The basics of motor circuit analysis

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Quite a bit of confusion exists on the subject of motor circuit analysis. The confusion is centered on two issues:

1. The very name of the technology.
2. What this technology is capable of.

This article will focus on alleviating that confusion with a discussion of the technology's capabilities and its proper name.

One of the biggest reasons why confusion exists about the very name of this testing methodology is the prevalent use of three-letter acronyms (TLAs) in the condition monitoring industry. We have TLAs for everything: CBM (condition-based monitoring), PdM (predictive maintenance), RCA (root cause analysis), FFT (Fast Fourier Transform), etc., etc.

It is the pervasiveness of TLAs that has created this confusion around motor circuit analysis. MCA can mean two different things. Motor circuit analysis (MCA) is often and easily confused with motor current analysis (MCA), which is an abbreviated version of motor current signature analysis (MCSA). This is a common mistake and one that has contributed to the confusion surrounding the second common mistake. For the balance of this article, the term motor circuit analysis will be referred to as MCA.

The second common mistake lies in the confusion around the capabilities of this technology for condition monitoring and testing. For those who have mistakenly associated MCA with motor current signature analysis, the belief is that the only type of testing performed is on the motor current. While a portion of this is correct, current analysis is just a part of the total testing barrage that is collectively known as MCA. There is a second group of people that believe MCA only pertains to measuring the motor circuit's resistance-to-ground characteristics. This belief also reflects an incomplete understanding of the spectrum of tests covered under MCA. While MCA does incorporate these aforementioned testing techniques, it also includes much more.

Before we go any further, let us clarify the ultimate goal of MCA. The goal of MCA is to ascertain the health of the motor. This assessment is accomplished through the detection of electrical imbalances in the motor and the detection of insulation degradation. The unbalances create stray, circulating currents through the motor. These circulating currents create excessive heat and lead to accelerated insulation degradation, inefficient operation and ineffective control techniques (in some motor types). Insulation degradation leads to shortened motor life and can lead to unsafe operating conditions.

To begin, let us break up MCA into two major categories. The first category is online testing, named because the tests are conducted while the motor is operating under normal conditions. The second category is offline testing; tests are conducted while the motor is de-energized.

MCA online can be further split into two categories - current analysis and voltage analysis. Current analysis is primarily focused on the rotating components. Loose or broken rotor bars, cracked end rings, rotor eccentricity, misalignment and coupling/belt problems are some of the "big-hitter" failure modes detected in the current signature. Power quality issues like harmful harmonics, voltage imbalances and under/over-voltages are among the issues

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identified with voltage analysis.

MCA offline is most famous for the resistance-to-ground measurement. But other measurements make motor circuit defects easy to find. Measuring electrical characteristics like impedance, inductance and capacitance tell the analyst plenty about the condition of the windings. Inductance is a great indicator of turn-to-turn shorts. Capacitance to ground measures the amount of winding contamination (water, dirt, dust, etc.). Changes in each of these affect impedance (total resistance of an AC circuit). These characteristics are measured phase to phase and phase to ground and compared to each other and to percent change from baseline to identify motor circuit defects.

Some of the tests can serve as one-time go/no-go types of inspection. Some must be trended over time to understand the defect progression. The best strategy is the testing of motors on a set schedule. This allows you to properly trend these characteristics and gives the reliability program the best conditional probability of finding motor circuit defects.

All of the failure modes listed are very real and create unplanned downtime. A comprehensive, failure modes-driven maintenance strategy for electric motors incorporates all of these test methods.

How many are you using to effectively and efficiently ensure your operation's production capacity?

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