THE AXES OF THE INTERFERENCE DIAGRAM

By William Sullivan

Since it's introduction in the mid 1970's, the interference diagram has become the preferred tool for displaying the interactions of rotor blade natural frequencies with periodic flowpath excitations for bladed disks with shrouds or tie-wires (typical of both compressor impellers and steam turbine stages). A typical interference diagram is shown in Figure 1. In our last two newsletters, we discussed aliasing and nodal diameters. In this newsletter, we will describe the axes.

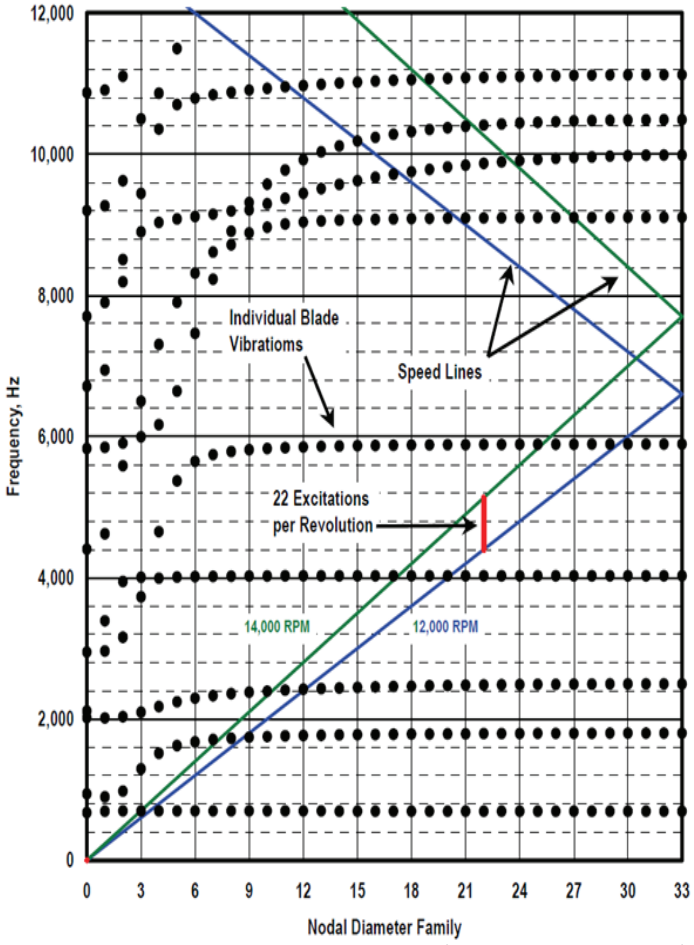

Figure 1: Bladed Disk Interference Diagram (66 Blades with Shrouds)

The X-axis, (abscissa) contains the nodal diameter families. Nodal diameter families are modes where the blades have the same number of circumferential nodes. Figure 2 shows simplified representations of three bladed disks with continuous shrouds. The blades on the disk on the left are being excited in the first fixed-fixed tangential mode. The blades on the next two disks are being excited in the second fixed-fixed tangential mode. All of these modes belong to the three nodal diameter family. The nodal diameter families on an interference diagram refer to the number of circumferential nodes of the blades but not necessarily the disk. The number of nodal diameters of the disk may be different, particularly at higher nodal diameters, where there may be very little disk participation in the blade modes at all.

For bladed disks with blades grouped into shrouded packets, counting the circumferential nodes (or locations of maximum deflection) can be difficult. For modal analyses, performed with a finite element analysis program for example, the nodal diameter families typically are determined by conducting a Fourier analysis on the blade deflected shapes.

The Y-Axis (ordinate) contains the frequencies. There are at least three sets of frequencies required for an interference diagram. One is the natural frequency of all of the blades for all of the modes of interest. Another is the rotational frequency of the rotor. Since rotor speeds are generally given in revolutions per minute (rpm) and frequencies in cycles per second (cps or Hz), the rotor frequency on an interference diagram is:

$$f = \frac{N * ND}{60}$$

Where:

f = Frequency, Hz

N = Rotor Speed, rpm

ND = Nodal Diameters

The third set of frequencies that must appear on the interference diagram is the frequencies related to the number of periodic excitations, which most typically are the upstream vanes (or nozzles). After all, without a source of excitation there is no interference and, therefore, no need for an interference diagram.

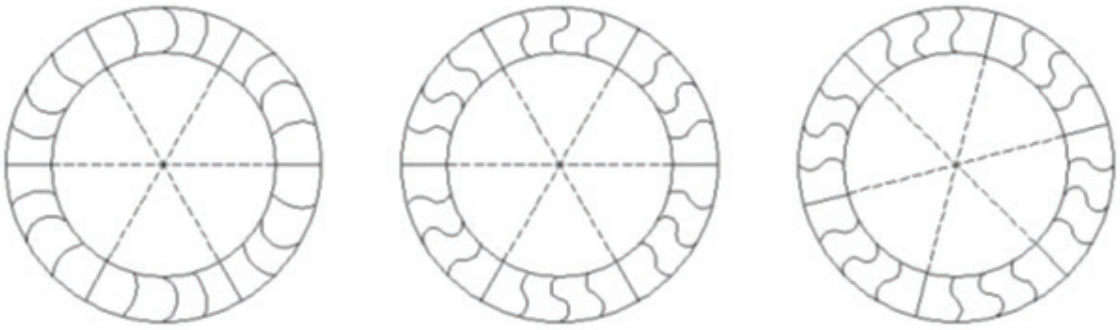

Figure 2: Simplified Representations of Three Bladed Disks with Continous Shrouds

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