Mode shape v2.1h Introduction (P-code Package)

The Mode shape program

Lamb waves are complicated guided plate waves. Lamb waves are of two basic varieties, symmetric Lamb–waves modes (S0, S1, S2, …) and antisymmetric Lamb–waves modes (A0, A1, A2, …). Both Lamb–wave types are quite dispersive. At any given value of the frequency–thickness product *fd*, a multitude of symmetric and antisymmetric Lamb waves may exist.

The Mode shape program is a tool for the calculation and visualization of Lamb wave propagating modes. The program use pre-calculated Lamb wave velocity to calculate the displacement field through the plate thickness, and along the wave propagation direction. The mode shape is the displacement distribution across the thickness of the plate. The program also provides the stress distribution of Lamb wave modes. The Mode shape program use a graphical user interface (GUI) to let the user choose the Lamb wave mode and frequency from the Lamb wave velocity dispersion curves. The program also provides animation of the displacement field to visualize the propagation of Lamb wave modes.

How to start the program

The mode shape program is provided as a zipped package *Mode_shape_v2_1h.zip*. To run the program, one needs to extract the contents of the zip file to a folder. The extracted files include a MATLAB program p-code *mode_shape_v2_1h.p*, the GUI figure file *mode_shape_v2_1h.fig*, and a group of CSV files with the pre-calculated Lamb wave phase velocity of anti-symmetric and symmetric modes. To run the p-code, start MATLAB, and change the *Current Folder* to the folder where the files were extracted. Select the *mode_shape_v2_1h.p* file, and then press *F*9 to run the program.

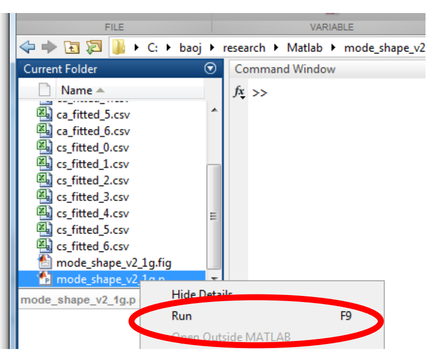

Figure 1 Extract the package to a folder, and select the program p-code (*mode_shape_v2_1h.p file*), then press the F9 button on the keyboard or choose "Run" on the mouse right-button-click menu to start the program.

The program will load the CSV files where the data of the dispersion curves are stored. The Lamb wave velocity data were calculated for materials with 0.33 Poisson's ratio, which can be applied for a wide range of metallic materials, such as 2024, and 6061 aluminum alloys. In each CSV file, there are two columns of data, the first column is the *fd* value, and the second column is the phase velocity. The *fd* value is the product of the frequency and half-thickness of the plate.

Program functions

There are four main plotting areas on the Mode shape program front panel. These plots visualize the **Dispersion Curve**, the **Displacement Vectors**, the **Mode Shape**, and the **Stress Distribution** plots. A screen capture of the Mode shape program is shown in Figure 2. The functionality of each plot type is discussed in the following sections.

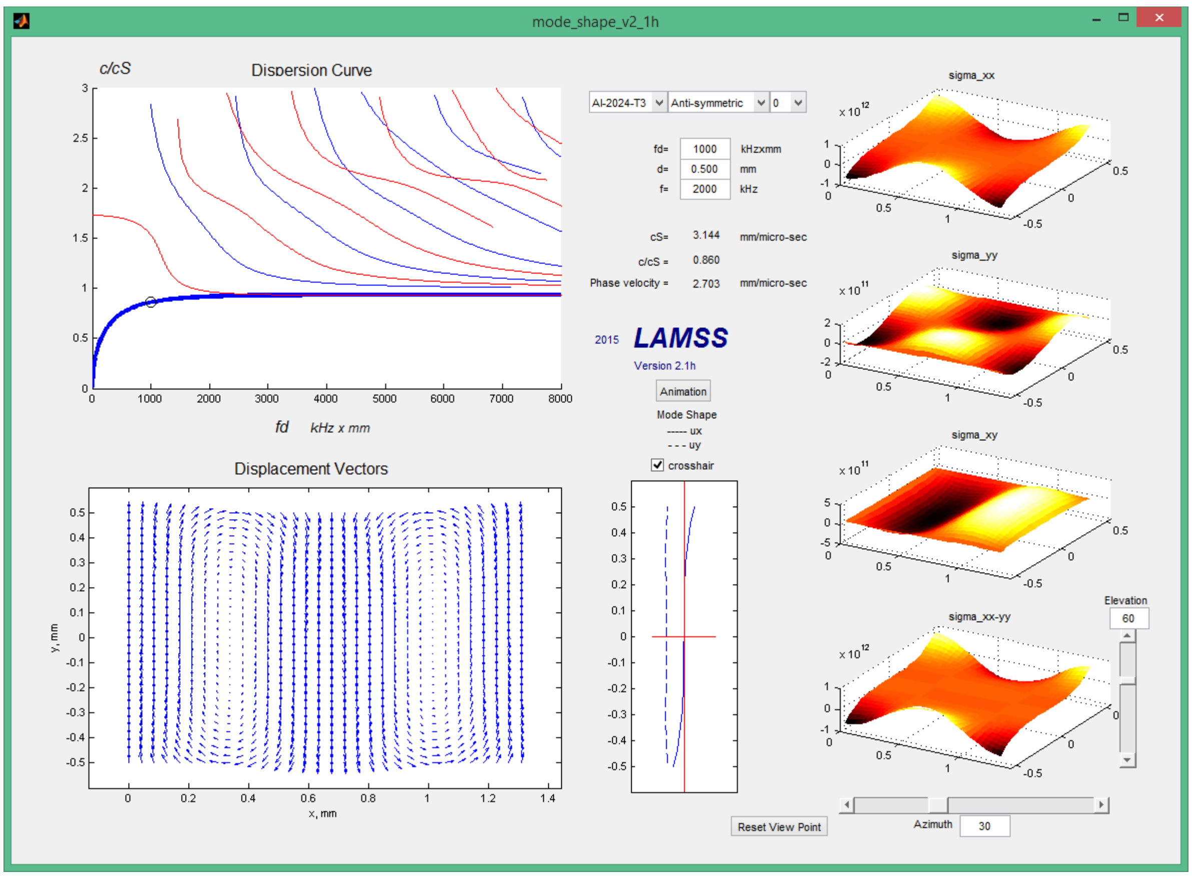

Figure 2 Mode Shape program GUI visualizes the Lamb wave displacement and stress field.

Dispersion Curve Plot

The Lamb wave velocity data were calculated for materials with 0.33 Poisson's ratio, which can be applied for a wide range of metallic materials, such as 2024, and 6061 aluminum alloys. The default material is AL-2024-T3. The default *fd* value is 1000. The half-thickness *d* is equal to 0.5 mm. The default mode is the Anti-symmetric 0 mode.

The Lamb wave phase velocity dispersion curves have symmetric and antisymmetric modes. The symmetric modes are plotted in red lines, and the antisymmetric modes are plotted in blue lines. The current selected *fd* value and normalized phase velocity c/c_s is indicated by a circular cursor on the plot. It is also possible to use the mouse left button to click on any dispersion curves to select a different wave mode and *fd* value. Once the cursor is moved to a new position, the selected wave mode, *fd* value, c/c_s value are updated on the displays to the right side of the dispersion curve plot. The material, Lamb wave mode, mode number, *fd* value, half-thickness *d*, and the frequency also can be changed with the pull-down menu and enter new values in the textboxes. Once changed, the cursor will be automatically updated to match the new values.

Displacement Vectors Plot

The particle displacement through the thickness of the plate is visualized by a "quiver" plot. A mesh grid is created to cover a full wavelength of the current selected wave mode and frequency. There are 32 segments along the wave length (*x* direction) and the thickness (*y* direction) of the plate. Straight crested wave assumption was used for the displacement calculation. Hence the particle displacement is in a 2-D plane along the wave propagation direction. The amplitude ratio of the displacement in the *x* and *y* direction is calculated by the differential equations of the Lamb wave mode. There is an **Animation** button to start an animation of the displacement vector plot. The animation indicates how the particles move during the Lamb wave propagation.

Mode Shape Plot

The Mode Shape plot shows the displacement distribution along the thickness of the plate. The 2-D displacement is presented by the u_x and u_y components. A check box labeled with "crosshair" is located above the mode shape plot to control whether or not to plot the "crosshair" identify the zero displacement line. If checked, a thin red line is drawn in the mode shape plot to show the zero displacement position.

Stress Distribution Plots

There are four surface plots presenting the stress distribution across the thickness of the plate. The various stress components are the σ_{xx}, σ_{yy}, and σ_{xy} on the cross-section of the plate along the wave propagation direction. There is also a plot showing the σ_{xx}-σ_{yy}, which is created in hope to help the user to identify dominant displacement. The view angle for all the stress distribution plots are controlled by two sliders next to the "sigma_xx-yy" plot. Using the two sliders, one can control the viewing angle for the stress plots. The default viewing angles are 30 degrees for azimuth, and 60 degrees for elevation. A "Reset View Point" button is also provided to reset the viewing angles to the default values.