Assignments for questions:

**Assignments**

**Assignment #4**

**Winter 2000 (due March 27)**

**Question 1**

Using the data of the turning operation you obtained in Laboratory 1, construct two sets of models for the cutting and thrust pressures. In the first set, the pressures will be constant. In the second set, the pressures will be nonlinear functions of the process variables with the form $P = Kf^\alpha d^\beta V^\gamma$. Only use the data during the first four passes. Note the lead angle is 90° and you may ignore the cutting tool corner radius effects. Compare the models to the experimental data and discuss your results.

**Question 2**

Determine the analytical expressions for the limiting depth–of–cut and corresponding spindle speeds as a function of the chatter frequency for a turning operation. Assume the part is much more rigid than the cutting tool and the feed force is given by

$$F(t) = Pd\left[f_{nom} + z(t) - z(t - T)\right]$$  \hspace{1cm} (2.1)

and the cutting tool structural dynamics are one dimensional (feed direction) and given by

$$\frac{z(s)}{F(s)} = \frac{\omega_n^2/k}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$  \hspace{1cm} (2.2)

where $F$ is the feed force (kN), $P$ is the component of the thrust pressure in the feed direction (kN/mm), $d$ is the depth–of–cut (mm), $f_{nom}$ is the nominal feed (mm), $z$ is the cutting tool structural displacement (mm), $\omega_n$ is the cutting tool structural natural frequency (rad/s), $\zeta$ is the cutting tool structural damping ratio, and $k$ is the cutting tool structural stiffness (kN/mm).

**Question 3**

Develop a simulation of the force process $(F_{lon}, F_{tan}, F_{rad})$ for the turning operation that includes the cutting tool structural vibrations in the feed direction and the nonlinearity of the cutting tool leaving the part. Use the constant pressure models developed in question 1 and assume the cutting tool structure parameters are $\omega_n = 750$ Hz, $\zeta = 0.05$, and $k = 15$ kN/mm. The inputs are the nominal feed, depth–of–cut, and spindle speed. Use the results of question 2 to plot the stability lobe diagram for spindle speeds between 2000 and 3000 rpm. Make sure to label the stability lobe number. Use the simulations to determine the limiting depth–of–cut for a spindle speed of 2900 rpm. Use a nominal feed of 0.1 mm. Plot this point on the stability lobe diagram. Plot $F_{lon}$, $F_{tan}$, and $z$ for depths–of–cut just below and just above the limiting depth–of–cut. Again, use a nominal feed of 0.1 mm. Discuss your results. Why do the structural vibrations appear in $F_{tan}$ when this force component is orthogonal to the direction of structural vibrations?