

# MODAL IMPACT TESTING TECHNIQUES & USES

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Modal impact testing is one example of the experimental modal analysis techniques used to find the natural frequencies of vibration of a structure. Impact testing uses an instrumented hammer to deliver an impulse force to a structure while the vibrations are measured with other instrumentation. It is important to determine the natural frequencies of turbomachinery structures like airfoils in order to be able to avoid matching the natural frequencies and the excitation force frequencies from objects like stator & strut vane wakes. This is because resonance occurs when frequencies are matched and vibrational energy significantly amplifies even small excitation forces to much higher levels, potentially causing high cycle fatigue stresses. Although finite element analysis (FEA) is often used to simulate structure vibrations, the natural frequencies can also be found experimentally with modal impact testing.

The typical equipment used for testing is the instrumented impact hammer to apply the force, a small accelerometer to record the vibrations, an analog to digital signal converter, and signal analyzing software capable of converting the vibrations from the time domain to the frequency domain. It is important to have a basic understanding of the proper setup and adjustments possible (such as frequency range, windowing, averaging, etc.) in the software in order to capture the correct data. Although modal impact testing can be applied to any structure, the most common example of use at RMS is on individual rotor

blades. Pictures of the equipment and process flow are shown below in Figure 1.

The basic testing steps include the following:

- 1) Connect all the equipment with cables and adhesively mount the accelerometer to the blade at a location of high motion during vibration.
- 2) Put the structure in either a “free state” by suspending it with elastic cord or placing it on a very soft cushion. This will closely simulate being unrestrained so that it will vibrate freely all over. Or put it into a “fixed state” by constraining the structure as it would be in operation. For the case of rotor blades held in a spinning disc, the “fixed state” is difficult to simulate since the constraint gets much tighter when the rotor is spinning than at assembly. Therefore, blades are typically tested in the “free state” and are used to calibrate to an FEA vibration model also with “free state” constraints.
- 3) Strike the structure with the hammer while the accelerometer records the vibrations. Watch the impact signal to make sure a very short duration impulse force input has been achieved and not a double impact.
- 4) Signal analyzing software processes the accelerometer data from the time domain in which it was collected and converts it into the frequency domain with a Fast Fourier Transform (FFT). The details

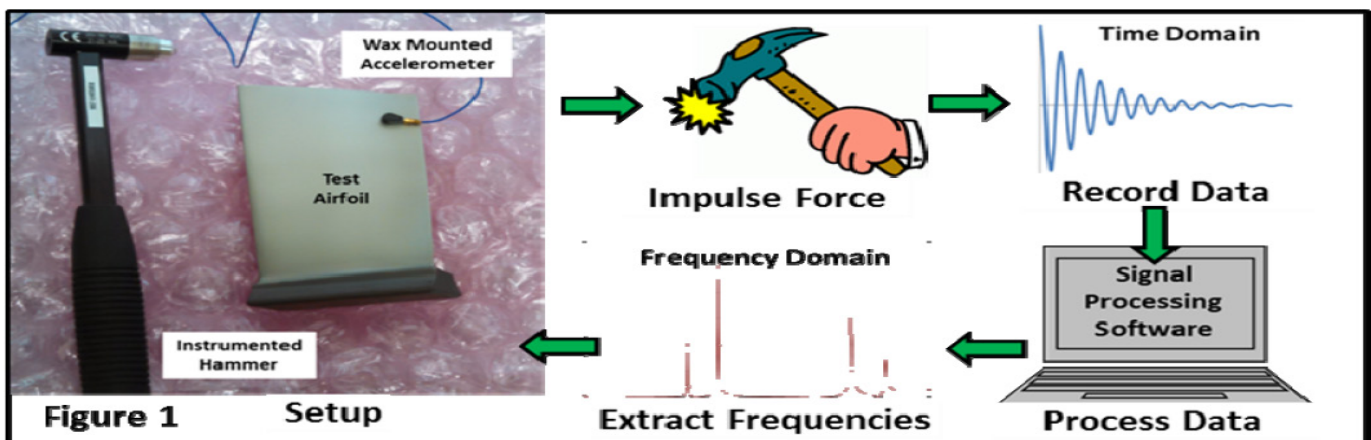


Figure 1

of signal processing math are beyond the scope of this article, but viewing the signal in the frequency domain enables a much easier identification of the largest components of vibration (the natural frequencies).

5) Typically the impact test is repeated and data gathered without changing the setup multiple times in order to be able to average the data together inside the software to reduce “signal noise”.

6) Finally, the structure natural frequencies are extracted by finding the locations of the highest responses from a plot of acceleration vs. frequency. RMS has developed peak find macros to automate this processing. An example plot with frequencies identified is shown in Figure 2.

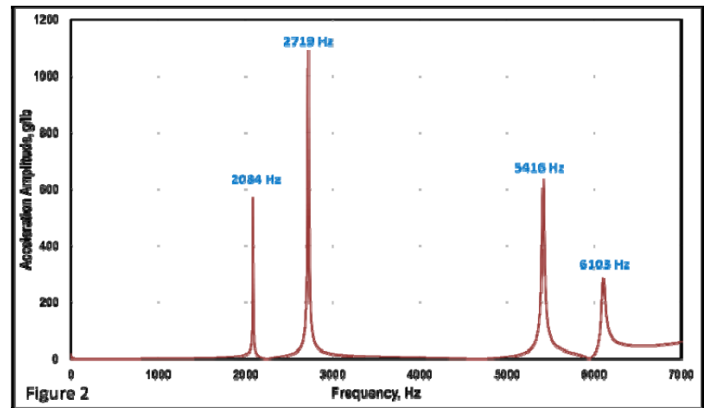


Figure 2

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