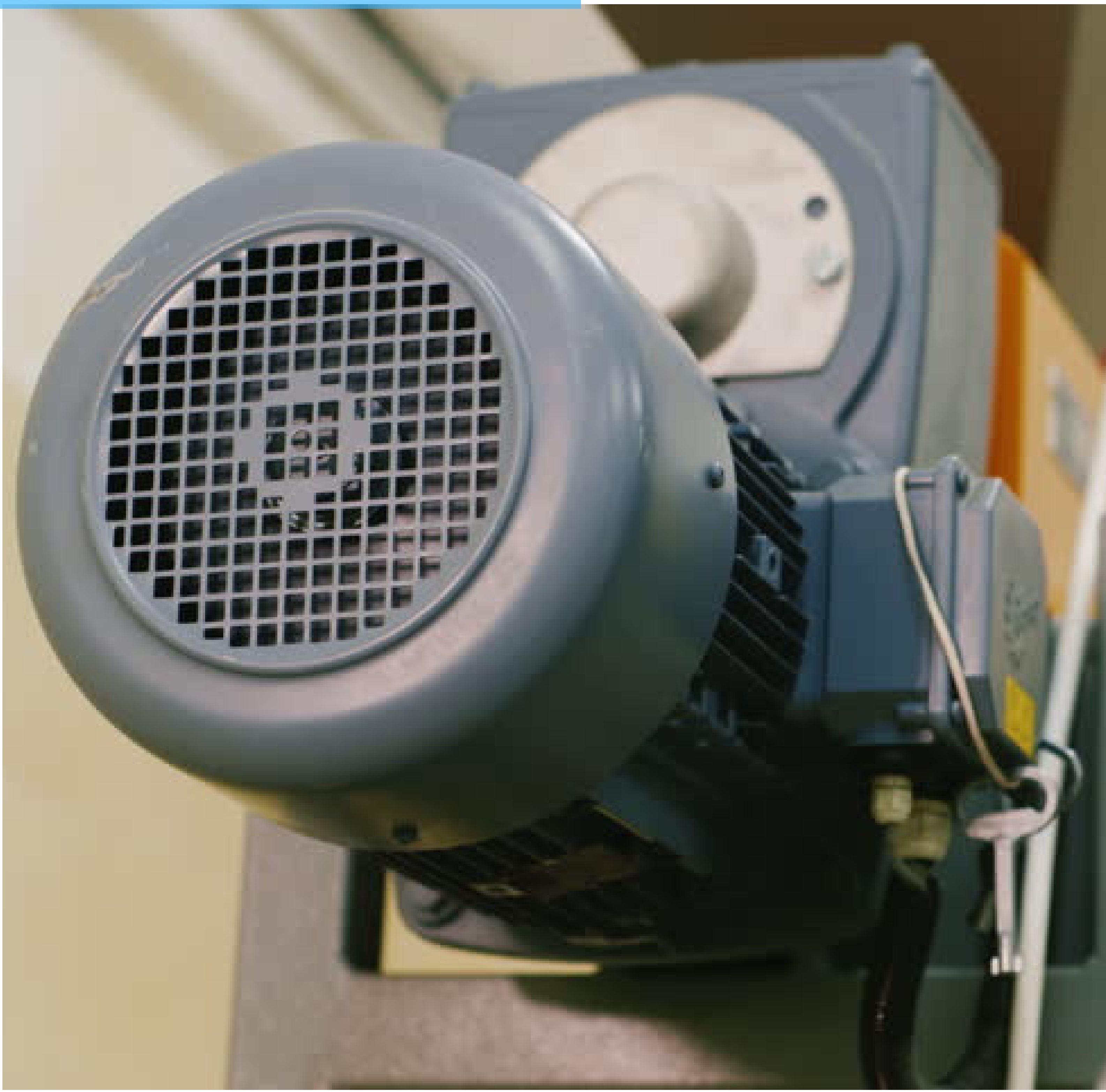
MOTOR CURRENT
SIGNATURE ANALYSIS

MCSA

Arrelic
Insights



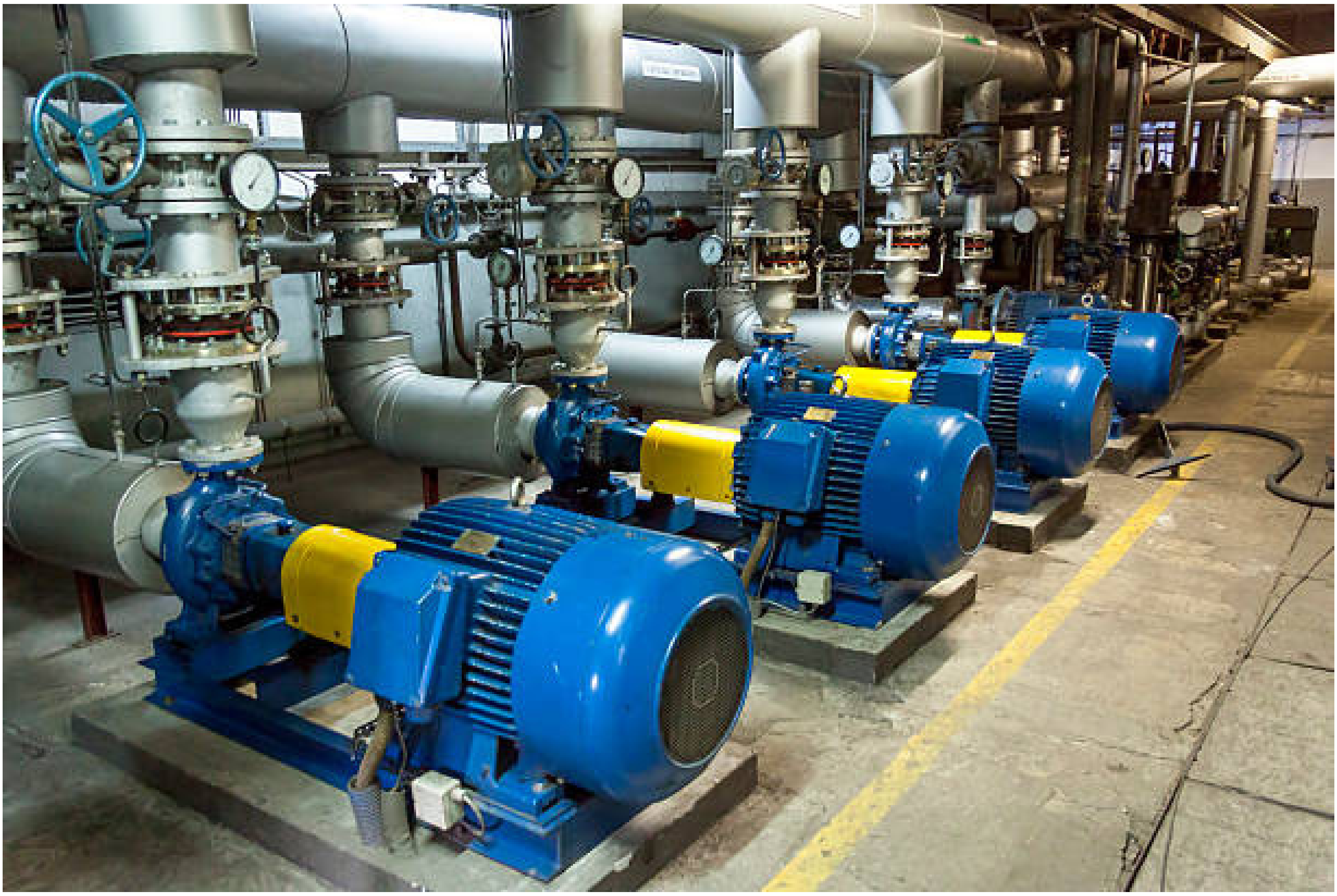
What is it?

Motor-current signature analysis (MCSA) is a non-destructive analysis technique used for detection of mechanical and electrical problems in motors, transformers, generators, alternators, distribution, valves and other electric equipment. It is a predictive maintenance tool used to analyze the dynamically energized systems and thus prevent expensive production outages. The technique can be used to analyze the driver, the driven load and the power supply. MCSA can be used as a preventative maintenance tool to perform a one-time test or periodic testing to record and analyze motor performance. The test analyzes the current waveform using Fast Fourier Transforms. The information is captured and thereafter analyzed for the following possible defects, Rotor bar faults, Stator faults, Winding lamination defects, Phase imbalance.

MCSA is based on the fact that an electric motor (AC or DC) actually acts as a transducer. Mechanical-load variations are sensed by the motor and are converted into electric current variations that are transmitted along the motor power cables. Even though the variations are very small, these variations can still be displayed and analyzed at a convenient location away from the operating equipment. A thorough analysis of these variations which can be recorded and trended indicates the current machine condition as well as a historical trend of the condition over time to provide an early warning of possible machine failure. Current and voltage measurements methods are performed according to the voltage level. For the low voltage motors, current measurements are done by simple split core current transformer clipped in the motor feeding cables, and voltage measurements are done by clipping the voltage probes on the motor terminals. For motors working on medium voltages, current transducers clipped on the secondary circuit of the current transformers can be used for for current measurements .Similarly, the voltage probes on the secondary terminals of the potential transformer can be used for voltage measurements

Applications

Although MCSA was developed for the specific task of determining the effects of aging and service wear on motor-operated valves used in nuclear plants, it has found application within a much broader range of plant machinery, such as electric motors. Motor-current signals can be obtained remotely using a current transformer, typically located in a motor control center, which may be located several hundred feet from the equipment being monitored. For temporary measurements, the signals can be obtained non-intrusively with a single split-jaw current probe placed on one of the power leads. Because no electrical connections need to be made or broken, the hazard of electrical shock is minimized. The resulting raw data signal is amplified, filtered, and further processed (using fast Fourier transform digital signal processing techniques) to obtain a baseline signal pattern measurement of the instantaneous load variations within the drive train and ultimate load.



A comparison of motor-current and mechanical-vibration signatures obtained simultaneously from a motor-operated valve, for example, reveals similarities and distinctions. Both spectra contain frequency peaks corresponding to the worm-gear tooth meshing, motor speed and its harmonics, though the differences lie in amplitude relationships. Subsequent signal signatures patterns can then be compared with the baseline to find faults and problem indicators. One distinction which is prominent and crucial is that in motor-current signature there is a strong spectral component that is defined as the slip frequency. This signal reflects the rate at which the motor armature lags behind the rotating electrical field generated by the motor's field windings. Since this motor slip-frequency component is electrical rather than mechanical in origin, it has no vibration counterpart and it is not present in the vibration spectrum.

Spot checking at intervals shorter than a year is of significant value only after a plant has developed its own baseline data. Once historical files have been developed, spot checking can be cost-effective for critical or expensive machines as well as for less-critical equipment.

It also can be used effectively as a troubleshooting tool. Information can be obtained by monitoring machinery once a month or once a quarter. Periodic MCSA can provide a subtle indication of bearing, packing, coupling, or gear wear, allowing personnel to project acceptable machine performance into the future. Advance notice of developing problems gives technicians' time to repair a component during normal, planned machine shutdowns, rather than allowing a serious machine failure to cause a plant forced outage. Because problems are detected when they are relatively minor, they are usually less expensive to repair.

The analysis of MCSA output is subjective in nature and the limited availability of industry-wide historical and comparative spectra available for specific applications makes it tough to analyze the faults. Thus, subject matter experts can help in analyzing the spectrums. In the past several years the technique has been simplified by several vibration data collector/analyzer manufacturers. This has improved the technique from a data-collection and data-analysiis standpoint and significantly increased the amount of practical field experience.

It's not only about Motors

The technique's non-intrusive nature makes it particularly useful. Measurements can be taken without making or breaking electrical connections and without shutting down or opening up machinery. This eliminates equipment downtime for inspection and improves personnel safety. In addition, because readings can be taken remotely, this technique can be more conveniently and safely performed on large, high-speed, or otherwise hazardous machines. The technique can be used in variety of valve applications which are discussed in the following details.

1. MOVs diagnosis

Tests on motor-operated valves indicate that MCSA is capable of detecting and tracking the progress of stem-packing degradation, incorrect torque-switch settings or varying switch trip points, degraded stem or gear-case lubrication, worm-gear tooth wear, restricted valve stem travel, obstructions in the valve seat area, and disengagement of the motor pinion gear. Worn mechanical and electrical components can compromise motor-operated valve (MOV) operation as the valves age. Routine tests with mechanical sensors, such as strain gauges, accelerometers and pressure transducers, require valve access, which may not be possible during normal plant operation.

As we know that in motor power cables current varies proportionally to the motor's mechanical load. This current variation can be large step changes, such as those induced by limit and torque switches or minute variations caused by small changes in mechanical loads. The latter, which show up as "noises" riding on top of the motor current, are particularly rich in information about motor and gear train condition and about the condition of equipment driven by the motor, such as the MOV actuator. This motor current noise, or signature, contains virtually all the information normally detected by mechanical sensors, such as motor rotational speed, worm-gear teeth meshing frequency, hammer blow, drive-sleeve rotation speed, valve-stem motion, and valve-disk seating and unseating. In addition, the signature contains electrical information which cannot be detected by mechanical sensors, such as slip frequency, no load, and running and peak currents.

Motor current signature analysis (MCSA) is possible with universal signal analysis software, just as with mechanical signature analysis. However, MCSA offers important advantages over mechanical signature analysis in MOV diagnosis. First, using clamped-on inductive current probes to pick up motor current eliminates the need to cut or splice the motor power cable. Second, the current probe can be clamped onto any point along the motor power

cable. The most convenient location is usually the motor control center (MCC), which can be several hundred feet away from the MOVs. This allows test engineers to monitor MOVs not only non-intrusively but remotely at a convenient central location. By acquiring motor current data regularly at the MCC, engineers can trend individual MOV conditions and detect degradation of the motor, its drivetrain or the downstream valve. Early detection allows remedial action before MOV problems jeopardize plant safety and operation.By itself, a motor current signature gives only qualitative information on mechanical loads. If, in addition to MCSA, test engineers use mechanical sensors such as strain gauges and displacement transducers to test the MOV, they can calibrate the motor current signature to yield quantitative information on mechanical loads.In one application of mechanical sensors to in-situ MOV testing, strain gauges are pre-mounted on collars designed and calibrated to specific valve stem

These instrumented collars can be quickly glued onto the valve stems, greatly facilitating MOV testing in restricted spaces and hostile environment

"Everybody recognizes that if you can make very efficient electric motors, you can make a quantum leap forward "

James Dyson

2. SOVs diagnosis

Solenoid-operated valves (SOV) draw electric current to energize a plunger, whose position is the prime interest in SOV monitoring. Test engineers can remotely monitor SOVs by slightly varying the MCSA technique described earlier. In dc-operated SOVs, an AC with known frequency must be injected into the solenoid power leads. The same signal conditioning electronics and signal analysis software used in MOV testing processes the data and assesses the plunger's position.

MCSA is a powerful diagnostic tool and a significant addition to vibration and thermal monitoring. This technology enables us to test a variety of mechanical and electrical problems both online and off line and has a wide range of applications. For those companies willing to commit resources to this PdM tool, the payback appears as attractive as for vibration analysis. And, for companies with limited budgets, there are several service companies that will perform motor current signature analysis on a contract basis.

About Arrelic

Arrelic is a fast-growing deep-tech firm aiming to bring the next level of IoT based sensor technology to transform the mode of manufacturing operation and maintenance practice of various industries with extensive expertise in Reliability Engineering, Predictive Maintenance, Industrial Internet of Things (IIoT) Sensors, Machine Learning and Artificial Intelligence. We provide a single ecosystem for catering all industry needs from Consulting to IoT and Analytics as well as providing Training and Development courses for different stakeholders. We aim to help manufacturing industries to improve their overall plant productivity, reliability and minimize total production cost by 25-30% by eliminating machine downtime, lightening management decisions by analyzing the machine data with right mind and expertise; for a worry-free operation.

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