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The test system for electrical drives consists of power analyzer/control unit, speed sensor and software.

GEARS

Acceleration Test Method Shows Gear Faults

Since seven years there is a very accurate test system on the market for testing electrical drives. It works with the acceleration method. This paper shall show how the method can also be used for testing gears.

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The company M.E.A. Testing Systems Ltd. has developed a method, which detects faults in electrical drives [1]. The method, shortly called M.E.A. system permits to assess the complete static and dynamic characteristics of an electro motor in seconds. Using this method a drive is accelerated from stall to no load speed. The load is only its own rotor's moment of inertia. In micro second intervals current, voltage and speed are measured over time.

Motor Encoder supplies Speed Signals

The speed measurement is either done by an external M.E.A. speed sensor or by a motor internal encoder, which supplies the speed signals. A very user friendly software calculates from the measured values the data listed in Tab.1, shows them in graphs and tables and saves them for evaluation, comparison, quality assurance etc.

The method may be used in research and development and also for production end control of motors, gear motors and electrical brakes, also drives of multi axis machines and for maintenance service. The method is based on the Newton law and uses the possibilities of modern software.

In case of gear testing one can run all gears with a master motor. Deviations of the test results are then due to differences of the gear. If the complete unit motor and gear is measured also deviations of the motors from the standard are shown.

The faults detectable by the M.E.A. testing system are listed in Tab. 2.

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Tab. 1: Evaluation of measurements of electrical drives by the M.E.A. Testing System

Static Characteristics:	• Power input – speed • Power output – speed • Efficiency – speed • Torque – speed • Friction torque – speed • Voltage - speed • Current - speed • Current - torque • Back EMF during deceleration • Sense of rotation • Stator temperature • Power output and torque at different motor temperatures • Determination of moment of inertia • Determination of load curves

Tab 2: Faults, which the M.E.A. System will find when testing an electric drive

Deviation from design in:	• Current • Voltage • Power input • Power output • Torque • Efficiency • Cogging torque • Mechanical losses
Magnetic problems	• Broken wires or cage bars • Insulation faults • Electric asymmetry of the rotor • Bad soldering of the rotor winding connection • Flash fails • Deviation in Back EMF • Cogging too high/low
Mechanical problems	• Brush problems • Bearing damage in the motor • Increased friction of the motor • Vibrations and Oscillations • Noise of motor • Unbalance • Bad alignment • Resonance areas • Gear noise • Increased friction of gear • Bearing damage • Faulty operation of a brake • Faulty controller setting • Faulty electronic motor control

Quelle: Verfasser

For fault finding in gear motors friction torque and spectrum analysis of the speed -and torque-oscillations are mainly decisive.

For the testing two different types of gear motors were made available.

Type A: 24 V ; 450 W at maximum efficiency

Motor 1 (noisy), 2 (noisy) and 3 (quiet)

Type B: 28 V ; 250 W at maximum efficiency

Motor 1 (noisy), 2 (quiet)

The gear motors were tested according to the M.E-A - method, i. e. test voltage, current, power input, power output, efficiency , friction torque, back EMF, and the dynamic characteristics, namely FFT of the torque- and speed-oscillations and the spectrum of the friction torque over the rotational angle were determined.

In case of motor A the static values differed only in the friction. All other static test values were close together (Fig. 1). Therefore the difference shown in the dynamic measurements ▹

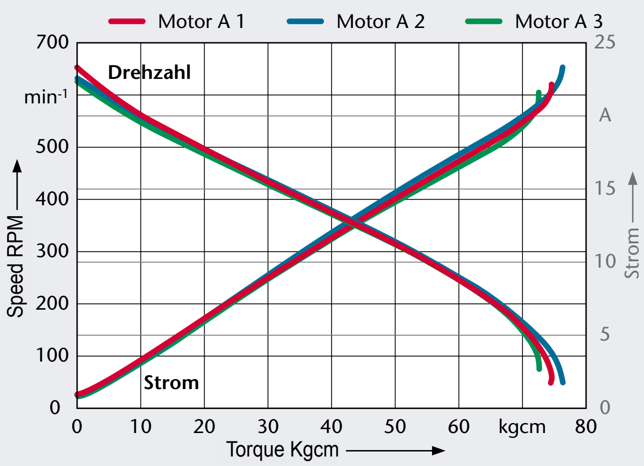

Fig. 1: Speed, torque and current of motor A. All three motors are close together. No difference between noise and quiet gear motors can be recognised.

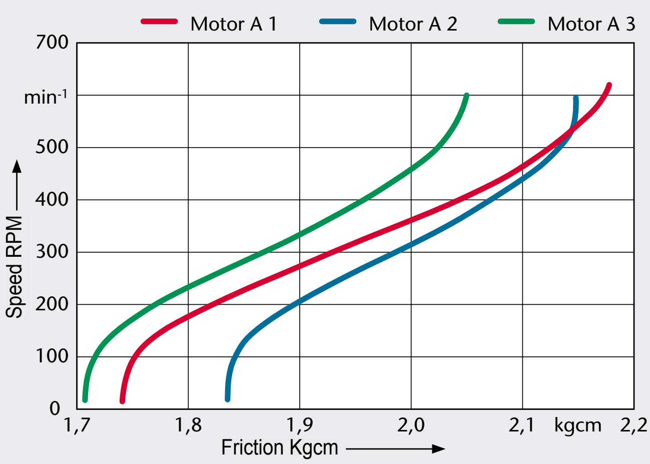

Fig. 2: Speed vs. friction torque of the three motors Type A. The quiet motor 3 has the lowest friction.

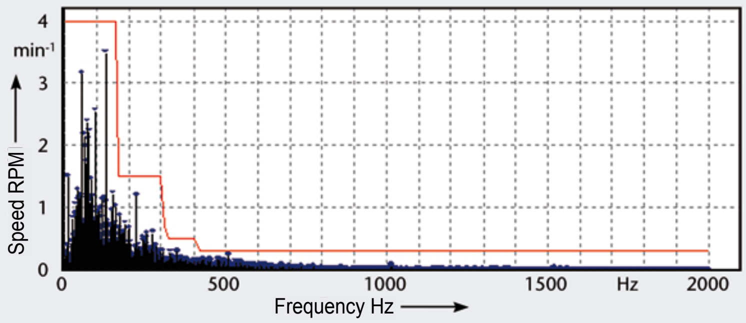

Fig. 3: Frequency spectrum of the speed oscillations of the quiet motor A 3.

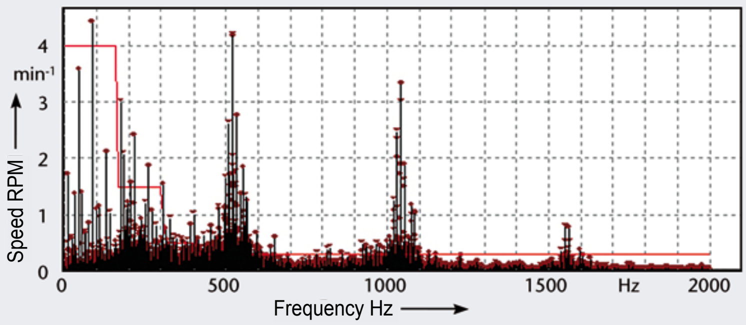

Fig 4: Frequency spectrum of the speed oscillations of the noisy motor A 1.

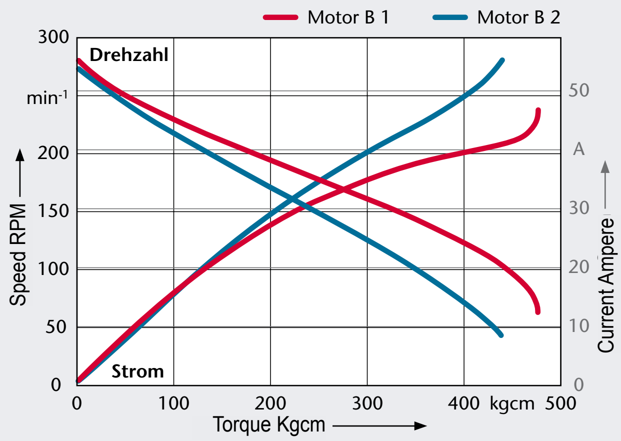

Fig 5: Speed,tTorque and speed of the motors B 1 und 2.

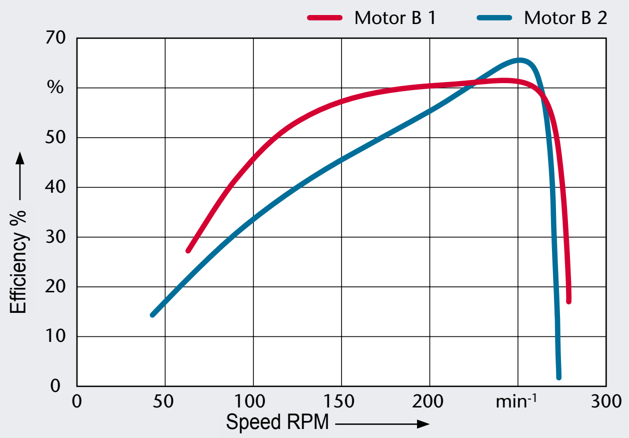

Fig. 6: Efficiency versus speed of the motors B 1 und 2. The motors have a completely different behaviour.

could only have been caused by the gears, since the motors were equally good.

Dynamic Tests show Noise Problems

The noise problems appear most pronounced in the dynamic test results. In Fig. 3 the analysis of the speed oscillations of the quiet motor A3 is shown.

It is used as master. A red curve is drawn as envelope around the amplitudes over the whole frequency range. The same red curve is used as tolerance limit in Fig. 4 showing the spectrum of the noisy motor 1. One sees very clearly more oscillations with higher amplitudes 1 exceeding the red tolerance curve derived from motor 3.

The likewise noisy motor 2 represents a similar picture. The faults are clearly shown in the spectrum of the torque and speed oscillations.

A different behaviour show the motors B. The static curves of the two B#1 and B#2 differ significantly. This can be seen in the current drawn, power input and efficiency (Fig. 5 and 6).

The characteristics of all static values show two different motors. Also here the friction of the noisy motor B#1 is higher (Fig. 7).

As in the case of the motors A the motor noise can best be detected in the frequency spectrum of the speed- and torque-oscillations. The procedure was the same as in the case of motor A. First the good motor was tested, the tolerance curve overlaid around the amplitudes over the whole investigated frequency range (Fig. 8) and compared with the results of the noisy motor B#1 (Fig. 9). In the range 60 to 450 Hz the tolerance limit was significantly exceeded. With deeper knowledge of the gear motor oscillations at defined frequencies can be interpreted and the reason of the faulty behaviour determined. In any case gear motors tested in such a way will never be supplied to customers. It can be assumed that motor B#1 passed a factory test, however, the fault was not detected.

Bilder: Verfasser

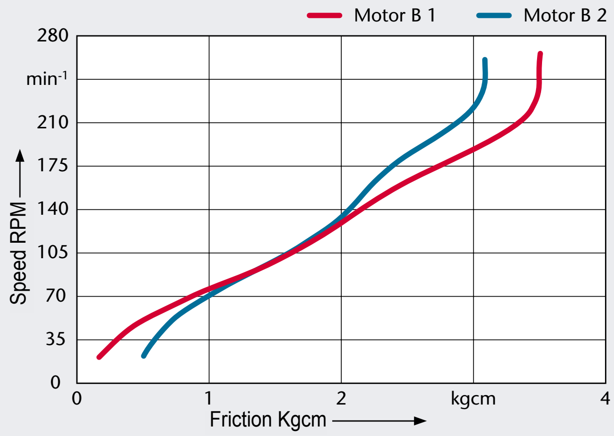

Fig 7: Friction torque and speed of the motors B 1 and 2. The noisy motor 1 has higher friction.

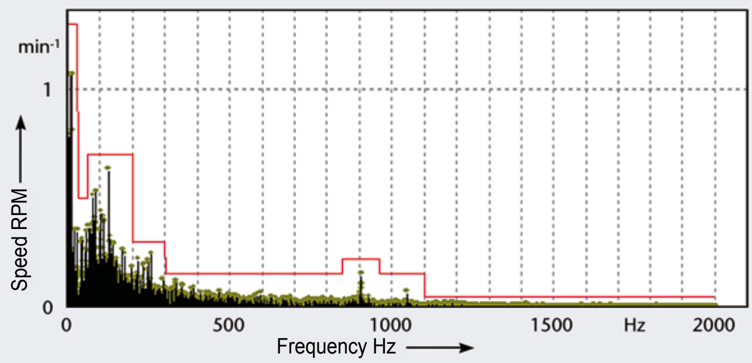

Fig. 8: Frequency spectrum of the speed oscillations of the quiet motor B 2 with tolerance curve.

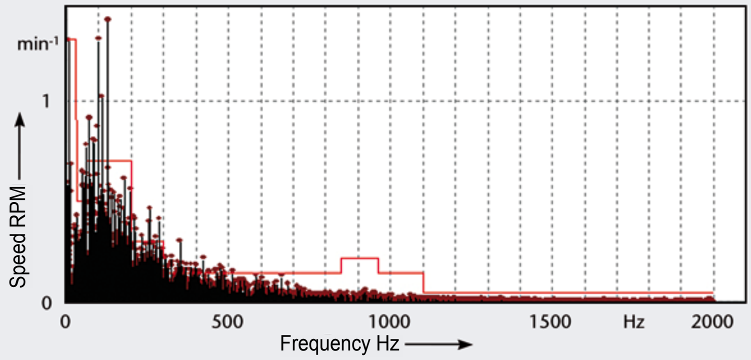

Fig. 9: Frequency spectrum of the speed oscillations of the noisy motor B 1. In a certain frequency range the oscillations exceed the tolerance curve of Fig. 8.

Conclusion

Practically for factory testing one would not only rely on one good motor to determine a master curve and tolerances. A larger number of good motors have to be measured in order to determine the natural spread. The M.E.A. software allows to form average values and tolerance ranges very quickly. The data of a certain motor type are saved and will be available any time when this motor type has to be tested.

All mechanical and electrical defects which may occur in an electro motor and effect the performance of a motor can be found in the production end control by the M.E.A. System. The present study was directed to the detection of gear noise and to quantify them. Frequently gears are only judged subjectively by the audible noise M.E.A. System is capable of applying an objective method. At the first glance the large number of criterions having been used may appear very complicated. One has, however, to consider that all these measurements were made with one instrument in one measuring step and the time used for all these readings, evaluations and display of the results requires only seconds. This M.E.A. method is superior to conventional test methods and offers highest security that production faults cannot pass through without being detected. Of particular importance in gear testing are friction torque and analysis of the speed- and torque-oscillations. The test reports delivered by the software are also a perfect quality assurance document of the tested product.

Literature:

[1] Wunsch, A. K.: Prüf- und Monitoring-System elektrischer Antriebe. ETZ Elektrotechnik und Automation (2005)/S4, p. 40/43.