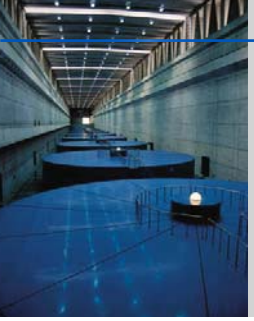

Overview of Typical Factors Affecting the Air Gap of a Hydrogenerator

Air gap results obtained by the AGMS® and ZOOM® systems from VibroSystM are measured by stator-mounted capacitive[1] sensors located on the same plane around the stator or on multiple planes on stators higher than 1.8 m/6 ft. The recorded gap values are therefore relative to the stator wall face on which the sensors are glued. Any radial movement of rotor and stator components will imprint on air gap results. Trends of these movements are important to detect and analyze the machine behavior.

Figure 1: Air gap sensors mounted around the stator wall perimeter.

To obtain meaningful results, you need measurement and processing accuracy. VibroSystM air gap sensors[2] achieve high precision in the order of the micron level. In addition, the ZOOM software offers many unique and powerful analysis tools to process air gap data and extract valuable and comprehensive information on a hydrogenerator condition. The air gap parameter has become an essential part of a sound hydrogenerator monitoring system.

Figure 2 illustrates most factors that affect the air gap of a machine: rotating component (rotor, shaft) movements, static component (stator) movements, magnetic and hydraulic forces. The rotating component movements include vibration and oscillation of the shaft (mechanical, hydraulic and magnetic imbalances), runout from shaft alignment (verticality, problem when coupling rotor to shaft), looseness in the rotor spider attachment to the shaft, expansion (centrifugal, thermal) and looseness (cracked welds) of the rotor spider, looseness in the rim-to-spider interface (rim keys, shrink fit), deformation of the rim (loss of shrink fit, lack of stiffness, design weakness, cyclic magnetic pull), looseness of the pole-to-rim interface (keys, vibration). Static component movements include vibration and displacement (loose soleplate key, soleplate hindering) of the frame-to-foundation, looseness in the frame-to-core interface, expansion of the frame and core assembly (thermal), vibration of the stator core, upper bracket movement if fixed on top of stator, and foundation movement or concrete growth on which stators are rigidly attached. Finally, the magnetic coupling pulling both on rotor and stator components is emphasized by uneven rotor and stator circularity.

(continued on overleaf)

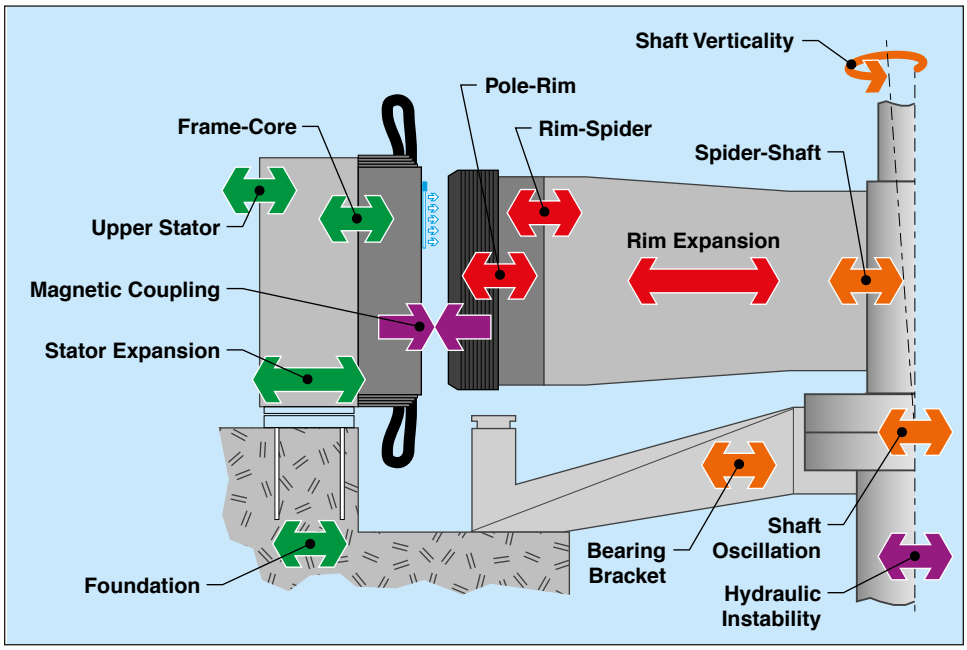

Figure 2: Diagram of typical radial movements affecting the rotor-stator clearance, i.e. air gap.

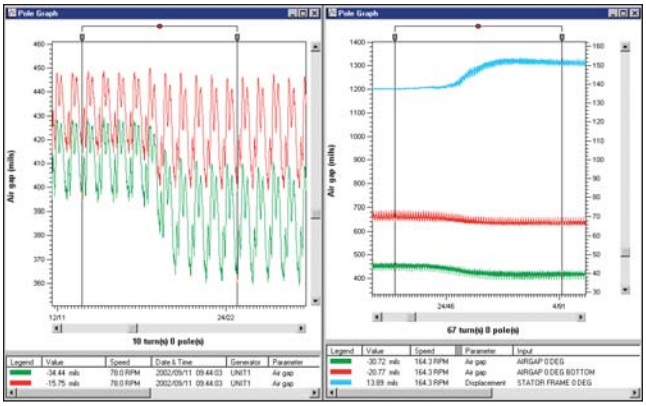

Figure 3: Examples of measurement comparison at field excitation showing difference in air gap reduction of opposite air gap sensor (left), as well as air gap and stator frame displacement variation on upper part of stator.

Any of these movements or, most likely, a combination thereof will affect the machine air gap and consequently have an effect on the dynamic behavior and overall condition of the hydrogenerator. Adding stator frame displacement sensors directly behind air gap sensors provides the absolute position of air gap sensors relative to concrete foundation. Only the ZOOM system allows the combination of air gap and frame displacement measurements to obtain absolute displacement of the rotor and stator components.

By comparing simultaneous air gap measurements from geometrically opposite air gap sensors (ex. sensors at 0° and 180°) or air gap signatures recorded under different operating conditions, it is often possible to determine what is responsible for a particular air gap variation. By correlating other integrated parameters, such as stator frame displacement, shaft displacement and vibration, etc., the diagnostic possibilities are greatly enhanced, and identifying the cause of a given problem becomes simple. Rotor-stator circularity and concentricity, as well as machine verticality can easily be monitored in static and dynamic conditions.

With VibroSystM air gap monitoring, it is possible to observe all these phenomena because they have a direct effect on the air gap and, when measured accurately, they provide a clear indication of the condition of the machine.

1 *Patented capacitive measuring technology.*

2 *VibroSystM air gap sensor precision improves from the values below as the distance is smaller:*
- *Accuracy: < 3% of reading*
- *Repeatability: ± 0.3% of reading*
- *Interchangeability: < 5% of reading*
- *Temperature Drift: < 500 ppm/C°*
- *Sampling Rate: 8000 samples/sec. minimum*

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