximize the material removal rate (or minimize the machining time).

The followings are the spindle and workpiece modal parameter data obtained from the system.

	Spindle X-direction	Spindle Y-direction	Workpiece X-direction	Workpiece Y-direction
Modal Mass (lbs)	0.38	0.36	0.037	0.098
Damping Ratio	0.08	0.0460	0.0260	0.0394
Modal Stiffness (lb/in)	4700000	4600000	37000	1560000
Modal Angle (degree)	34.2	19.1	-9.8	2.6

Note: On the onset of chatter, system does not become totally unstable due to the process non-linearity. Instead, you will see a sudden jump in the vibration amplitude as illustrated below. Below the chatter limit, the cutting force will increase proportional to the depth of cut. You can set the chatter limit when you first see the sudden jump with increasing axial depth of cut.

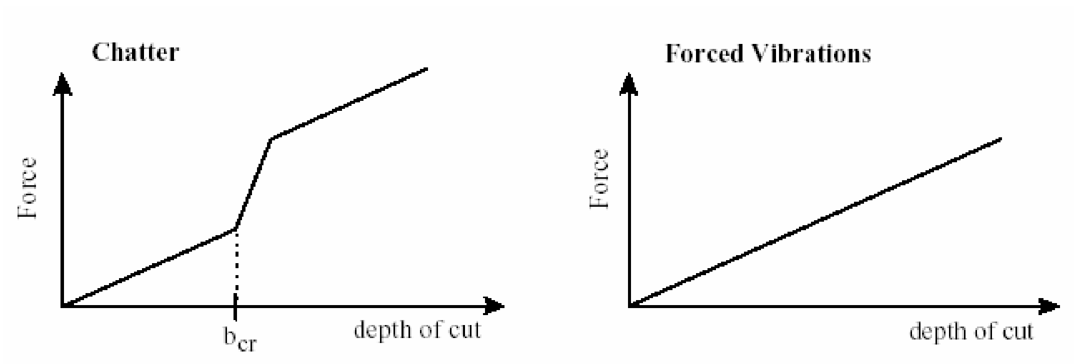
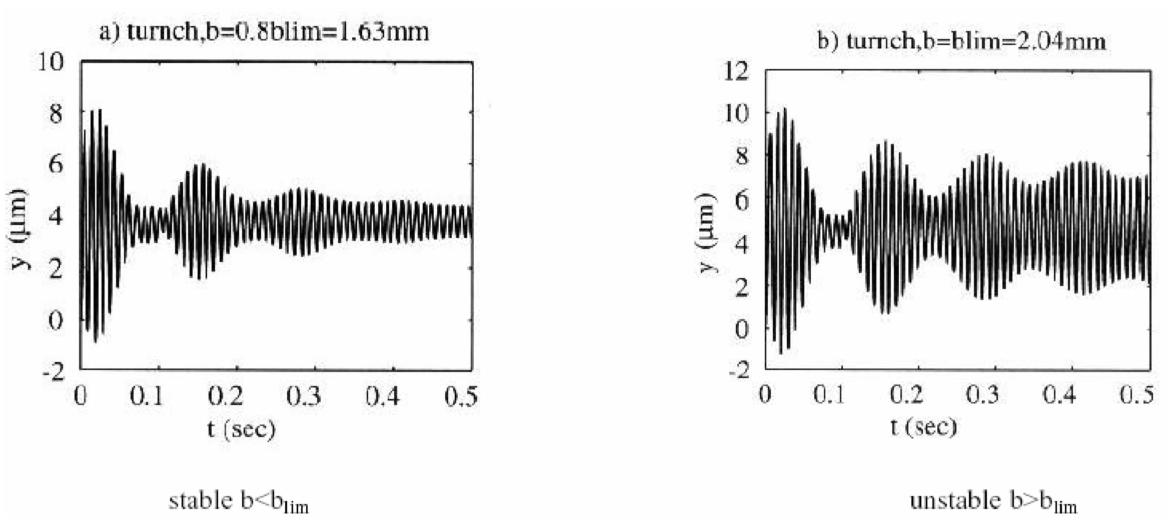


Figure 1: Comparison of force trends between chatter and forced vibrations.

Vibration patterns for both stable and unstable cases are shown below for illustration purpose.



Steps to Access the IDMS Program

- Access any of the four DELL computers installed in the Intelligent Manufacturing Lab (Room #36) and use your "login ID" and appropriate password to get access to these computers.Use *Windows Explorer* to get to the sub-directory "projects" *D:\ME363\projects*

- Double click on the *SpinGUI.exe* icon in the sub-directory "projects" to load the machining simulation software.

- Click on the “Face Milling” button on the side tool-bar to select facemilling process.

- The sub-directory "projects\facemill" also houses an input file "defaultm.in" which can be *browsed* and *loaded* into the input window. You can then change the different input parameters in this window to appropriate values given on the first page of this handout and *save as* a different file name. Use the various output options to get suitable results for your report.

  Use the values shown below for each of the following options:

  Simulation Option:
  Calculation Methods - Instantaneous, Angular Increments – 1° (100x0.01°), Total number of revolution to be simulated – 5, revolutions to be skipped before displaying - 2
  Machine Setup Data,
  Start angle of cut – 41.4°, End Angle of cut – 138.6°
  Cutter data,
  Enter pertinent data, Insert Material – Carbide (K68-L)
  Runout data,
  Set the values to zero
  Cutter and Workpiece Modal Data,
  Enter the given data

- Select “OK” to save the modified parameters and close the input window.

- Click on “Run” option on the top menu bar to open the run window.

- Select “Single case” and click “Run” button to run the simulation. When the message window of “Simulation Run Success” pop up, click “OK” to show the output plot. The text output files have the extension .fx.dat, .fx.dat and .fx.dat for force in x, y and z directions respectively. Similarly, the vibration data files of spindle and workpiece have the extension sx.dat, sy.dat, sz.dat, and wx.dat. wy.dat, wz.dat respectively.

- We can also choose the “multiple case” option and select a range of cutting conditions for simulation. Only peak-to-peak value of the force will be displayed. The output file has the extension .pp, in which the first two columns are spindle speed and depth of cut, the third to fifth columns are peak-to-peak forces, the sixth to eighth and ninth to eleventh columns are peak-to-peak vibrations of spindle and workpiece respectively.

- If you are unable to access the program send me an email message at shin@ecn.purdue.edu.

WHAT YOU NEED TO SUBMIT

- **A two page (maximum) typed report**. Attach all relevant plots for each milling pass you determine necessary to machine the feature. Divide the report into the following sections: Problem Statement (in your own words), Solution Procedure, Results and Discussion, Conclusions. Attach a table listing the machining passes determined by you with the corresponding feed per tooth and radial depth of cut values. And also, include the estimated machining times for cases you considered.

- It is very likely that each one of you will arrive at a different result. **So make sure that you turn in your own work and show how you arrived at the conclusion**. You are however encouraged to discuss the problem among yourselves.

- Also include a short write-up (on a separate page) on whether this simulation exercise helped you to better understand and appreciate the material on machining processes. You can also include any suggestions/comments about the exercise itself.