Modal Analysis

Modal analysis studies the dynamic properties or "structural characteristics" of a mechanical structure under dynamic excitation (shock, vibration or oscillation):

1 - resonant frequency - (fundamental and harmonics)
2 - mode shapes
3 - damping

To explain this in a simple manner, we'll take a plate as a theoretical example. We'll apply a force that varies in a sinusoidal fashion on one corner. Then, we'll change the rate of oscillation (frequency rate) of the sinusoidal force, but the peak force stays the same. And then, we'll measure the response of the excitation with an accelerometer attached to the other corner of the plate.

The measured amplitude can vary depending on the frequency rate of the input force. The response amplifies as we apply a force with a frequency rate that gets closer and closer to the system's resonant or natural frequencies. [see Signature, Chord of Mass]

The resonant frequency is the frequency at which any excitation produces an exaggerated response. This is important to know since excitation close to a structure's resonant frequency will often produce adverse effects. These generally involve excessive vibration leading to potential fatigue failures, damage to the more delicate parts of the structure or, in extreme cases, complete structural failure.

Example: when spinning, the washing machine's drum vibrations induce such a powerful resonant frequency that the machine begins to actually move causing the door to spring open.

If we take the time data and transform it to the frequency domain using a Fast Fourier Transform algorithm to compute something called the "frequency response function", we see the functional peaks that occur at the resonant frequencies of the system.

Deformation patterns (bending, twisting, etc.) at these resonant frequencies take on a variety of different shapes depending on the excitation force frequency. These deformation patterns are referred to as the structure's mode shapes.

Example of second mode animation: Noise and vibration engineers appreciate the animated resonance display of LMS Test.Lab

Structural damping provides information about how quickly the structure dissipates vibrational energy and returns to rest when the excitation force is removed.

Example: in the well-known case of the Tacoma bridge, the damping was not high enough to absorb all the excitation energy.

Modal analysis refers to a complete process including both an acquisition phase and an analysis phase. The structure is excited by external forces such as an impact hammer or shaker. In this case, we talk about **experimental modal analysis**. [http://www.lmsintl.com/modal-analysis]

Modal testing systems consist of transducers (typically accelerometers and force cells), an analog to digital converter or front-end to digitize the analog instrumentation signals and a host PC to review and analyze the data.

Operational Modal Analysis complements traditional **modal analysis** methods. It only measures the response of test structures under actual operating conditions. It is used to test cars, airplanes, wind turbines and any other applications that are difficult or even impossible to excite by external force, owing to boundary conditions or sheer physical size. **Modal testing** results can also be used to correlate simulation analysis and create a 'real-life' simulation model.

To guarantee realistic high fidelity simulations, it is essential that simulation models meet stringent accuracy standards. Ensuring reliable simulation results requires component, subsystem and full-system models to be compared with experimental data, or alternatively validated models of similar structures. Building and validating system models from the bottom up is the only way to prevent accumulating inaccuracies. Besides more reliable what-if analyses, validated models provide a better understanding of assumptions made regarding material properties, connections, joints and boundary conditions. Modal Analysis

See Also

Attenuation
Chladni Plate Vibrations
Chord of Mass
Chord of the Mass
Cymatics
Cymatics - Jenny
Eigenfrequency
Ernst Florens Friedrich Chladni
Figure 17.03 - Analysis of the Octave Gravity Bar
Finite Element Analysis
Frequency Response
Fundamental
Graduation
Megan Watts Hughes
Mass Chord
Modal Analysis - Part 2
Mode
Oscillation
resonant frequency
resonating plates
Robert Hooke
Signature
Table of Plate Harmonics and Intervals
Vibration
wave plate