GE
Measurement & Control

Machinery Diagnostics Services

Structural Testing Fact Sheet

Behind every suite of great products is a team of great people, and the Bently Nevada* Machinery Diagnostics Services (MDS) Team is one of the most experienced in the industry. Our dedicated service teams focus on providing proactive, consistent support throughout the lifecycle of your operations.

Our MDS engineers model, acquire data and analyze rotor behavior on rotating machinery but they also look at the behavior of the non-rotating components. Measuring natural frequencies and mode shapes helps to understand how they might affect the response of a structure when a force excites the structure. This is particularly the case in variable speed machines, where the interaction of the machine and its supporting structure may generate excessive vibration during normal startup and shutdown.

Over the last two decades, advanced signal processing techniques and improved processing power in computers have resulted in two techniques that are commonly utilized to improve the understanding of machine behavior. These techniques are the Operating Deflection Shape (ODS) study and Modal Impact Testing. The two techniques are different, most notably the ODS study is accomplished on a running machine, whereas the Modal Impact Test is commonly accomplished on a static component of a non-operating machine such as a bearing pedestal or turbine blade.

Operating Deflection Shape (ODS)/ Experimental Mode Shape Analysis

A preliminary baseline survey should be completed prior to the ODS analysis. The baseline survey allows the engineers to determine what areas of the machine and supporting structure are exhibiting high vibration levels, the dominant excitation frequencies during normal operation and what data should be used in the construction of the model used in the ODS study. The baseline survey data is acquired with the machine in normal operating mode, on rotating equipment bearing housings, and supporting structural framework and foundations. Assuming that the focus of the analysis is on rotating components in a given machine section, it is essential that data be acquired on all bearing housings and in three orthogonal directions (X, Y and Z). Collecting data in three directions at each measurement location allows for the future construction of ODS matrix model. A typical grid or matrix is shown in Figure 1.

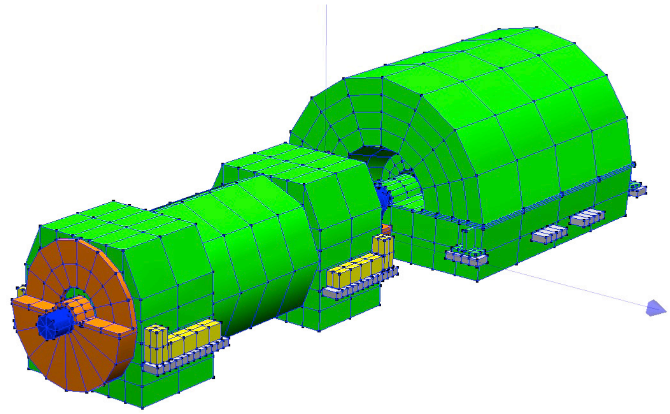

Figure 1. Example of ODS for Structural Vibration Study of an LP Turbine and Generator

The pre-defined points have been optimized based on the baseline study and allows the visualization of the forced motion of a machine. Visualization tools include the ability to view three dimensional animations showing the structural deflections to study the machine motions at a particular point in time or speed.

In an ODS study, there is a requirement to have a minimum of two channels of simultaneous data. One transducer is fixed and one transducer is considered to be a roving transducer. The fixed accelerometer measurement provides the reference for phase measurement between all measurement locations.

Complex data is collected at all predefined points and input to a modal software package to show the exaggerated motion of the machine at certain speeds and/or loads. In actual practice, triaxial accelerometers are frequently used. Having a large number of input channels in the data acquisition system greatly shortens the time required to acquire all the data. When utilizing a triaxial accelerometer a minimum of four input channels are desired in the analyzer—one for the reference and one each for the X, Y and Z axis signals. The machine speed and load conditions should be maintained as constant as possible during the data acquisition phase. This is typically not a problem for rotating machinery, although coordination with the customer is essential. The data is then processed using modal analysis software to show the animation of a three dimensional model of the structure, showing relative amplitude and phase between all measured points, at any selected frequency. If the normal operating condition data is fit to natural frequencies of the system, identified through speed trials or by impact testing, the resulting shapes obtained in the modal analysis software are experimental mode shapes.

The typical on-site time requirement for the ODS study is 8 to 16 hours for most normal machinery testing. Additional time (16 to 32 hours) is needed for data processing, geometry modeling, curve fitting, data analysis and reporting.

Modal Impact Testing

Modal Impact Testing established the natural frequencies of various components so that under operating conditions forcing frequencies which may be destructive may be avoided. For example, it is not recommended having the piping associated with a 1500 RPM pump to have a 25 Hz or 1500 cpm resonance.

Impact testing involves striking a point on a structure with a special hammer, usually the Impact Hammer Kit (P/N 285570-xx). Impact hammer testing involves striking a mechanical structure with an instrumented hammer and collecting response information from transducers mounted on the structure. The response from a single accelerometer yields important characteristics of the structure and integration of response information from multiple accelerometers at various points allows for modal analysis. The hammer has an attached force sensor and the structure has transducers to allow measurement of the response of the structure at different locations. Due to the mass and stiffness associated with rotating machinery frames, this form of testing is generally practical only on individual components (i.e. rotor bearings, turbine blades, mounting brackets, piping spans, motor pedestals, etc.), as shown in Figure 2.

Figure 2. Example of Modal Impact Test on Machine Section

Additionally, if testing small structures, it is important that the added mass of the transducers not significantly affect the resonance of the test object. Impacting testing is relatively easy for experienced personnel, but care should be taken to ensure that the test structure is not damaged in testing and that a sufficient number of points are tested so as to determine all modes of interest and determine all relevant vibration transmission paths.

The typical time requirement is 4 to 8 hours for most normal machinery testing.

GE Measurement & Control
1631 Bently Parkway South
Minden, NV 89423-4119

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