SYSTEMS OF TECHNICAL CONDITION MONITORING AND SYNCHRONOUS GENERATORS DAMPHER WINDING DAMAGE DIAGNOSIS

Kotusenko V.A., bachelor, Geraskin O.A., Ph.D., associate professor, Tsyvinskyi S.S., Ph.D., associate professor, Dubchak E.M., senior lecturer
Igor Sikorsky Kyiv Polytechnic Institute, electromechanics department

Introduction. Synchronous generator (SG) is a device designed to convert mechanical energy of rotation into electrical energy of variable nature. A feature of such machine is the presence of an excitation winding, due to which the electromagnetic field of the rotor is coupled with the stator field and the generator can operate in synchronous mode. The peculiarity of synchronous generators is that they can be synchronized with other similar electric machines. Thus, it is possible to use devices in industrial energy and connect backup generators in excess of rated power during peak hours. Three-phase traction synchronous generators are also used on locomotives. Alternating currents of power motors from such generators are rectified by semiconductor devices. Synchronous generators are also used in hybrid cars to ensure the battery charging process. During the operation of a hybrid car on an internal combustion engine, the car collects electrical energy to switch to work from the electric motor and thus provides an increased power reserve.

Damage often occurs in synchronous generators due to prolonged operation, namely: abnormal excitation operation, interturn or interphase short circuit, mechanical break in the damping winding (DW), overheating, sparks in the collector, bearing failure, axial displacement of the rotor and so on.

To avoid major material damage, especially in cases of high-power synchronous generators damage, it is necessary to conduct regular diagnostics. Diagnostic methods that will be observed in article: thermal, electrical and vibroacoustic.

Objective. Analyze the literature and make a review of the system for monitoring the technical condition and diagnosis of synchronous generators damping winding damage.

Research result. According to the literature analysis, the following methods for monitoring the technical condition of the synchronous generator were identified.

The thermal method is to analyze the temperature of the generator in operating mode with a rated load. To obtain temperature data, it is necessary to install temperature sensors or use a thermal visualizer. If the damper winding of the synchronous generator is damaged, the temperature of the damaged rod will decrease and the temperatures of the whole rods will increase. To detect damage, it is necessary to compare the rate of temperature change in the poles for a fixed time [1].

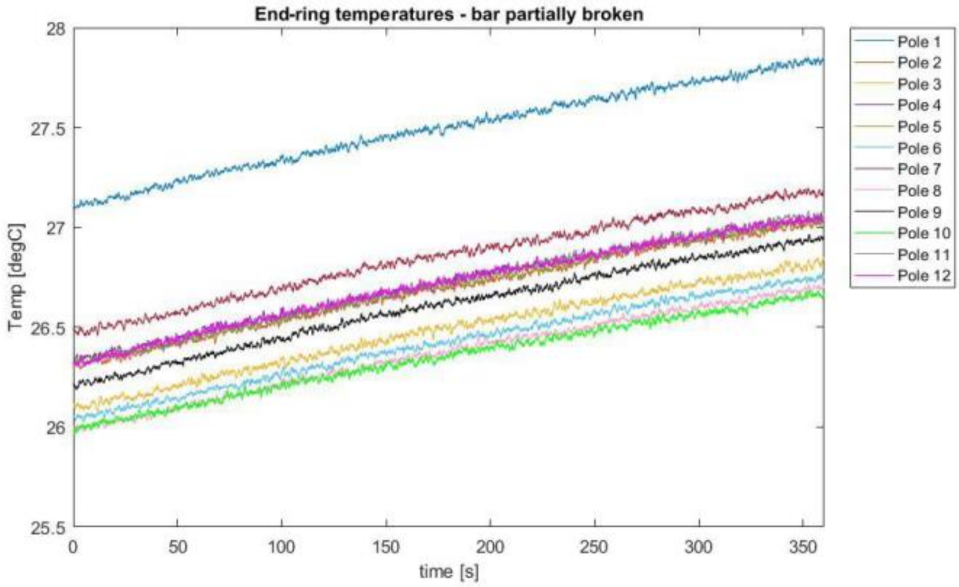

Figure 1 – Temperatures in the short-circuiting ring for the case of a semi-broken central rod at the pole [1]

Fig. 1 shows that for the case of SG, loaded by 50%, one half-broken rod there is a uniform increase in temperature at the poles over time. The rate of temperature change is approximately 0,7 ° C, which is approximately 2 times higher than in the case of intact SG [1]. However, this method is inefficient because the main heating occurs at the poles of the rotor of the synchronous generator, and therefore it is difficult to track the heating in the rods of the damper winding [1].

Electrical method. A diagnostic coil can be used to diagnose short circuits in the excitation coil and the rods to the rotor poles. With the help of a diagnostic coil mounted on the stator tooth (fig. 2), can observe the current value of the signal that is proportional to the EMF in it. The presence of jumps in excess of the nominal value in the time signal or changes in the sonogram of the signal means the presence of an interturn short circuit or damage of the DW rods, respectively (fig. 3, 4).

Figure 2 – Mounting a diagnostic coil on a stator tooth [2]

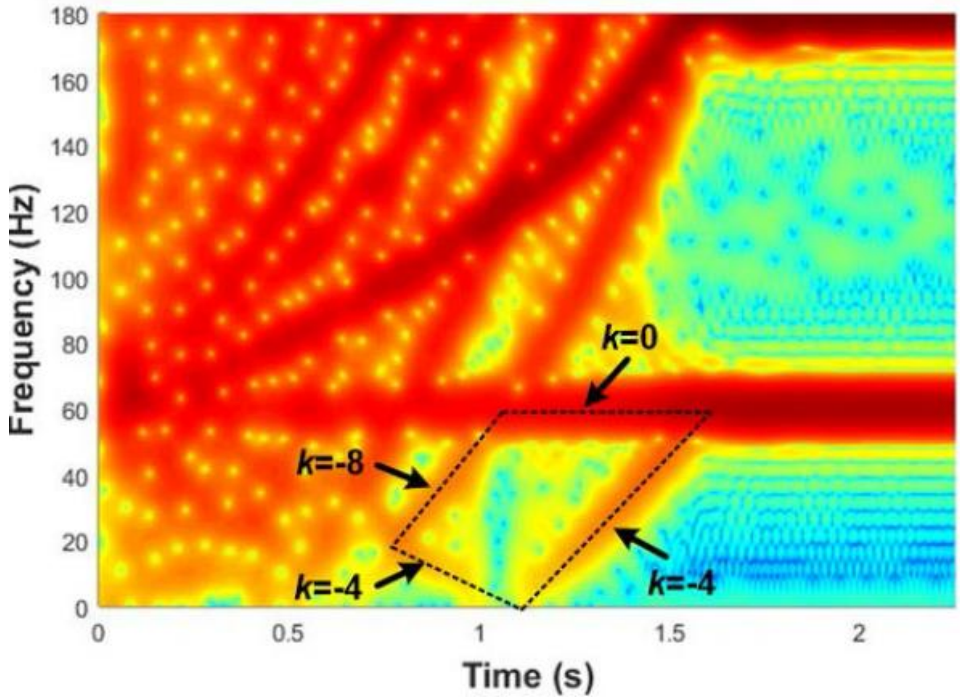

Figure 3 – Sonogram of diagnostic coil signal based on two-dimensional simulation of intact synchronous generator [2]

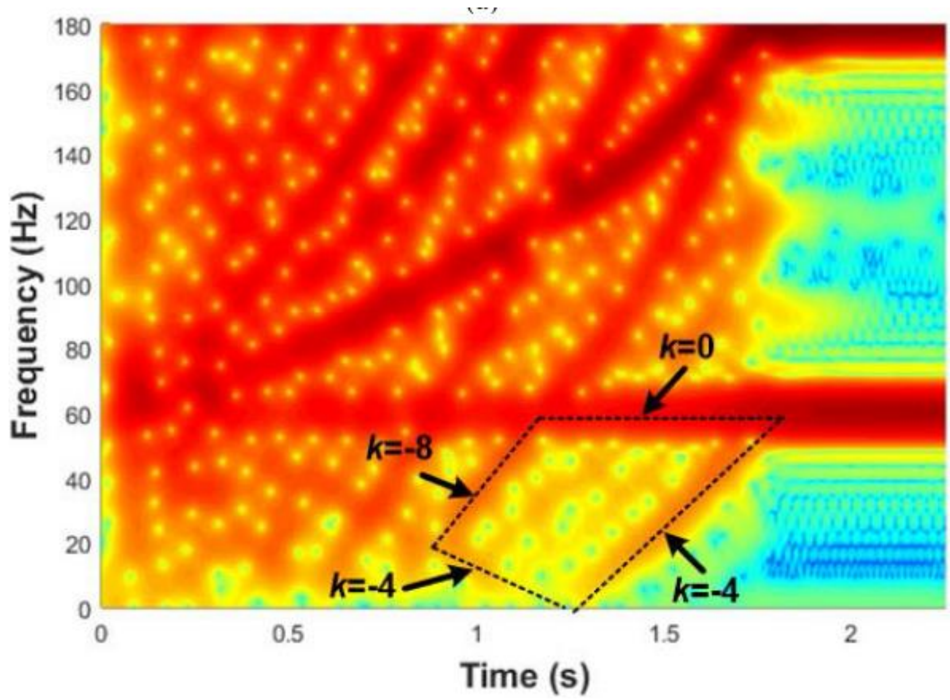

Figure 4 – Sonogram of diagnostic coil signal based on two-dimensional simulation of a synchronous generator with one broken damper winding rod [2]

Vibroacoustic method. During operation, the synchronous generator creates not only noise but also vibration. This acoustic noise can be read by means of acoustic sensors which need to be established on a support at distance of 1 meter from the case or to measure vibration of the case by means of the vibration sensor (fig. 5). In case of damage, the noise level will increase by some amount.

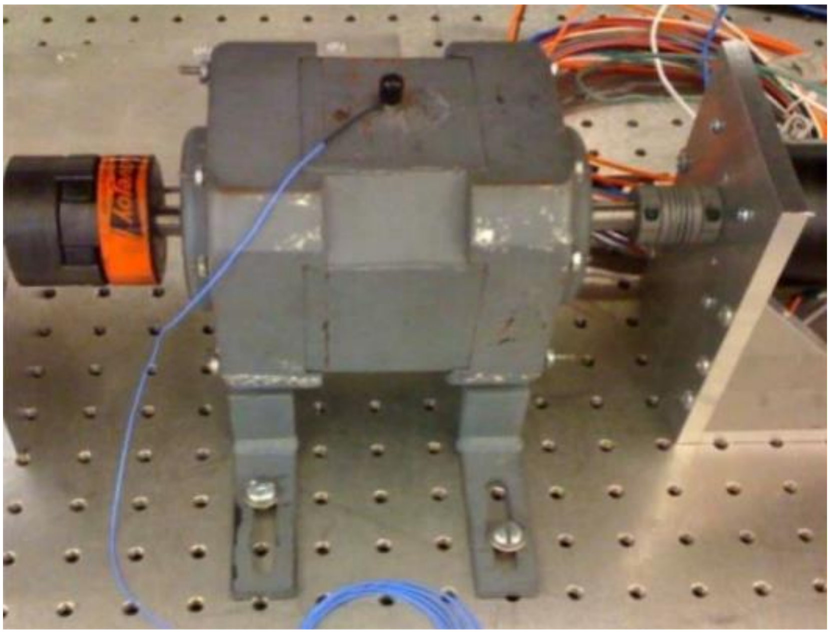

Figure 5 – Mounting a sensor for reading motor vibrations [3]

In fig. 6 showed the spectrum of sound power emitted by the outer surface of the stator of a synchronous generator.

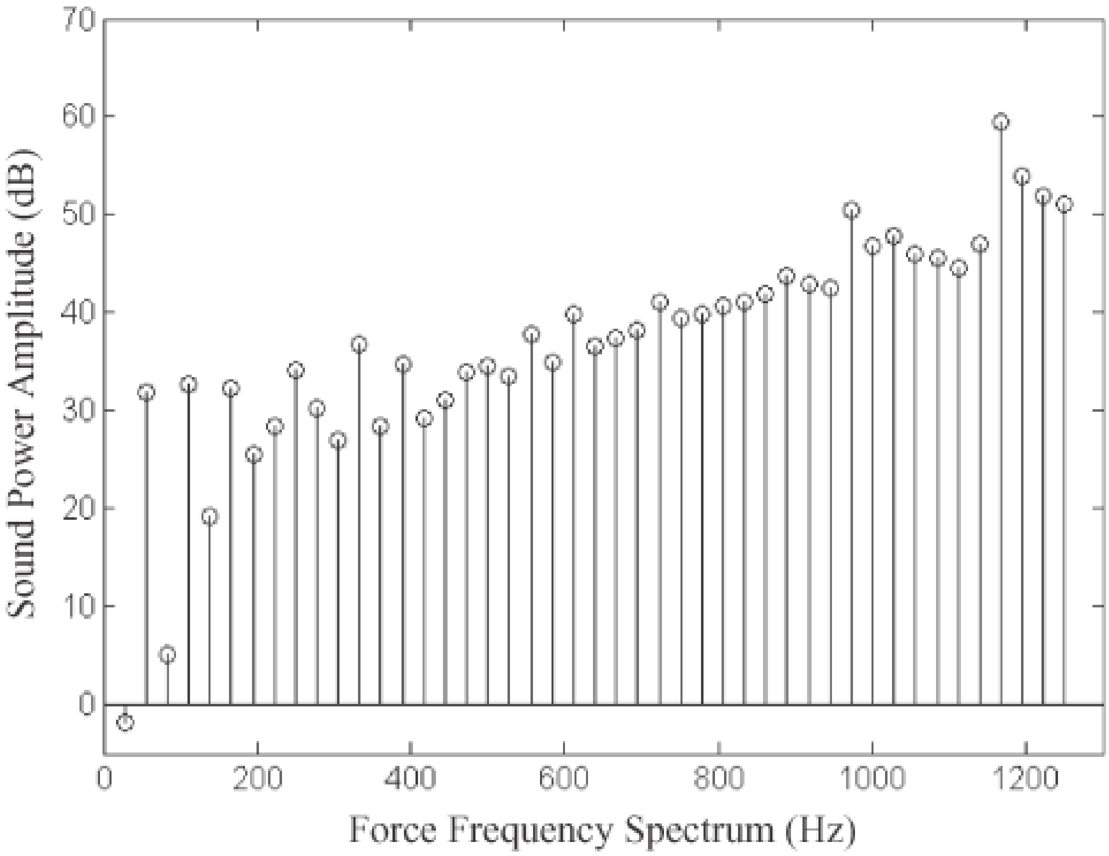

Figure 6 – Noise level in case of undamaged synchronous generator [3]

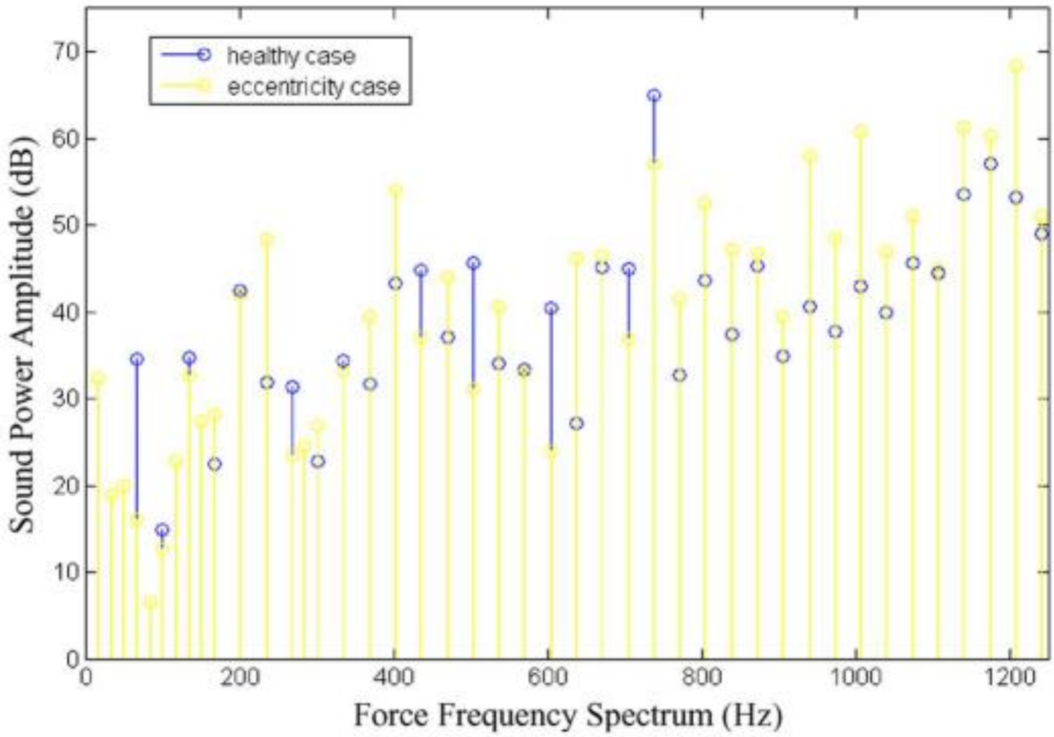

Figure 7 – Noise level in the presence of static eccentricity [3]

From fig. 7 it can be observed that the spectral power of the sound emitted by SG in the presence of static eccentricity is greater than that of an intact machine. The average increase in sound power for the case of static eccentricity increases by 26 dB, and the peak value - by 40 dB (table 1).

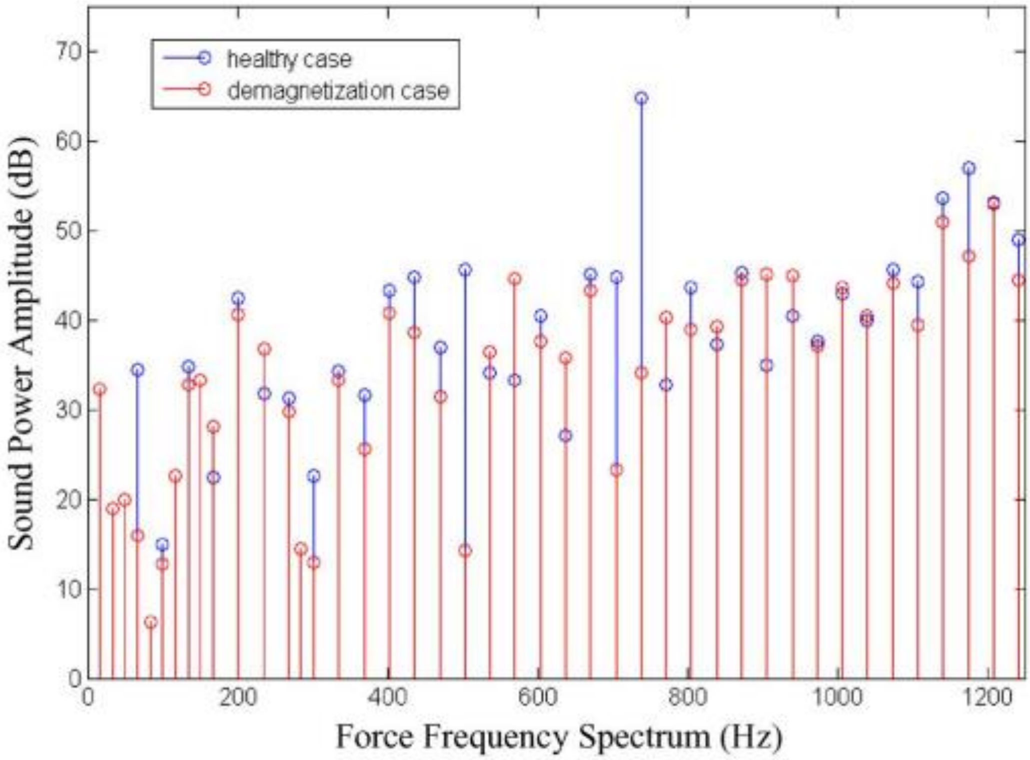

Figure 8 – Noise level in case of partial demagnetization [3]

In the case of partial demagnetization of SG, there is a decrease in the magnitude of harmonics in the acoustic signal, as well as the electromagnetic moment compared to intact SG and SG with static eccentricity (fig. 8). The average increase in sound power for the case of demagnetization of SG increases by 17 dB, and the peak value - by 30 dB (table 1).

Table 1 – Comparison of noise values for 3 cases of synchronous generator state [3]

Case	Average Torque Reduction	Average Sound Power	Peak Sound Power
Healthy Condition	T	P	M
Static eccentricity Fault	0.91T	P + 26dB	M + 40dB
Partial Demagnetization Fault	0.95T	P + 17dB	M + 30dB

Conclusions. Human hearing is not able to detect such changes in noise in a synchronous generator. And by means of system of acoustic diagnostics accurate observation of a difference in noise levels of the synchronous generator is possible. The presence of noise level jumps in the diagram, compared to an undamaged machine, indicates the presence of damage in the synchronous generator [3].

References

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