



UNBALANCED MAGNETIC PULL AND AIR-GAP MONITORING FOR LARGE HYDROGENERATORS

AN INNOVATIVE MEASUREMENT DEVICE FOR MONITORING STATOR AND ROTOR MAGNETIC CIRCUITS IN HYDROGENERATORS

Patented

MEASUREMENTS

- Deviations in the stator and rotor magnetic circuits
- Relative effective static and dynamic eccentricities
- Magnitude and direction of unbalanced static and dynamic magnetic pulls
- Air-gap magnetic flux
- Stator and rotor magnetic profile harmonic content

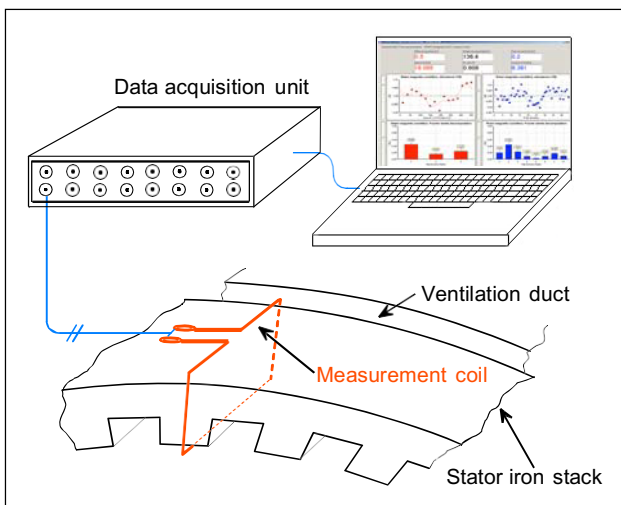


1. OBJECTIVES

Large low speed hydrogenerators have a very small specific air-gap to stator bore diameter ratio, making it nearly impossible to perfectly center the components during the assembly process. Thus, the machines are operated with an eccentricity that while small, is not negligible, and is the cause of undesirable effects such as unbalanced magnetic pull, vibration, and additional losses. Therefore, it is important to assess and trend a Unit's eccentricity and UMP in order to guarantee safe operation and prevent any serious damage. This is the aim of the UMP Monitoring system.

2. PRINCIPLES AND EQUIPMENT

The UMP measurement system consists of 3 parts: sensors, a data acquisition unit and a processor for control and processing.



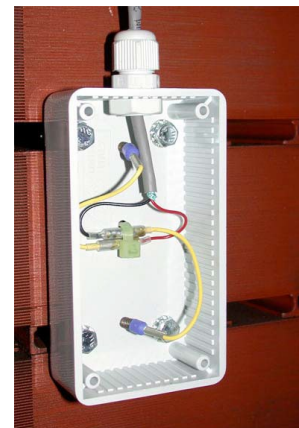
UMP Monitoring equipment

A. Sensors to Measure the Magnetic Flux

The magnetic flux in the air-gap of the machine is measured using coils distributed on the periphery of the stator, routed through stator core ventilation ducts.

These measurement coils may be put in place by the manufacturer or owner of the machine. For generators already in operation, these sensors are put in place from the back of the stator yoke using a simple and efficient method. It does not require access to the rotor. The installation of 15 to 20 sensors takes only a few hours.

For measurements of limited duration (such as for diagnostic testing) the measurement coils can be easily removed.



Sensor terminations in a 128 MVA generator

B. Data Acquisition Units

Typically, the device used to acquire data has a 12-bit resolution and 5 kHz sampling rate with a straight connection to the PC.

For users who desire it, the system is equipped with the capability of remote access over an internet connection.

3. MEASUREMENT MAIN FEATURES

The measurement is performed in real time over a complete revolution of the rotor. Consequently, the period between two successive measurements depends directly on the rotation speed of the generator.

Analysis of the measurements provides complete information regarding the condition of the magnetic circuits related to the air-gap:

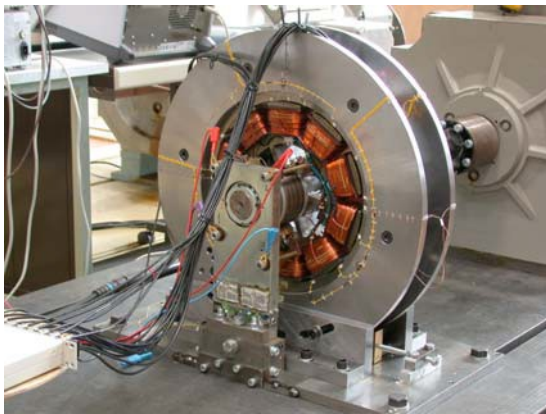
- deviations of the stator magnetic circuit;
- relative effective static and dynamic eccentricities;
- magnitude and direction of the magnetic pulls;
- air-gap magnetic flux.
- Harmonic content of rotor and stator magnetic profiles.

The UMP-monitoring HMI provides numerical and graphical representations of all of the above-listed characteristics.

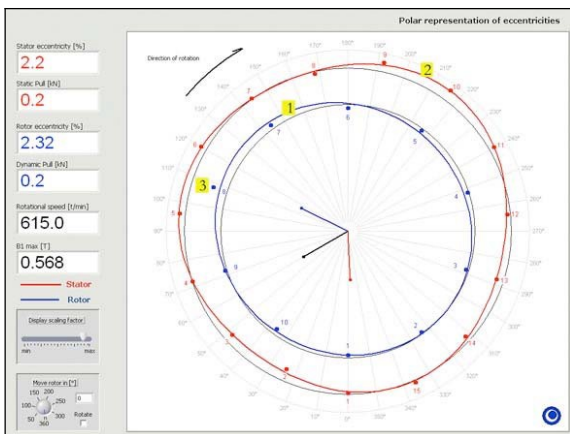
4. EXAMPLES OF APPLICATION

A. Laboratory Prototype Machine

The prototype machine (18 kVA) has a rotor and several interchangeable stators to allow for the measurement of different defects. One of the stators allows specific windings (parallel paths, equipotential connections) making possible the electrical compensation for eccentricity unbalance.



Laboratory experimental device



Laboratory test machine under 3 different scenarios (polar view):
1. Static eccentricity. 2. Third order deformation of the stator bore. 3. Pole n° 8 displaced.

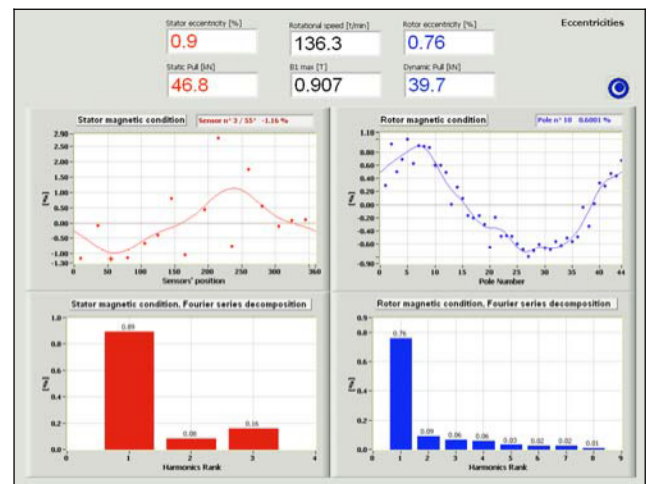
B. Power Plant of Verbois 4 x 33 MVA (Geneva)

Generator ABB, 9 kV, 136.4 rpm.



General view of the machines

The diagnostic establishes the (minor) extent of rotor and stator eccentricities and related UMP's as well as highlighting stator circularity deviations.



Result of measurement in Verbois power plant (scalar view)

5. UMP DECISIVE ADVANTAGES

- Static and dynamic unbalanced magnetic pull measurement
- Real-time assessment of air gap condition
- Very low cost sensors allow high number of measurement points;
- Arbitrary number and placement of sensors;
- Easy to install and to remove (no gluing)
- Insensitivity to external conditions (humidity and temperature)
- Capability to recognize deformation of any shape.