LOCATING EXCITATIONS ON THE INTERFERENCE DIAGRAM

By William Sullivan

In this article we will describe how possible sources of excitation are located on the interference diagram. The discussion will be limited to evenly spaced disturbances located along a path concentric to the circular path of the blades around the rotor axis. Most typically, the excitation sources are upstream vanes, but downstream vanes and other structures such as upstream struts, could be sources of excitation as well.

To illustrate, we will start with an impeller with 12 blades that will be operating at 7,200 rpm. A source of excitation consisting of 4 evenly spaced struts will be plotted on an interference diagram (Figure 1). Then, sources of excitation consisting of 10 and 15 vanes will be added to the diagram.

Figure 1: Interference Diagram Impeller with 12 Blades

As mentioned in earlier installments of this series, nodal diameters from 0 to ½ the number of blades are plotted along the X Axis of the interference diagram. The subject impeller has 12 blades. Therefore, 0 to 6 nodal diameters have been plotted on the diagram. Since the 4 struts are less than ½ the number of blades, the nodal diameter for the struts are plotted where the speed line crosses the 4 nodal diameter ordinate.

The 10 nodal diameter excitation will be located using the "reflection" phenomenon described in the first installment of this series. The sixth nodal diameter position is at the extreme right of the diagram. The seventh nodal diameter is just to the left, on the 5 nodal diameter position as indicated on the X Axis.

Therefore, a 10 nodal diameter excitation is plotted 4 nodal diameters from the right of the diagram, at the 2 nodal diameter position as indicated by the X Axis.

The 15 nodal diameter excitation is more than the number of impeller blades but less than 1 ½ times the number of blades. It is located on the speed line at the 3 nodal diameter position (15 – 12 = 3). This procedure continues for higher excitations.

The frequency of an excitation for any rotor speed can be found using the following relationship:

$$F = \frac{E * N}{60}$$

E = Excitation Order (The Number of Excitations per 1 revolution of the Rotor)
N = Rotor Speed, rpm
F = Excitation Frequency, Hz

This relationship can be useful for determining frequency separation margins, etc. The interference lines in Figure 1, for example, were plotted with +/- 5 % margins on frequency (which is the same as +/- 5 % margins on rotor speed).
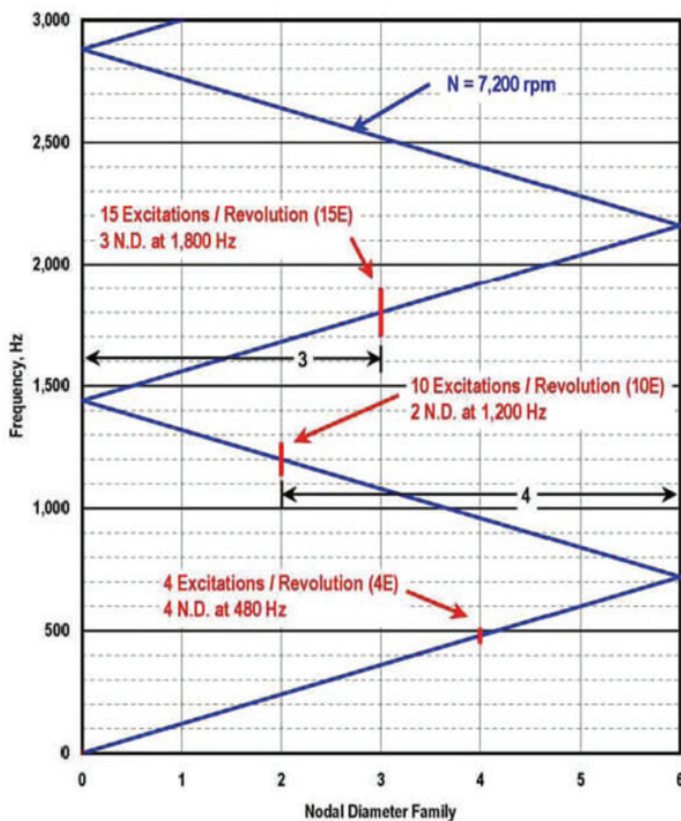
Rotors with odd numbers of blades are handled similarly except that the right side reflection is at a ½ blade position. Remember that at the 0 nodal diameter position at the extreme left of the interference diagram, the excitations always are whole number multiples of the number of blades. Figures 2 and 3 have been included to help visualize the excitation positions. Figure 2 is Figure 1 with no excitations plotted. Figure 3 is a diagram for an odd number of blades (specifically 13).
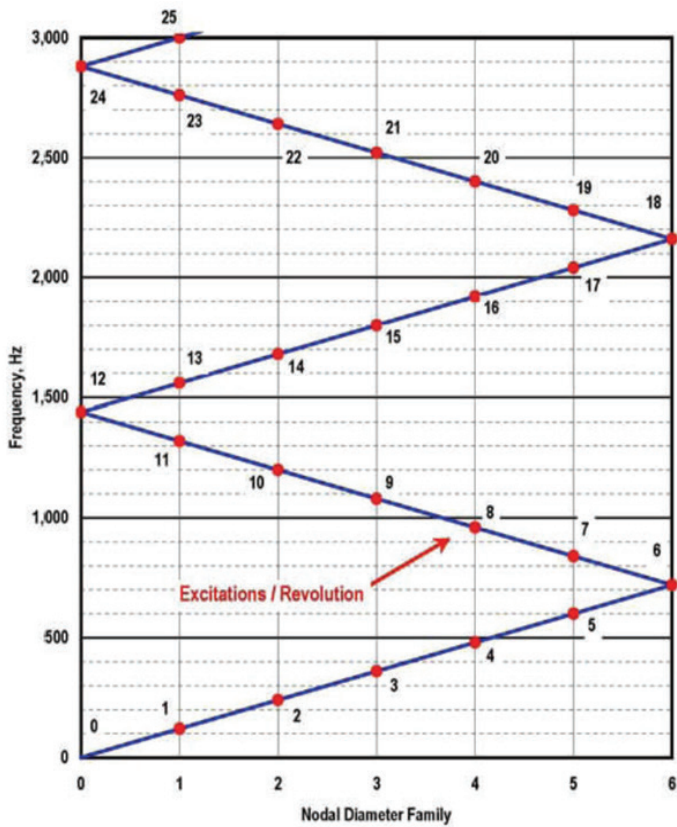

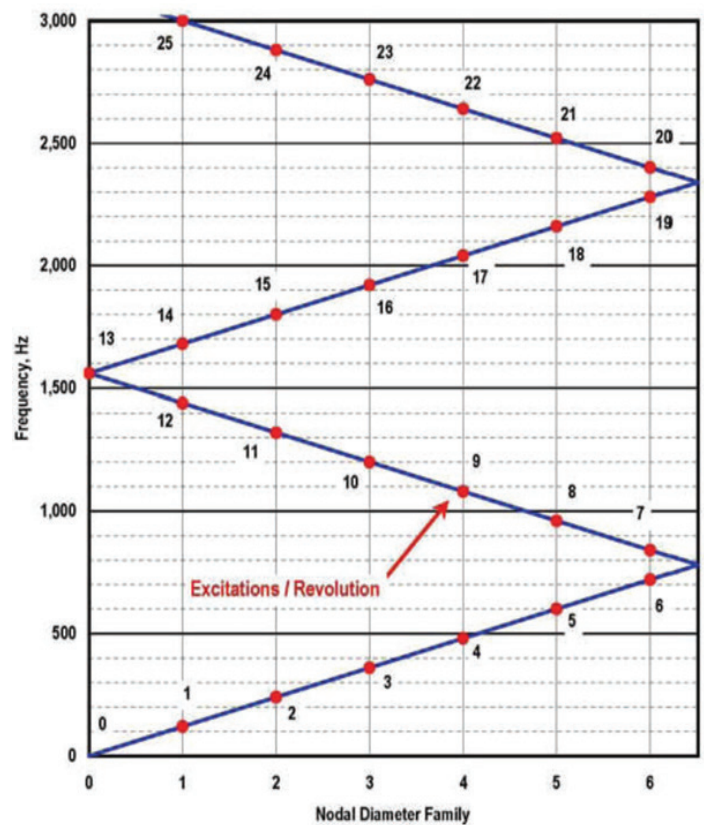Figure 2: Interference Diagram Impeller with 12 Blades

Figure 3: Interference Diagram Impeller with 13 Blades

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