ME 584 – Computer Control of Manufacturing Systems

ASSIGNMENT #5

Winter 2000 (due April 10)

Download the Matlab based Lathe simulator. To download to a Unix machine at UM, go to the directory you want to put the simulator in and type `{cp -r ~kevinma/Public/LatheSim .}`. Make sure to include the period (.). The folders and files may also be accessed from `/afs/engin.umich.edu/u/k/e/kevinma/Public/LatheSim`. Make sure to maintain the folder hierarchy and that the files are in the correct folder.

Question 1
For a turning operation, if the part has a diameter of 30 mm, the depth–of–cut is 4 mm, and the spindle speed is a constant 2000 rpm, what is the cutting speed in m/min? If the maximum spindle power is 12 hp, what is the maximum allowable cutting force in Newtons?

A modified Taylor’s tool life model is

\[ Vf^mT^n = C \]  

where \( V \) is cutting speed in m/min, \( f \) is feed in mm/rev, \( T \) is tool life in hr, \( m = 1.4 \), \( n = 0.16 \), and \( C = 235 \). For the cutting speed calculated above and a minimum tool life of 8 hr, what is the maximum allowable feed (\( f_{\text{max}} \))?

You are given the part shown in Figure 1.1. In the simulator, give the initial tool position as \( X = 7 \) mm and \( Z = 5 \) mm. Load the part program GCODE1.m and run the simulation without the force controller. You may need to adjust the simulation time. Next, run the simulation with the force controller. Set the upper limit of the feed command to 1 mm/rev (your answer from above should be close to this value) and the lower limit to 0 mm/rev. Use an integral gain of \( K_i = 5 \) (mm/s)/(Ns) and a reference cutting force of 3500 N (your answer from above should be close to this value). Discuss the differences between the two simulations. Explain why the force reference is not tracked when \( d = d_1 \) and when \( d = d_3 \). How would you change the controller to produce the desired performance when \( d = d_1 \)? Can you change the controller to produce the desired performance when \( d = d_3 \)? Explain why or why not.
Question 2
In the simulator, include noise in the force measurement, make the radial force stiffness (acting in the X direction) 50000 N/mm. Give the initial tool position as X = 11 mm and Z = 0 mm and set the radial force process gain equal to the cutting force process gain. For the part shown in Figure 2.1, determine the reference radial force and design an integral controller to regulate the force process with a fast response but no overshoot (you may select the closed-loop time constant). Use the part program GCODE2.m to simulate the system. Zoom in your plot to show if the requirement is met. Change the simulation time if necessary.

Spindle speed is sometimes varied sinusoidally to reject chatter. Use a spindle speed trajectory of \( N_s = 2000 + 1500\sin(10t) \) rpm in the simulator for the problem above. How are the cutting force response and part surface affected? What can you do to compensate for or reject this effect?