Electric Motor Testing on the Production Line

The growth in the electric motor and appliance industries has led to an increased demand to develop better motor testing equipment and improved motor testing methods.

Many motor defects can be detected by testing the motor torque output. Unfortunately, various motor testing systems performing this test have considerable limitations. One example is lengthy test cycles, a serious drawback in 100-percent production line testing.

Other motor defects can be detected by spectral analysis of various high-resolution time recordings of motor data.

Basic No-Load Testing

Basic no-load testing of motors is considered the easiest testing method to implement. As the name suggests, there is no load coupled to the shaft while a rated voltage is applied to the motor. The current and power consumption, and sometimes the speed, are measured and compared to the limits derived from a master motor. This method merely establishes whether the motor input parameters and the no-load speed are acceptable or not.

Basic no-load testing is simple to perform and capable of detecting gross manufacturing faults and defects. The procedure is fast and results are quickly obtained. It is very useful for 100-percent production testing.

However, the primary downfall with this method is that it is unable to test the motor torque output. Therefore, there are many faults and defects that this method is unable to detect.

Testing by Modeling

Testing by modeling is very similar to no-load testing; however, input is measured and output is calculated. This is done by using a mathematical model that links input to output. Input parameters, such as the tested motor's current, power, and resistance, are fed into the model to calculate its output parameters. The calculated motor output parameters are then compared to the master motor output parameters.

As with no-load testing, the model testing method is fast enough to carry out 100-percent production testing. In addition, when the model is properly calibrated, it is easy to apply.

However, calibrating the model is generally a lengthy process. This is due to the fact that it involves bench top testing of many motors in order to obtain the model constants. It is also difficult to successfully model some types of motors, and the existing models may not detect certain types of common manufacturing defects and faults.

Comprehensive Testing by Loading the Motor

Testing by loading the motor uses a number of different mechanisms in order to apply a torque load to the running motor. The resulting motor input and output parameters can then be measured.

The torque is generally measured using a strain gauge. This is used together with a mechanical connection to the rotating shaft, motor housing, or test fixture. An eddy-current, hysteresis, or another type of electromechanical brake is also used in order to generate a variable torque load. Sometimes a separate d.c. electric motor is used.

To carry out the test, the load's shaft has to be coupled to the motor's shaft. During testing, power to the load device is adjusted in order to apply the desired torque load to the motor. Before any measurement is taken, the motor and instrumentation must be allowed to stabilize.

Load testing is superior to the other methods previously mentioned in its ability to actually measure the motor output parameters and its provision of test results that relate directly to the performance of the motor under test.

However, the disadvantages to load testing include lengthy process time, complex implementation, inaccurate results due to excessive heating of motor, and the need to frequently calibrate the strain gauge.

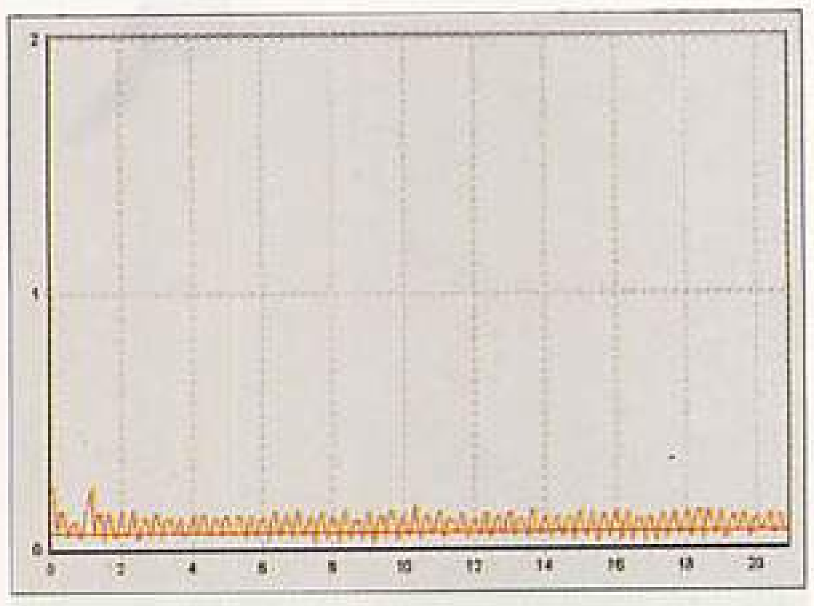

Figure 1. Low-frequency speed spectrum of a normal motor.

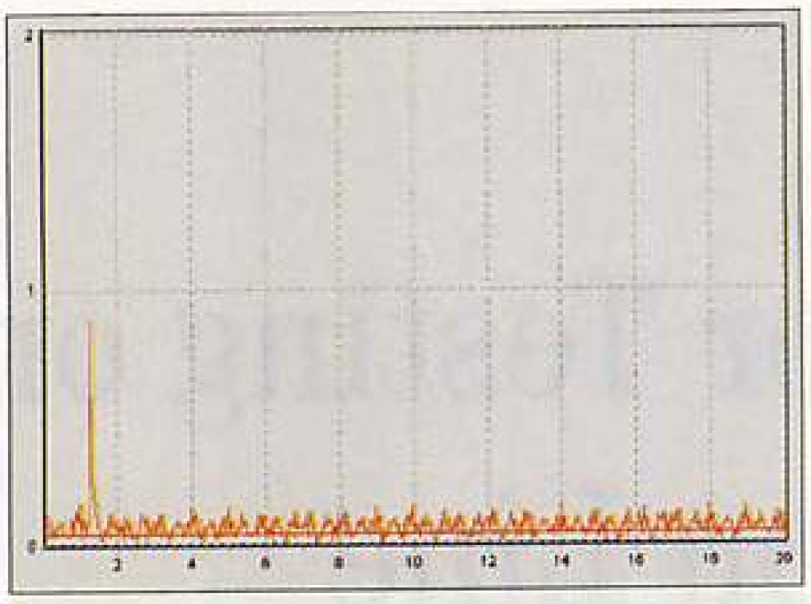

Figure 2. Low-frequency speed spectrum of a motor with a missing conducting bar.

Comprehensive No-Load Testing

Comprehensive no-load testing benefits from the best of both worlds. It reveals complete motor characteristics, yet can be very fast. It uses inertial load instead of electromechanical load to achieve this. For the inertial load, either a flywheel can be used, or the rotor's intrinsic moment of inertia. If using a flywheel, the testing cycle is prolonged by the need to attach it to the motor shaft. When no wheel is used, the testing time is very short.

The moment of inertia coupled to the motor determines the free acceleration of the motor. By measuring the free acceleration and the current and power consumption during acceleration, the entire motor characteristics are obtained.

This method has obvious advantages. It provides the motor input and output parameters, yet it is very easy to apply and its testing cycle is very short. Hence, this is the best method to employ for 100-percent production testing.

Example of Defect Detection by Testing Current and Torque

Detecting manufacturing problems in a.c universal motors by testing their torque-speed and current-speed characteristics can be very helpful. Conventionally, commutator problems are detected by placing the commutator between magnetic poles and observing the voltage generated at the brushes while the commutator is rotated. Any asymmetry, such as broken wire, copper in slot, or a missing tang, will be manifested as an irregularity in the voltage signal. This procedure is time consuming and subjective. The process can be improved by replacing the testing procedure with one that is applied to a complete motor and that automatically compares the test results to predefined limits.

Examples of Defect Detection by Spectral Analysis

1. Open Bars and End Ring Problems

The electrical symmetry of a PSC and shaded-pole rotor is important for the smooth running of the motor and, when lacking, results in low-frequency speed variations. Production faults, which cause rotor electrical asymmetry, are "Open Bar," "End Ring Problems," and other aluminum casting defects.

Since the rotor rotates slower than the motor's magnetic field, the electrical asymmetry experiences a periodic force at the slip frequency multiplied by the number of poles. This periodic force creates a periodic perturbation in the motor rotational speed, which can be detected by spectral analysis of a few seconds of speed recording. The perturbation is shown in the resulting spectrum as a peak at the expected frequency. The detection procedure is fast enough to meet production line rates.

Figures 1 and 2 show typical results that were obtained by using the MotorLab system from M.E.A. Testing Systems of Netanya, Israel. Figure 1 shows the low-frequency speed spectrum of a normal motor. Figure 2 shows a speed spectrum of the same motor after a small portion of one of its conducting bars was removed. The peak at the slip frequency, multiplied by the number of poles, indicates the open bar problem.

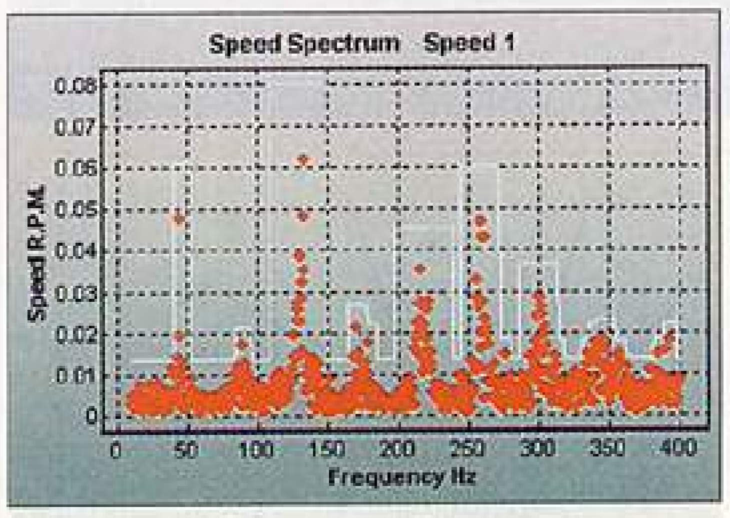

Figure 3. Speed spectrum of an acceptable gear.

2. Noisy Gear

When a gear motor is manufactured as a single integrated component, it is important to test the performance of the complete unit. Examining the spectrum of speed recordings taken at the gear output axis can reveal excessive allowances inside the gearbox.

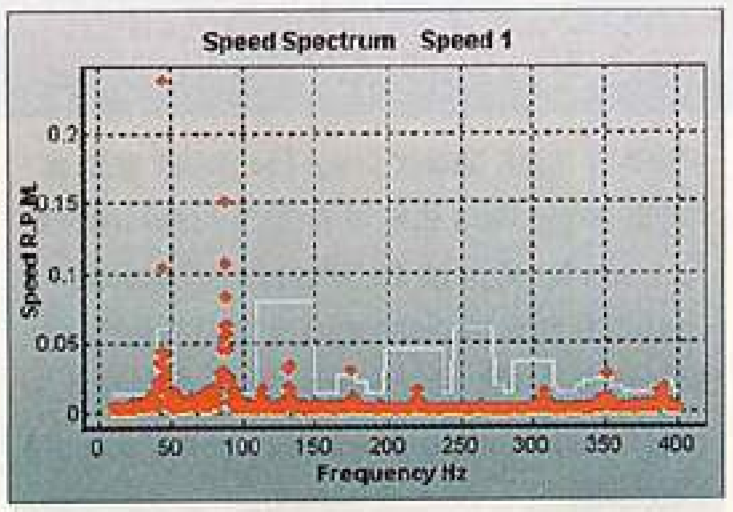

Figure 4. Speed spectrum of a noisy gear.

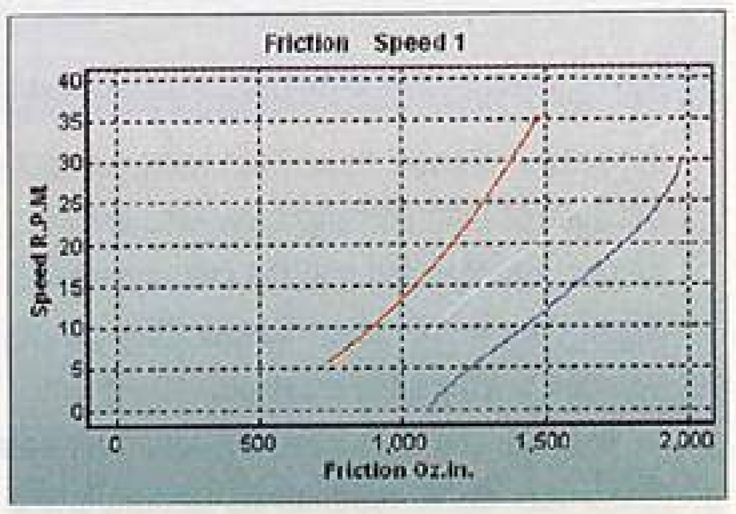

Figure 5. Friction torque of a noisy gear.

Figures 3 and 4 show two spectra of a d.c. PM gear motor—one of an acceptable gear (Figure 3) and the other of a noisy gear (Figure 4). It can be seen that the two spectra differ considerably. The noisy gear has an elevated level of spectral components at the rotation frequency and its harmonics, while the acceptable gear has more power at higher frequencies.

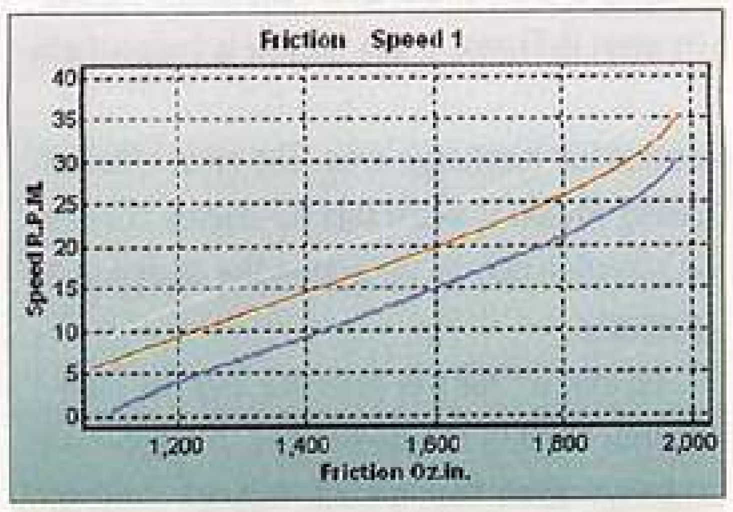

Figure 6. Friction torque of an acceptable gear.

The two tested gear motors also differ in their friction torque. As can be seen in Figures 5 and 6, the friction curve (in red) of the noisy gear (Figure 5), which is out of the acceptability limits (the light green and blue lines), is lower than that of the acceptable gear (Figure 6).

This information is provided by Yoram Tal, R&D manager for M.E.A Testing Systems LTD. (Netanya, Israel).

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