Turbine Generator Vibration Testing

using the ZonicBook™

Energy

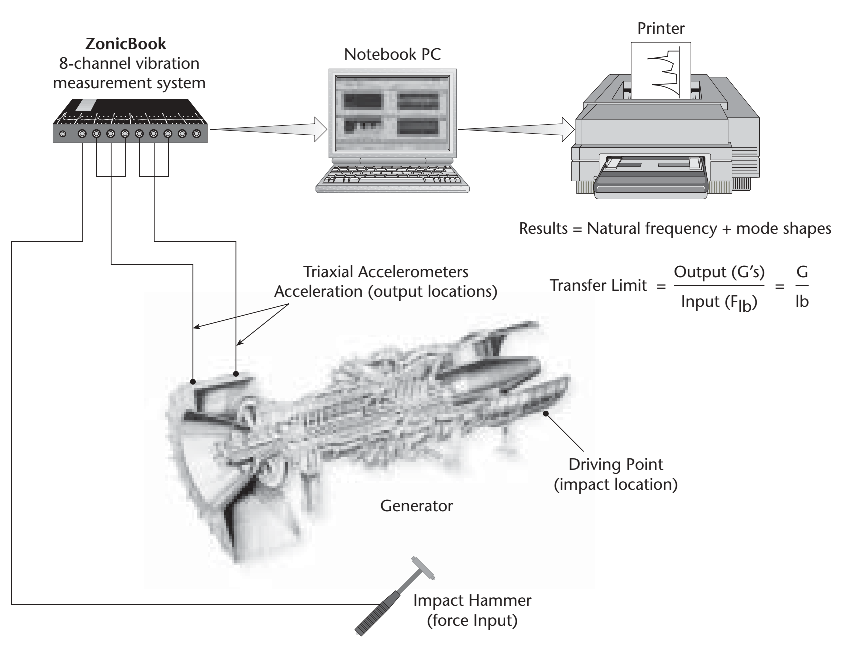
Application Note #64

Application Summary

Design calculations for the steam and combustion turbines and electrical power generators that supply international energy needs are typically computer generated. But the calculations are normally verified in a hardware lab with actual component tests. Design and test engineers also use the lab to proof design modifications, fine tune finite-element models, and perform vibration analyses.

The engineers spend most of their time in the lab collecting data on both new and old turbines, generators, and components, but occasionally, they assist the field service group. Dan Faby, Mechanical Test Designer at Siemens-Westinghouse Corp., Casselberry, Fla., says, "When the field service engineers become unusually concerned about a particular problem, we are called to take a more detailed look. For some, we "rap" out the natural frequencies with an impact hammer and find the mode shapes. Then we can better determine the type of failure that might have occurred and how to modify it." Faby analyzes the natural frequencies and determines how the driving forces could affect the parts.

Typical Modal Analysis Hardware Setup



Most new turbine component testing is carried out in the lab where engineers use an impact hammer for modal analysis. Although the test engineers occasionally use an exciter to perform a swept-sine test or a white-noise generator, the impact test is quicker and can be done in the field on an operational turbine as well.

Possible Solution

Like many labs performing these types of tests, Siemens had, for a number of years, employed two different brands of data acquisition systems. But, although both kinds of analyzers were accurate, they had only two input channels and were too heavy and large to be carried to various sites that needed engineering-quality assistance. Moreover, they comprised a cumbersome, three-component system that further limited portability.

IOtech's Solution

The old equipment's limitations prompted Faby to search for another system that was smaller and more portable but did not sacrifice the accuracy he needed for the shock, vibration, and modal testing that was so critical in both the lab and the field. He evaluated several different data acquisition system manufacturers and selected the IOtech ZonicBook™. Says Faby, "Going to 8-channels from a 2-channel instrument housed in a huge and heavy chassis was a big step for us. To have a little black box that weighs less than 5 lbs. with 8-channel capability is a tremendous advantage. Now, I can put it in my briefcase and I'm out of here, and that's exciting. In this business you've got to be ready to go anytime."

Faby primarily uses the ZonicBook to fine-tune the FE analytical model. Calculations are made on a new design and the part is built. Then he tests it in the lab to see how close the part comes to predicted behavior. Generally, the design engineers are very close, but the additional input that they get from the ZonicBook helps them tune their analytical model even closer, so they can predict better. Faby and his colleagues have used IOtech ZonicBooks for FFT analysis, but generally they concentrate on the transfer function.

From time to time, Faby uses a shaker or an exciter to do a swept-sine analysis or a large speaker to inject "white noise" into a component such as a combustion turbine transition. Most often in the field, however, he uses an impact hammer as an exciter. The shaker or noise injection procedure is considered a lab test, not a field test. "We are usually under a time constraint too, so obviously impact tests go a lot faster than swept sine," states Faby.

Faby says he likes the ZonicBook's small size the best, but another handy feature is the 8-channel input. He uses two triaxial accelerometers and runs them both at the same time while using one channel for another input. When using 7 channels his data acquisition time is cut in half. "That's a tremendous advantage," says Faby. "A multi-channel system for this particular kind of field application isn't necessary because I don't acquire all the signals simultaneously." Basically, he excites one point and then runs the accelerometers over the geometry of the part.

The frequency range covered is 0 to 5 kHz, which pretty much handles most of the testing. Says Faby, "Sometimes the engineers want data at 10 kHz, and I ask why. Not much happens at 10 kHz on a mechanical structure, and I am reluctant to take unnecessary data." At the other end of the spectrum, no one really measures 5 Hz or less. And if they did they would probably not be satisfied with the resolution. Faby says he would have to do something differently, but he is rarely concerned about anything in that range.

ZonicBooks are rugged. "We try to be careful with them," says Faby, "but sometimes we work in the middle of a generator stator frame where it is quite dark. We try to put our ZonicBook in a safe place, and just when we think we have, it slips to the level below. So I can tell you that it does withstand some pretty good g forces."

The data Faby collects is more than satisfactory, and he has had no hardware problems. The only thing seen are the classical signal acquisition problems that everyone deals with such as cable routing, connector integrity, electrical noise tables, and so forth. Also, he doesn't usually have a problem with electromagnetic fields interfering with the accelerometers, because most often, the equipment is not running when acquiring data. However, when he does an operating deflection shape, the machine would be running, and the only worry is whether 60 or 120-Hz signals are being picked up. If they are, he shields the sensors, and that generally takes care of the problem. Or he might add a ground wire from the box itself to some external ground. That usually takes care of the noise, but interference is certainly something the engineers always look at very closely.

Conclusion

Turbine and combustion generator manufacturers test component parts such as rotating blades, stationary blades, or an entire segment of a generator frame in the lab. At Siemens Westinghouse, these measurements are collected by an IOtech ZonicBook data acquisition system. It helps engineers verify their design calculations and lets them fine tune their finite element models so they can run even more accurate calculations on the following design job. Part of the testing includes rapping the component with a hammer and recording the vibrations for analyzing vibration modes, frequency response, and coherence. This allows them to determine the natural frequencies, modal shapes, and numerous other signal components needed to ensure a safe, robust MW turbine generator.