IDENTIFYING INTERFERENCES ON THE INTERFERENCE DIAGRAM

By William Sullivan, PE

In this installment of articles on the interference diagram we will see how interferences are identified. To do this we will look at a situation that often arises as part of a turbomachinery re-rate.

Figure 1 is an interference diagram for a steam turbine stage with 51 blades. The "reflection" line on the right side of the diagram is 51 / 2 = 25.5 nodal diameters. The minimum speed of 5,535 rpm "reflects" at 5,535 * 25.5 / 60 = 2,352 Hz. The maximum speed of 6,565 rpm reflects at 2,790 Hz. There are 5% separation margins included with the speed lines (one just below the minimum speed and one just above the maximum speed). This turbine stage has 32 vanes just upstream of the rotating blades.

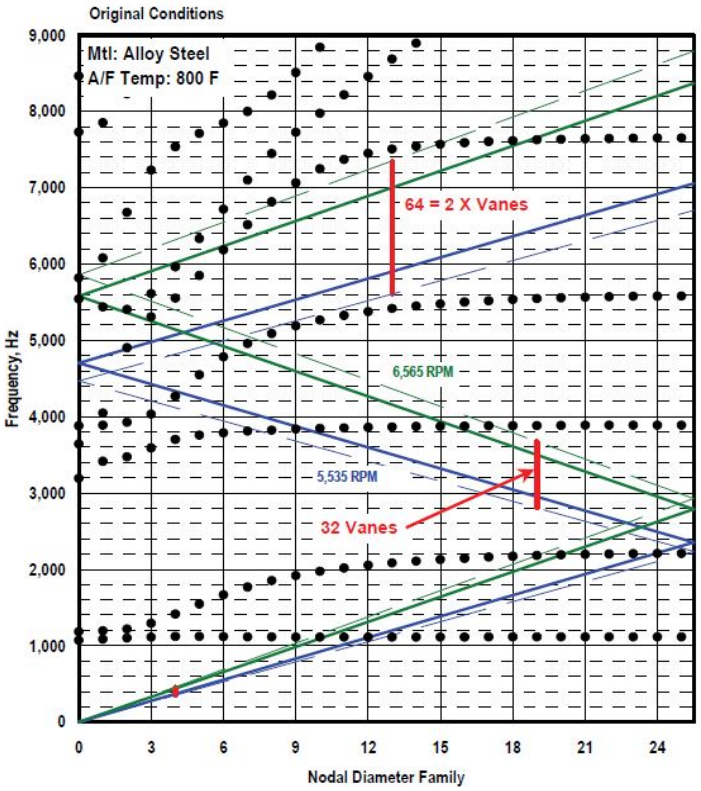

Figure 1: Steam Turbine Bladed Disk (51 Blades) Interference Diagram

First we locate the 32 vanes at 19 nodal diameters. We then place a vertical line on the diagram at 19 nodal diameters extending from the minimum speed margin line to the maximum speed margin line. We do the same for twice the number of vanes.

There are no interferences on the "Original Condition" interference diagram (Figure 1).

The rerate consisted of increasing the airfoil height and increasing the inlet temperature to increase the power output of the turbine. The combination of increasing the airfoil length and increasing the airfoil temperature caused the disk and blade natural frequencies to decrease. Figure 2 is the interference diagram for the rerate conditions. There now are two interferences,

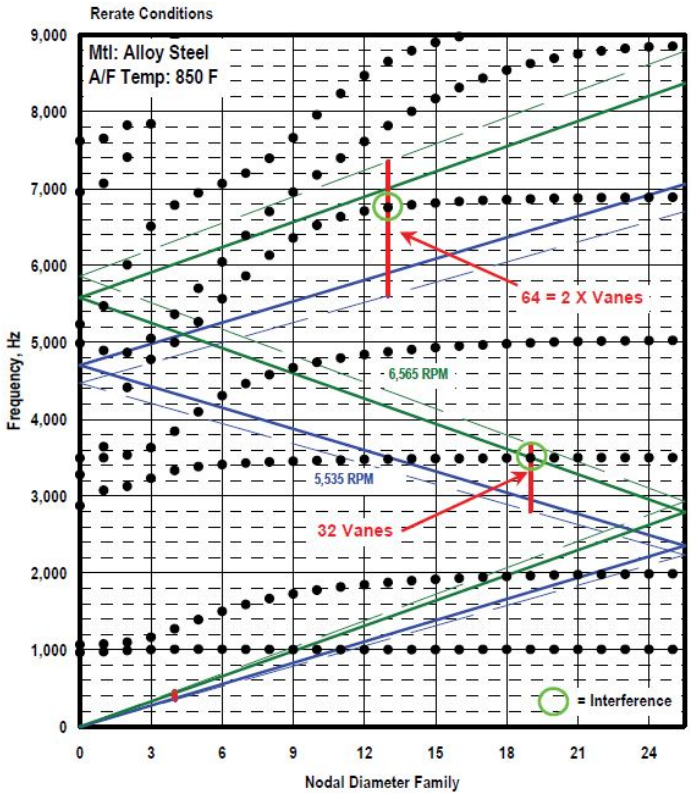

Figure 2: Steam Turbine Bladed Disk (51 Blades) Interference Diagram

highlighted on the diagram by bright green circles. One interference is the third blade mode at 19 nodal diameters with the 32 vanes. The other interference is

the fifth blade mode at 13 nodal diameters with 2 X the vanes.

Generally, we want to avoid interferences on lower order blade modes, particularly the first two bending modes and the first torsional mode. Therefore, to eliminate the interference with the third mode, we will reduce the vane count to 30. The interference diagram with 30 vanes is shown in Figure 3. The interference with the third blade mode is eliminated but there is still an interference with the fifth mode at 9 nodal diameters and twice the number of vanes.

Higher order modes are more difficult to excite than lower order modes and the stimulus at twice the vane frequency is substantially less than the stimulus at the vane frequency. There is also evidence from the position of the ninth nodal diameter point of the fifth mode that there is limited blade movement (more about that in the next newsletter). Therefore, the remaining interference probably poses little risk to the reliability of the turbine and the changes required to remove the interference would most likely compromise the performance of the turbine.

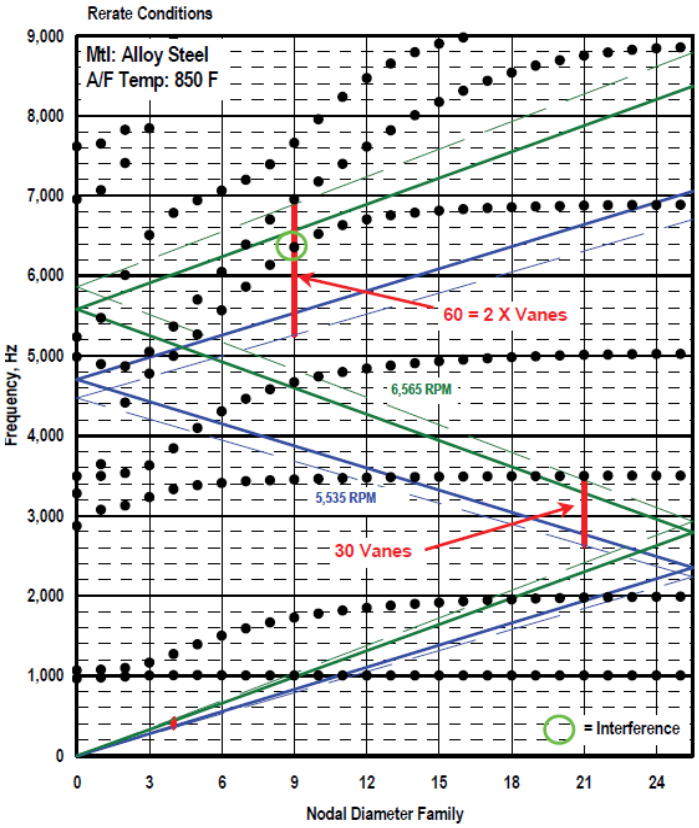

Figure 3: Steam Turbine Bladed Disk (51 Blades) Interference Diagram

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