On- and offline electrical signature analysis: Why and how do we do it?

Content

In this course, we introduce you to Motor Circuit Analysis (MCA) and Electrical Signature Analysis (ESA & MCSA) as condition verification technologies for electric rotating machinery. After a contextual introduction of the nowadays maintenance strategies and condition monitoring techniques, the common electric machine topologies and their corresponding working principles are discussed. Next, the propagation of the most common mechanical and electrical machine failures are elucidated with the focus on differentiating direct and indirect modes. Several basic and advanced techniques are presented on how the condition-indicating patterns and parameters can be extracted out of the electrical signals. The teachers' experience enables a pragmatic interpretation of the theoretical fundamentals, fully driven by industrial examples. As closure, the gained theoretical and practical insights are applied on several industrial case studies. At the end of the course, the training participant will be able to measure, visualize and interpret a current signal in order to obtain the basic overall condition of an electric machine.

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Session 1 discusses the importance of the current condition monitoring systems in the industrial landscape. Inevitably, as well the applicable maintenance strategies are presented together with their strengths and weaknesses. The focus in this section is on understanding the importance of matching the condition monitoring strategy and/or technology with the drive train's Failure Mode Effect and Criticality Analysis (FMECA). Some basic fundamentals regarding electromechanics are discussed in order to straighten up all definitions in order to maintain uniformity during the following sessions.

Session 2 takes a step further towards the electric machine and its working principle. From DC to AC, from concentrated to distributed windings, from reluctance to magnetized rotors, most common machine topologies are presented with their relevance to industrial applications. Understanding the basic working principle is required to successfully differentiate between the frequency content of currents from an electric machine in a healthy condition and a problematic condition. Additionally, several control strategies are presented with their effect on the expected voltage- and current signatures.

Session 3 gives an overview of the main types of machine failures by their occurrence. By categorizing failures as direct and/or indirect, a differentiation can be made between the reason a machine eventually fails and the reason why the machine began to fail. Bearing problems, stator winding short-circuits and common mode shaft currents are a few examples of failure modes addressed in this session. The presented modes are linked to their most effective monitoring techniques. Not only low-voltage AC machines, as well high-voltage and DC-motors are discussed in their most prominent failure modes.

Session 4 is covering the main off-line testing strategies used on disconnected and/or disassembled machines. The use of dedicated equipment enables a thorough analysis of the equivalent motor parameters such as inductance, resistance, impedance... Test sequences such as the surge-impulse test, the reflection test, high potential test and step voltage test are fully focusing on the insulation condition of high-voltage machinery. Quantified parameters like Polarization Index, Dielectric absorption and Dielectric discharge are correspondingly presented in detail. Assembled and disassembled rotor tests are presented to close this session.

Session 5 starts with how and where to measure the electrical signals and where this is situated in the overall diagnostic process. The focus is on measurement strategy and hardware requirements. In essence, it will be pointed out that a classic vibration analyzer suits the demand for performing basic MCSA diagnoses. Some basic -but nonetheless essential- acquisition parameters are discussed briefly such as sample-rate, dynamic range, accuracy, aliasing... During this section, currents and voltages are live acquired from a demo-unit of which the results will be processed and analyzed in the following sections.

Session 6 focuses on the core of this course: condition monitoring with ESA. From power quality parametrization towards spectral analysis, several fault-indicating patterns are presented to enable a diagnostic interpretation of the machine and its drive-train. The previously discussed failure modes are matched with their reflection in the electrical signals. This section is constructed in such a way that the content is direct applicable for the attendees by using a classic vibration analyzer in combination with a commercial available standard current clamp.

Session 7 is an advanced version of the previous section. Several transformation techniques are applied in order to extract even more content out of the electric current and voltage signals. Fortescue's symmetrical components, lateral/torsional vibration signals and system impedance functions are all calculated and presented together with their applicability in the diagnostic process. Additionally to the standard MCSA techniques, these techniques enable a deeper dive into the failure mode and usually results in an even more detailed proactive maintenance actions to avoid abrupt failure.

Session 8 consists of five industrial cases which are handled in detail from gathering operator information till the implementation of the most adequate and proactive corrective solution. The cases are selected as such that the main machine failure modes and their interpretation techniques from previous session are practically elucidated.

AGENDA

DAY I

Timing	Description	
08h00 - 08u30	Breakfast & coffee	
08h30 - 10h30	S01	Introduction to condition monitoring and electromechanics
10h30 - 10h45	Break	
10h45 - 12h30	S02	The electric machine and its control techniques
12h30 - 13h30	Lunch break	
13h30 - 15h30	S03	Failures modes of electric rotating machines
15h30 - 15h45	Break	
15h45 - 17h00	S04	Offline electric analysis techniques (MCA)

DAY II

Timing	Description	
08h00 - 08u30	Breakfast & coffee	
08h30 - 10h30	S05	Measuring electrical signals in the field
10h30 - 10h45	Break	
10h45 - 12h30	S06	Motor Current Signature Analysis (MCSA)
12h30 - 13h30	Lunch break	
13h30 - 15h30	S07	Advanced Electrical Signature Analysis
15h30 - 15h45	Break	
15h45 - 17h00	S08	Case studies