Modal analysis obtains important information about the natural frequencies, damping coefficients and mode shapes of a test unit to optimize its design and improve its structural behavior. The modal parameters and mechanical properties of a structure provides crucial information regarding its vibration characteristics during operating conditions.

The case described in this article studies the modal characteristics of processing equipment acquired through experimental modal analysis. A hammer impact test is carried out with two tri-axial accelerometers to study the modal behavior of the test unit. The roving response method obtains a complete FRF column. Since the processing machinery is large, a sledgehammer is chosen to provide sufficient excitation to the equipment. The hammer impact test module of the EDM Modal suite assists in executing this test.

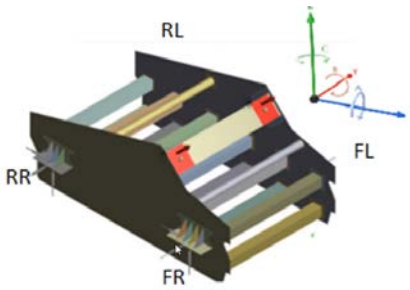

Figure 1. Hammer Impact Modal Test of the Processing Equipment

A geometry mesh configuration of 28 measurement points is uniformly distributed throughout the machinery to create a coarse 3D model. The equipment is installed in its operational condition for the experimental setup. The tri-axial accelerometers are roved through the different measurement points, and the sledgehammer is used to excite the structure at one fixed reference location. Measuring the excitation force and response acceleration in the X, Y and Z directions facilitates in obtaining the 3D mode shapes.

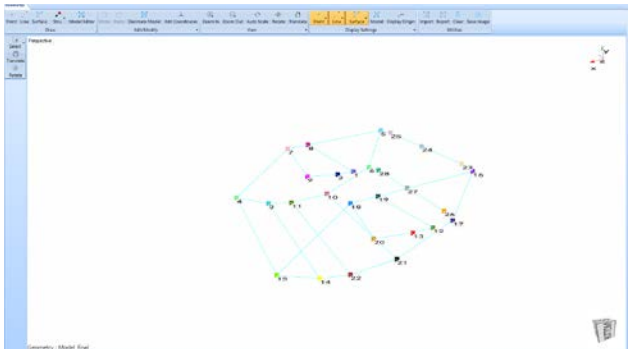

Figure 2. Processing Equipment 3D Geometric Model

Since the machinery has modes in the lower frequency range, a sampling rate of 200 Hz is set. A block size of 4096 is selected to ensure that the response decays naturally and windowing does not need to be applied. A fine frequency resolution of 0.05 Hz is produced with these configuration settings. Measurements of higher accuracy and reduced noise are obtained by linearly averaging 3 blocks of data at each measurement DOF.

The hammer impact excitation imparts energy across a broad frequency range of 100 Hz. With this setup, there will be no leakage and a uniform window can be selected.

Figure 3. Hammer Impact Measurement of the Processing Equipment

The FRF measurement shows resonance peaks in the desired frequency band. Overlapping the FRFs shows the peaks have good alignment. Since the sensors are small and weigh significantly less than the machinery, the mass loading effect is extremely minimal.

Figure 4. Modal Data Selection tab showing the overlapped FRFs

The Poly-X method is used to curve-fit the FRF's to procure the following stability diagram. Flexible modes are selected within the desired frequency range. Multivariate Mode Indicator Function (MMIF) is used to indicate the valleys at natural frequencies.

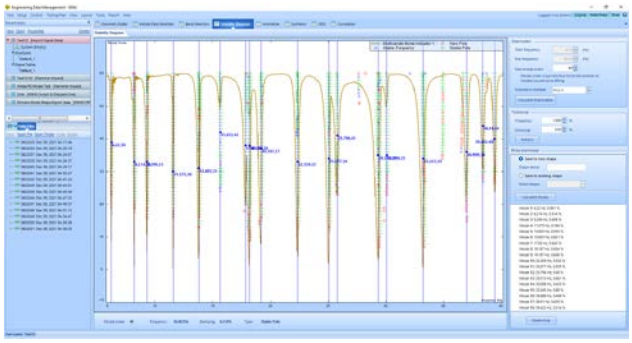

Figure 5. Stability Diagram for the flexible modes

The Auto-MAC matrix helps users validate the results. The Auto-MAC matrix below shows that the modes are orthogonal to each other (low off-diagonal elements) and are uniquely identified (high diagonal elements). Some off-diagonal elements are high, which indicates that the spatial resolution is low for the modal test of this machinery. Using more measurement points for the modal test could provide a better MAC matrix.

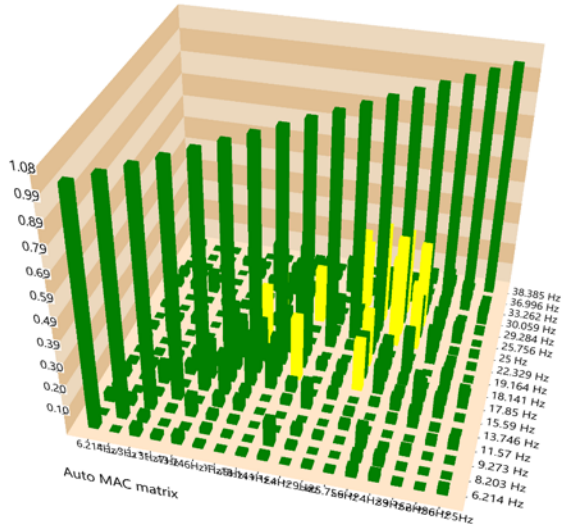

Figure 6. Auto MAC chart for the Processing Equipment Hammer Impact Modal Test

The animation for a few mode shapes associated with the stable physical poles are shown in the following screenshots.

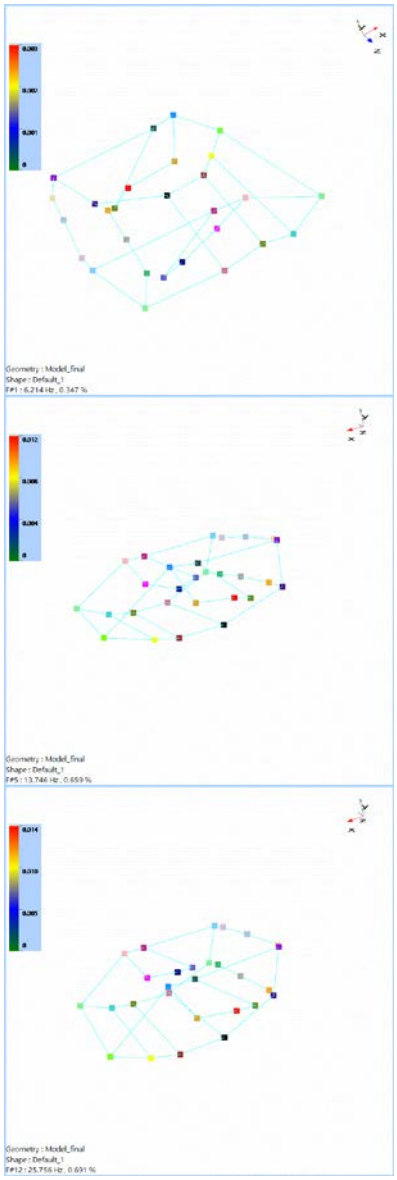

Figure 7. Flexible Mode Shapes of the Processing Equipment

The results show the strength and efficiency of Crystal Instruments EDM Modal software to execute complicated modal tests on large intricate structures.

To learn more about EDM Modal software, visit: www.crystalinstruments.com/structural-testing.

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