Lab 9

Spinning machinery comprises an important category of mechanical systems. Often these systems are composed of shafts that rotate at high speed and attached to these shafts are disk-shaped objects. It is important that such machines operate at frequencies that are well separated from the natural frequencies of the shafts, the disks, as well as the shaft-disk system.

In this lab you will look at a simplified system that consists of a single disk attached to a rigid shaft. The disk has a radius of 300 mm and a thickness of 15 mm. It is attached to a spinning shaft of radius 20 mm.

1. Assume that the disk is made of AISI 4340 steel and compute the 6 lowest natural frequencies of the disk. In your report, indicate how you have assured yourself that the your estimate for the frequencies is accurate.

   (a) Examine the mode shapes associated with these natural frequencies of vibration. It can be helpful to add deformation to the plot to better visualize the shapes and to contour different components (or combinations of components) of the displacement vector. Why are the first vibrational frequencies essentially equal to each other? Why are the 4th and 5th vibrational frequencies essentially equal to each other?

   (b) Describe the vibrational mode associated to the 6th natural frequency.

2. Suppose one wishes to push the first vibrational frequency above 200 Hz. If the geometry is to be held fixed, then the only other design variable available to you is the choice of material. Find a material that achieves this goal.

   (a) Looking at the materials that you have tried, if you plot the first vibrational frequencies versus the axial wave velocity $\sqrt{E/\rho}$ what do you observe?

3. Find the vibrational mode shape closest to 10 kHz. Is the mesh you used to compute the 1st mode of vibration suitable for this higher mode of vibration? Explain.