Bearing Failure Detection on an Air Compressor

CASE HISTORY

This sample is from a two stage compressor at an aluminum smelter, as shown in figure 1. The analysis of this machine can be quite complicated, due to the large number of fault frequencies that could be generated. All of the bearings have their fault frequencies, and even though there are only two different types of bearings in use, they all run at different speeds, thus generating different frequencies.

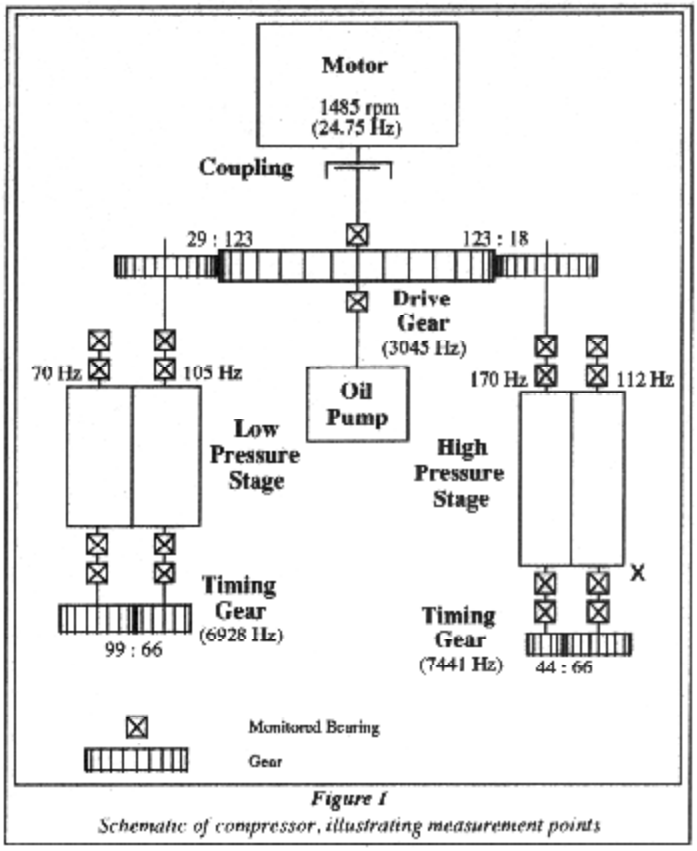

Figure 1
Schematic of compressor, illustrating measurement points

There is a drive gear and timing gears, and the oil pump is also driven off a series of gears (not shown). The two stages of the compressor, the high pressure (HP) and low pressure (LP) sections, also generate frequencies at their running speeds. If there is a rub between the elements, they will generate harmonics (peaks at multiples of a speed) at the running speed of the element with the dominant rub. Due to the design of the structure, many of the frequencies can be detected from all around the structure.

This machine is actually tested at three frequency ranges. The first measurement is from 0 to 1,000 Hz and is shown in figure 2. This will cover all the running speeds of all the elements and the motor. It will highlight any harmonics of the running speeds and it will show the fundamental of the bearing fault frequencies, denoted by fundamental train (FT), ball spin (BS), ball pass inner race (BPI) and ball pass outer race (BPO). This measurement, however, is not enough. It does not cover the gear meshing frequencies (3045 Hz,

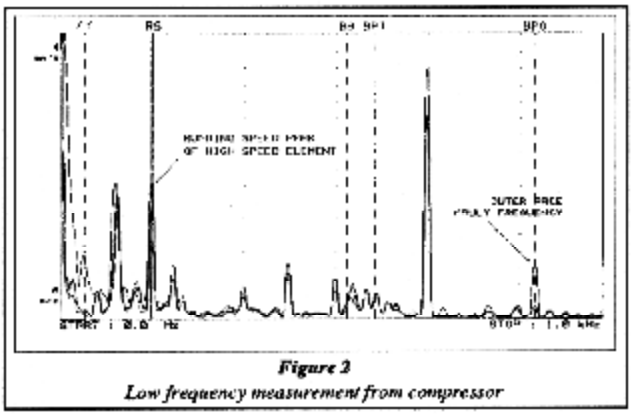

Figure 2
Low frequency measurement from compressor

6928 Hz and 7441 Hz) and it will not show the harmonics of the higher frequency ball bearing faults (BPI and BPO).

This is important, as often the actual calculated fault frequency does not show a change. For example, it may coincide with other frequencies. However, harmonics are generated, which means a higher frequency must be investigated. So a measurement from 1 to 11 kHz is taken, shown in figure 3.

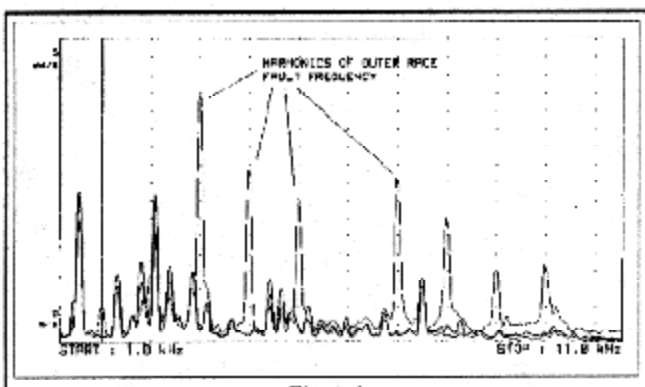

Figure 3
High frequency measurement from compressor

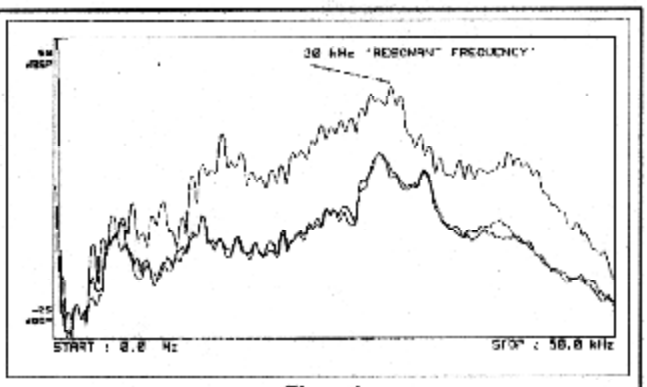

Figure 4
Shock pulse spectrum from compressor

The manufacturer of this compressor suggested that shock pulse measurements be taken. Shock pulse measurements basically look at the bearing resonance frequency at around 30 kHz. A measurement is also taken from 0 to 50 kHz, shown in figure 4, using the shock pulse transducer which is structurally tuned to this frequency. This allows an accurate look at exactly what is changing at this frequency.

Figures 2, 3 and 4 are measurements taken on the 28th of March, 2nd of May and 28th of June from position X, as shown in figure 1, across the three frequency ranges. Figure 2 shows the running speed peaks of the two elements of the compressor, with harmonics of both frequencies, as well as a significant component at 100 Hz (twice line frequency).

The dominant change indicated is that of the BPO bearing fault frequency. Figure 3 clearly shows the harmonics of the BPO frequency. There is no doubt as to the nature of the fault. Figure 4 also shows a significant change in the spectrum at the shock pulse frequency.

You will also notice that there is a change in the levels of the harmonics of the running speed, 170 Hz. It is suggested that as the bearing began to wear, the clearances began to change, causing a slight rub between the two HP elements, in turn causing harmonics. It is also suggested that the change in tolerances would cause looseness between the bearing and the shaft, resulting in the high level of harmonics.
It would be a simple task to extract trends highlighting the changes at any of these discrete frequencies, and of the change in any of the harmonic or sideband series. This capability would further help to identify changes when the fault is not as well developed as that shown in this example. As mentioned previously, cepstrum analysis and demodulation would have also been useful in this example, as firstly it was necessary to extract the bearing fault frequencies from the dominant running speed peaks, and there are a large number of harmonics generated from various sources.

In this case, the problem was solved, and after investigation by the compressor manufacturer, it was confirmed that there was an outer race fault.