Bearing Wear Example #2 – Inner Race Fault

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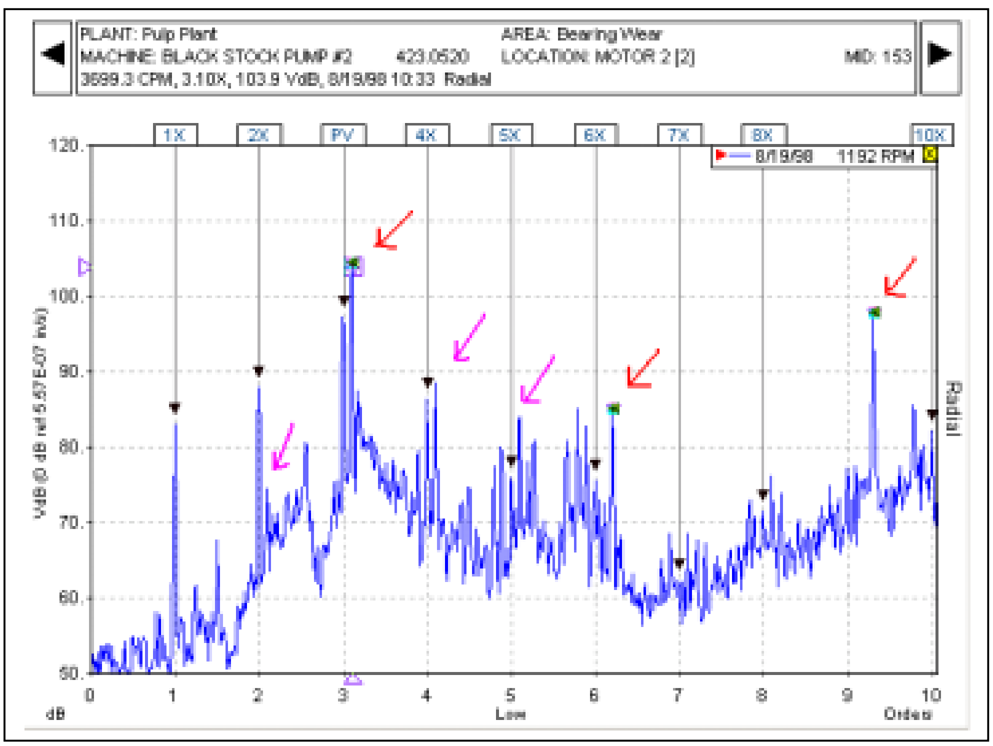
Introduction

This aim of this short paper is to point out and explain the evidence of a bearing problem in an AC motor. Both demodulated and spectral data will be used, and brief explanations will be given as to how to interpret the data. It should be noted that the analysis can and will be done without the need to know the make and model number of the bearing in question.

Motor End Spectral Data

In figure 1 below, the X-axis of the graph is labeled in "orders" where "1" corresponds to 1 times the motor shaft rate. The vertical axis is in velocity decibels or VdB. Units of VdB are utilized for this example because they allow relatively small signals to appear along side relatively large signals in the same graph. This is especially important when trying to diagnose bearing problems, as the vibration generated by a fault in a bearing may be quite small in comparison to the vibration generated by the shaft. In linear units of in/s or mm/s, these bearing tones are often lost in the noise floor. A change in amplitude of 6 VdB is a doubling of amplitude in the linear scale.



(Figure 1, Motor Spectral Data – Low Range)

The first item to note when discussing bearing tones is that they frequently appear at frequencies between 3 and 12 times the shaft rate. This is the reason we are looking at a “Low Range” graph with a frequency range of 0 to 10x the shaft rate. The second item to note is that bearing tones rarely show up as integer multiples of the shaft rate. This is to say that they may show up at 4.6x, 7.2x, 5.8x etc. but rarely at exactly 3x, 4x or 5x. Therefore, after determining the shaft rate peak (marked “1x”) and its multiples or harmonics (marked 2x, 3x, 4x), we look for peaks that are not multiples of the shaft rate. These peaks are termed “Non synchronous” and may be bearing tones.

The peak marked with the red arrow, towards the left hand side of the graph is at a frequency of 3.1x and is therefore a good candidate for a bearing tone. The other two peaks marked with red arrows are at 6.2x and 9.3x. These are harmonics (multiples) of the tone at 3.1x.

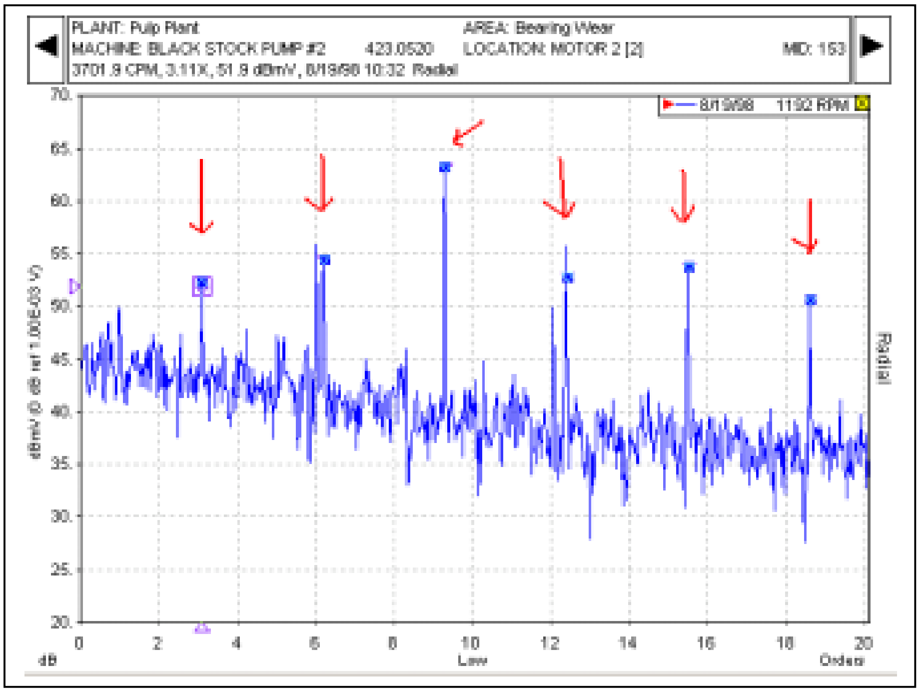
Note now the peaks marked with purple arrows. These peaks are at 2.1x, 4.1x and 5.1x. These peaks are called “1X Sidebands” and are common in bearings. These peaks are caused by an effect termed “amplitude modulation”. Basically, if one has a fault on the inner race of the bearing, this fault rotates in and out of the load zone, and balls hitting the fault hit it harder in the load zone and softer out of the load zone. To complete 1 cycle of this increase and decrease, the shaft need turn 1 revolution, and it is this cycle time that determines the distance between the sidebands. This is why they are separated by a distance of 1X on either side of the tone at 3.1x.

Because we have this pattern of sidebands, we can be certain that the peak at 3.1x is in fact a bearing tone and not vibration arriving from another source. This is because an external vibration could not cause this modulation effect and the corresponding 1x sidebands. This is also one reason why we didn’t need to know the make or model of the bearing in order to confidently detect a bearing problem.

Demodulation

Another tool we could use to confirm that the peak at 3.1x is in fact a bearing tone (although at this time we need no further evidence) is high frequency demodulated data. The demodulation or enveloping technique is quite good at filtering out machine noise and zooming in on the little clicks made by a ball passing a fault on a race. Because demodulation is discussed in detail in a variety of other papers available from DLI Engineering, I will simply note that if we see the same peak at 3.1x in the demodulated data, that we saw in the spectrum, we can conclude without a doubt that this is a bearing problem.

Figure 2 below shows the demodulated spectrum from the motor end of the machine. The peaks marked with arrows are 3.1x and its harmonics. Note that the shaft related peaks (1x, 2x, 3x etc.) are filtered out of the demodulated spectrum and only the bearing tones remain.



(Figure 2 – Motor End - Demodulated Spectrum)

Conclusion

In diagnosing a bearing problem in this motor, we first began by identifying the motor shaft rate peak and its harmonics (1x, 2x, 3x etc.). Then we looked for peaks that were *not* multiples of shaft rate in the general region between 3 and 12x. Here we found a peak at 3.1x and noted that it had harmonics at 6.2x and 9.3x. At this point we were fairly certain that these peaks were bearing tones, however, when we noticed additional peaks on either side of the 3.1x peak spaced 1x apart, we were sure that not only did we have a bearing tone, but that we had an inner race fault. The peaks spaced at 1x on either side of the bearing tone are called sidebands and are caused by amplitude modulation as the inner race travels into and out of the load zone. The fact that this pattern could not arise from outside the machine allowed us to rule out external vibration as an explanation for the peak at 3.1x and its harmonics. Finally, we confirmed our diagnosis even further by looking in the demodulated data, where we found the same peak at 3.1x and its harmonics.