Guidance - Detecting Rolling Contact Fatigue

Types of Rolling Contact Fatigue

The standard pitting type failure in gears is MICRO-PITTING. This is surface propagated pitting at a MICRO scale and occurs under mixed lubrication regimes, in other words, under regimes where the surface asperities come into contact. The hint is in the word MICRO. This produces very small pits in the surface, in some cases limited to a slight greying of the surface. MICRO-PITTING is very hard to detect with a vibration sensor, as the small surface pits may not generate significant or measureable vibration.

MACRO-PITTING is sub-surface, pressure generated, pitting, which occurs in rolling contacts operating under full elasto-hydrodynamic separation, in other words, the surfaces are separated by a lubricant film that is so thick that there is no contact between the surface asperities. MACRO-PITTING starts with sub-surface cracks, which grow to the point where a large chunk of the surface detaches; the clue is in the name: MACRO. If a large chunk of material comes out of the surface, this will generate significant vibration and usually an extremely loud noise; you'll hear it in the building next door! For obvious reasons, you can detect MACRO-PITTING with a vibration sensor or microphone.

If you want an analogy, think of MICRO-PITTING as a slightly worn road surface and MACRO-PITTING as a road with deep potholes!

Vibration Sensor

We do not use an accelerometer for detecting MACRO-PITTING as the formation of pits results in a very rapid (almost step) change in vibration level, hence there is simply a requirement to sense a large change in vibration (or noise) level, in order to shut down the machine. With this rapid transition, there is no meaningful value that can be attributed to the measurement, in other words, the requirement is to sense a change in vibration, not to measure the actual level of vibration, as would be the case with a more progressive form of failure.

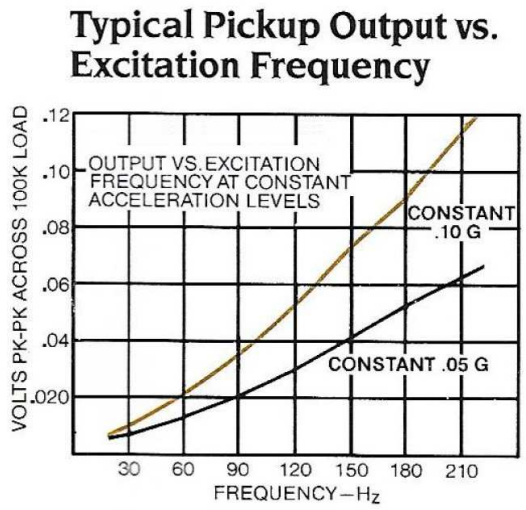
Our preferred solution is to use a low cost piezo ceramic "buzzer", which is a surface mount speaker/microphone of a type typically used in PCs and similar devices. Unlike a coil and magnet type speaker/microphone, the buzzer is a very stiff piezo device, with no moving parts, providing a very high frequency response.

The sensor is used in conjunction with an adjustable gain vibration cut-out circuit, the sensitivity of which is adjusted once the test has started, thus providing a trigger level. A subsequent increase in machine vibrations will trip the circuit and stop the drive motor.

The cost of the sensor is approximately £0.50 (2017) making it an extremely cost effective solution. In comparison, a piezoelectric accelerometer from Kistler, with associated charge amplifier, costs about £4,500.00.

If we were to buy an expensive piezo accelerometer, we would end up throwing away most of the apparently enhanced functionality, because with our specific application, we are only interested in a change in the magnitude of the input signal, not the absolute measurement of the vibration level. In other words, we have no interest in frequency analysis of the measured vibration signal, as would be the case if monitoring a large and complicated piece of machinery, with multiple different bearings, with different signatures; we are simply interested in setting a detection level that will stop the test, with the vibration generated by a single machine element.

Details of the piezo buzzer response are as follows:



All data taken at 25°C. unless otherwise specified.