Analyzing Dynamic Behavior of Aluminium Sheet Metal

Understanding the dynamic behavior of materials and components is essential for designing robust and reliable structures. **Vibration analysis** plays a crucial role in this process, providing insights into how materials respond to dynamic loads. This article highlights a case study demonstrating the application of **Mercury RT**, a powerful tool for full-field vibration analysis, to characterize the vibrational behavior of aluminum sheet metal under laboratory conditions.

Objective

In this case study, the primary objective was to perform a detailed **vibration analysis** of an aluminum sheet metal specimen. The goal was to accurately determine the **three-dimensional displacement** and **operational deflection shapes (ODS)** of the sheet metal at specific frequencies using Mercury RT.

Description of the Case Study

The test specimen consisted of a sheet of aluminum with approximate dimensions of 400 x 20 x 1 mm. To capture the three-dimensional nature of the vibration, a high-speed **3D Digital Image Correlation (DIC)** setup was employed. This setup included:

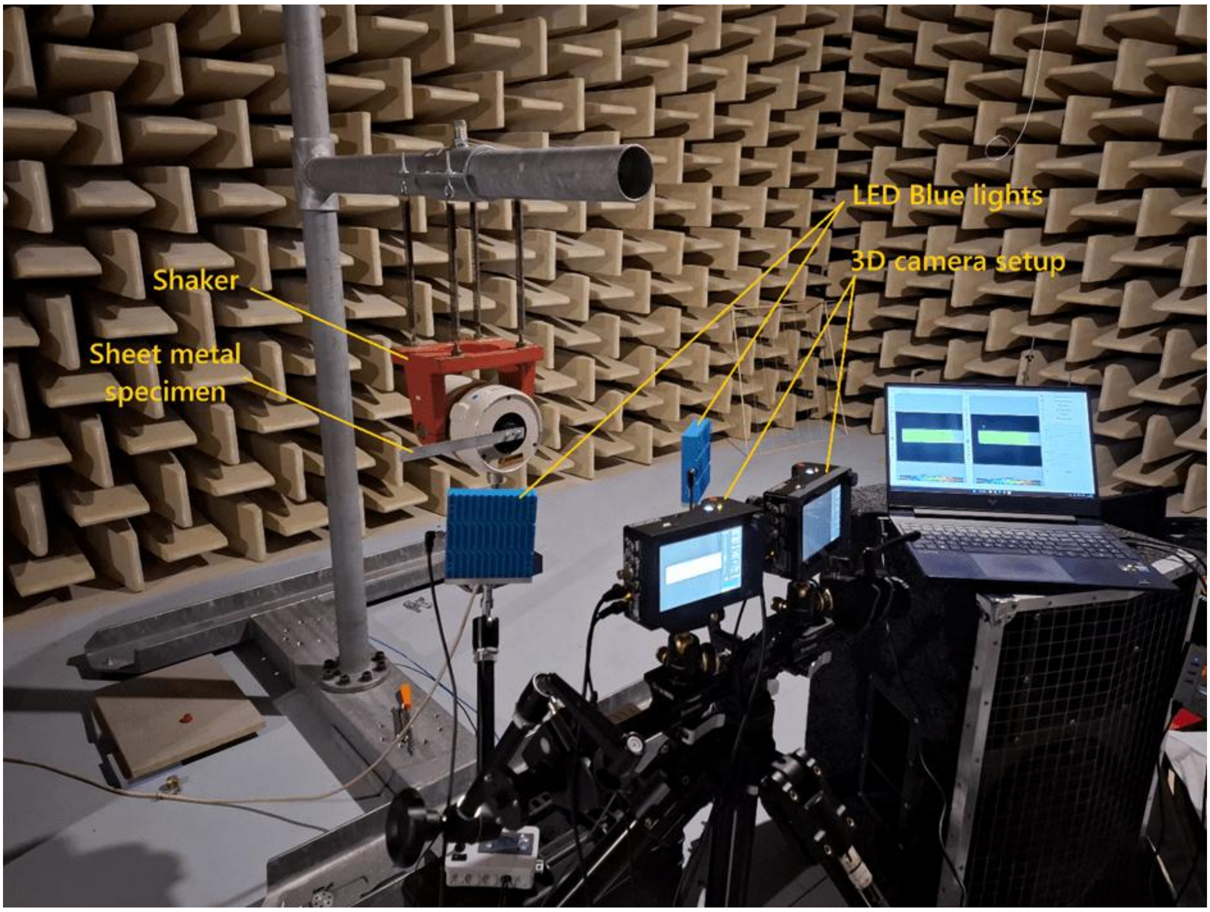

Fig 1: Experimental setup

MERCURY RT

Test setup

- **Excitation Source:** Signal generator and shaker
- **Cameras:** Two synchronized Chronos 1.4 high-speed cameras
- **Resolution:** 1280×1024 pixels
- **Frame Rate:** 1070 frames per second
- Calibration Grid: 3 mm
- **Lighting:** Two non-flickering LED blue lights to provide consistent illumination
- **Lenses:** 50 mm lenses, with the cameras positioned at a distance of 600 mm from the specimen. (Note: Due to hardware limitations, measurements were focused on the outer part of the specimen).
- **Software:** MercuryRT with 3D DIC and Vibrography modules

Fig 2: Test setup

Step-by-Step Vibration Analysis with Mercury RT

The vibration analysis was conducted using the following step-by-step procedure within the Mercury RT environment:

- **Real-Time Scene Preparation**: The aluminum specimen was prepared by applying a base layer of matte acrylic white paint, followed by a speckle pattern created with matte black acrylic paint. The speckle pattern, crucial for **DIC analysis**, was evaluated using Mercury RT's **Focus Tool**. Real-time camera calibration was performed using a **3 mm calibration grid**, which also established a custom coordinate system for accurate measurements.
- **Chosen Frequency Analysis**: A signal generator and amplifier were used to drive a shaker, which excited the aluminum sheet metal. A sinusoidal waveform was used as the excitation signal. Critical frequencies were identified visually, and the signal generator was set

to these specific frequencies for detailed analysis. Measurements were performed and recorded using Mercury RT at **frequencies of 25 Hz and 36 Hz**.
- **Deflection Rendering**: The full-field displacement data acquired by Mercury RT was processed using the **Vibrography tool**. This tool generated a frequency spectrum, allowing for the identification of peak frequencies. Mercury RT then visualized the **operational deflection shape (ODS)** of the sheet metal at the selected excitation frequency.
- **Dynamic Animation**: To enhance the visualization of small vibrations and displacements, Mercury RT's dynamic animation capabilities were utilized. This feature amplifies the magnitude of the measured deflections and allows for adjusting the speed of the shape's movement, making the vibrational behavior more apparent.

Measurement Results

- Using **3D DIC**, the full-field displacement and strain fields were captured. Displacement in the **Z-direction** (**out-of-plane**) was measured across both test frequencies.

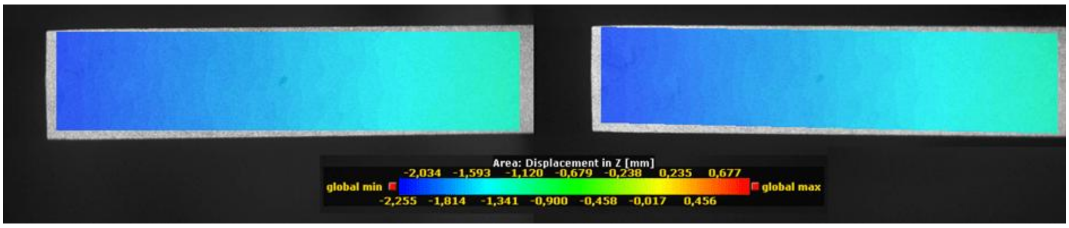

Fig 3: Full-fiedl displacement in Z [mm]

- Results at 25 Hz

Mercury RT captured the full-field displacements in three dimensions: X (green), Y (blue), and Z (red).

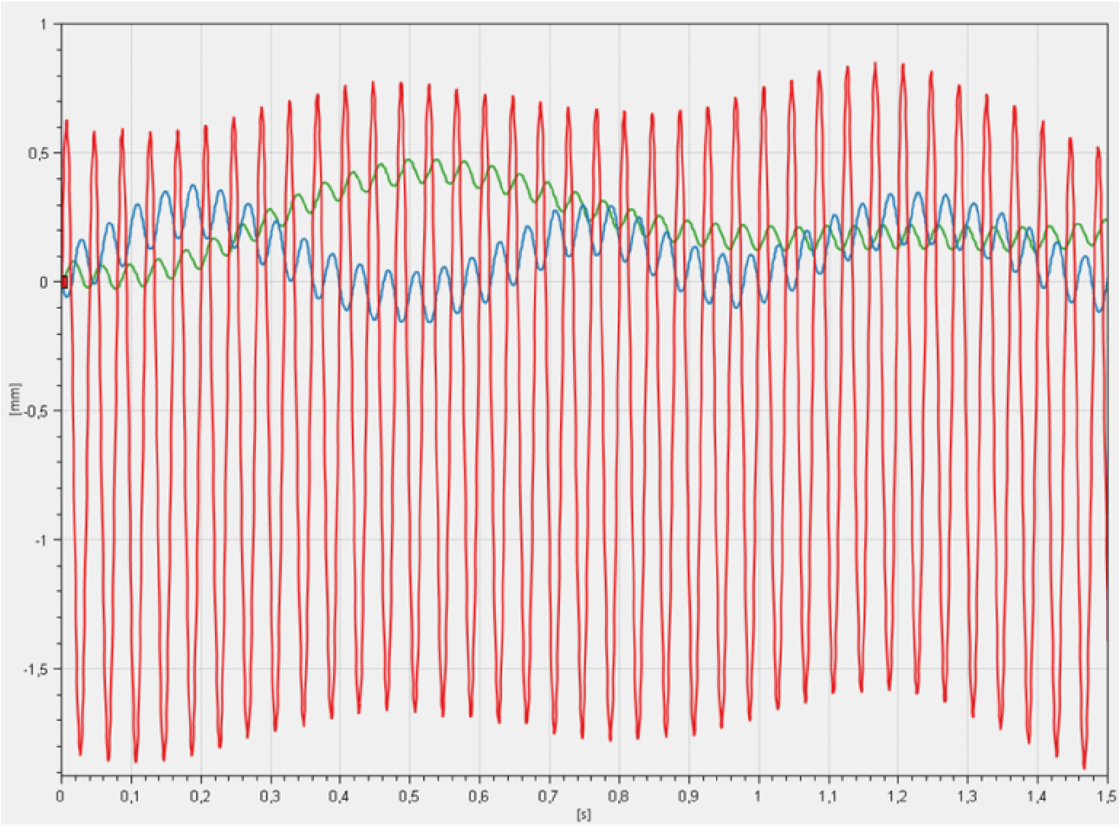

Fig 4: Vibration analysis – displacement at 25 Hz

The displacement data was then analyzed using **Vibrography** to generate the frequency spectrum.

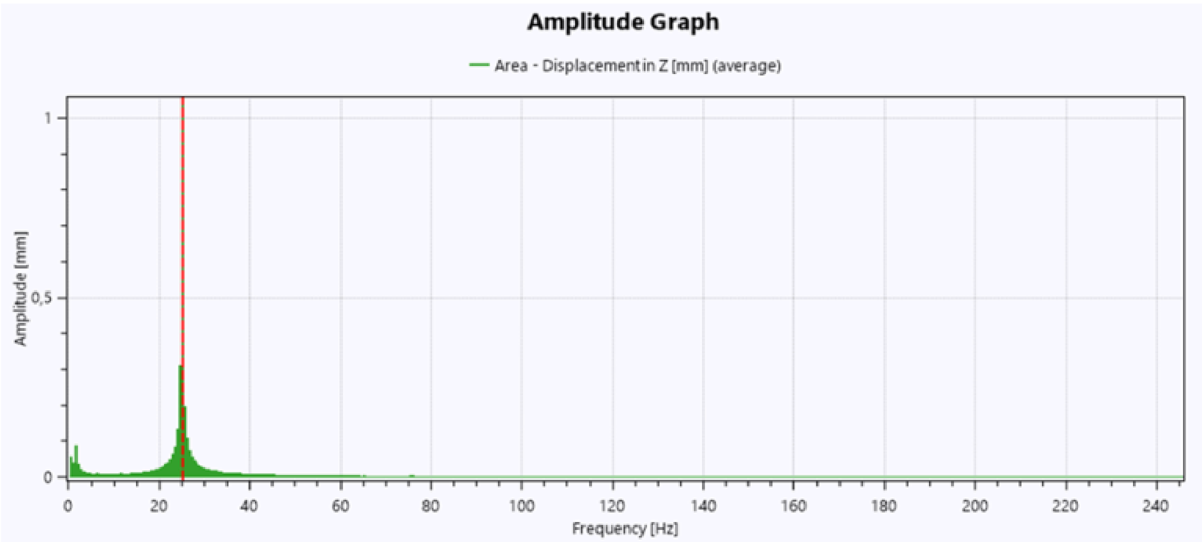

Fig 5: Amplitude graph at 25.1 Hz

The analysis revealed a peak amplitude at a frequency of 25.1 Hz. The corresponding operational deflection shape (ODS) at this frequency was visualized in **Mercury RT**.

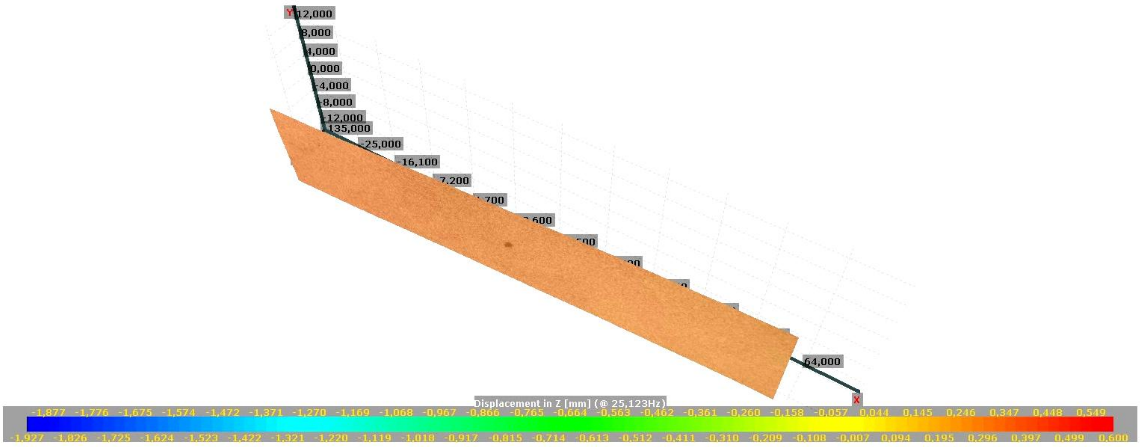

Fig 6: Operational Deflection Shape (ODS) at 25 Hz

❖ Results at 36 Hz

Similar to the 25 Hz analysis, full-field displacements in X (green), Y (blue), and Z (red) were captured.

Fig 7: Osciloscope at 36 Hz

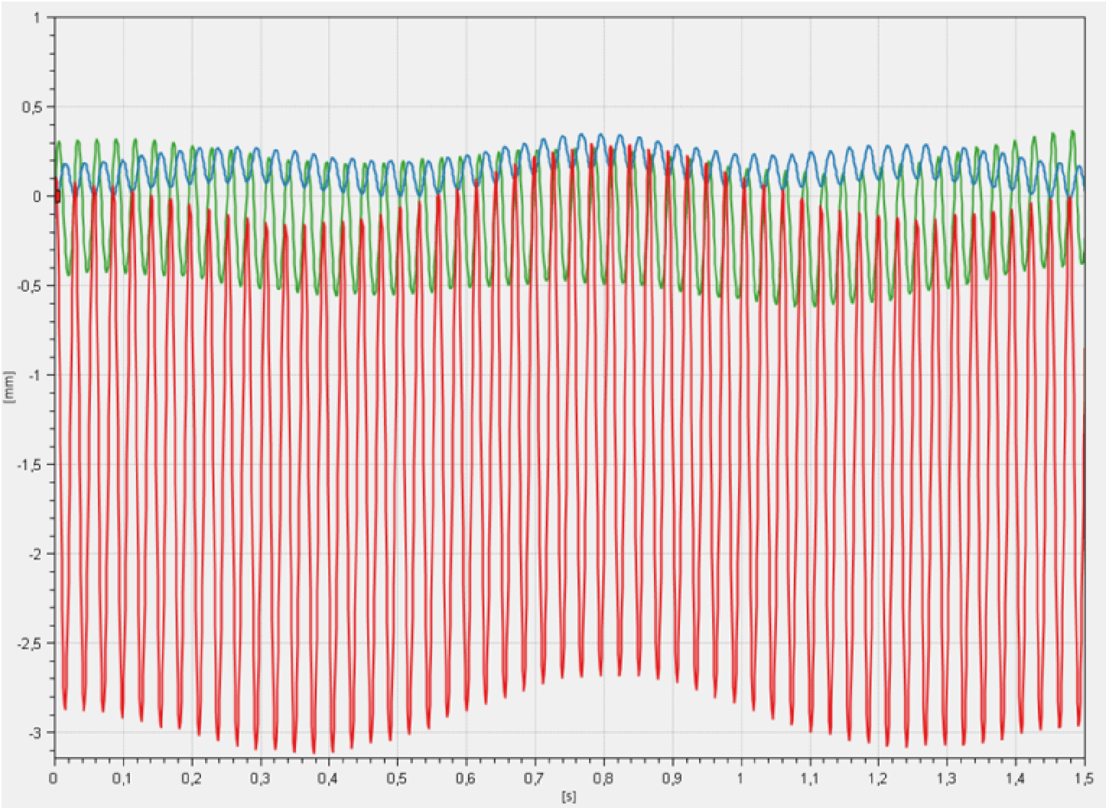

Fig 8: Displacement at 36 Hz

Vibrography analysis was performed to obtain the frequency spectrum.

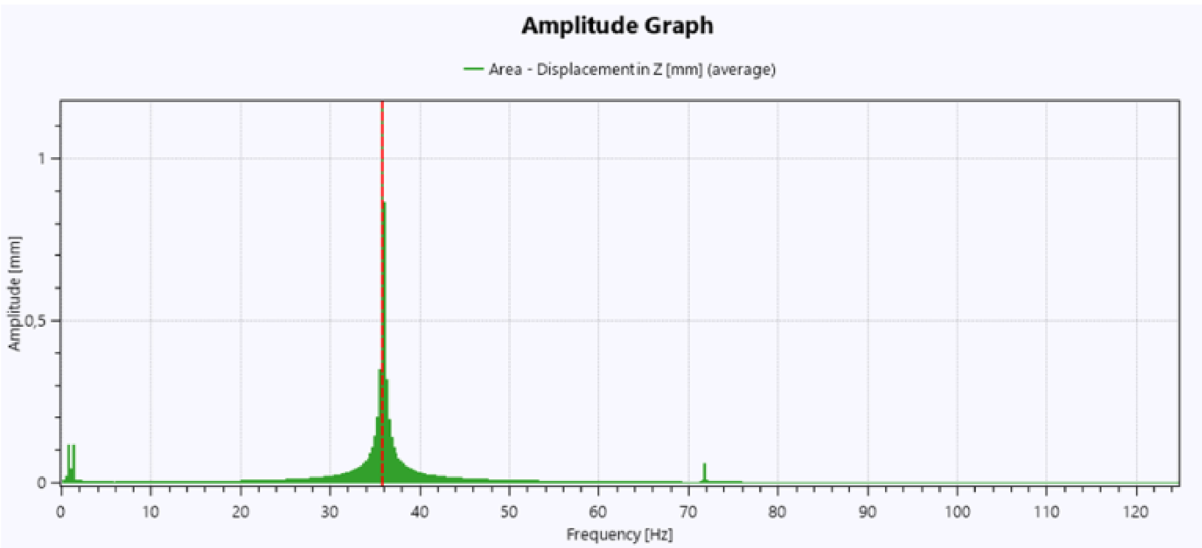

Fig 9: Displacement at 36 Hz

The spectrum indicated a peak amplitude at 35.9 Hz, and the operational deflection shape (ODS) at this frequency was visualized.

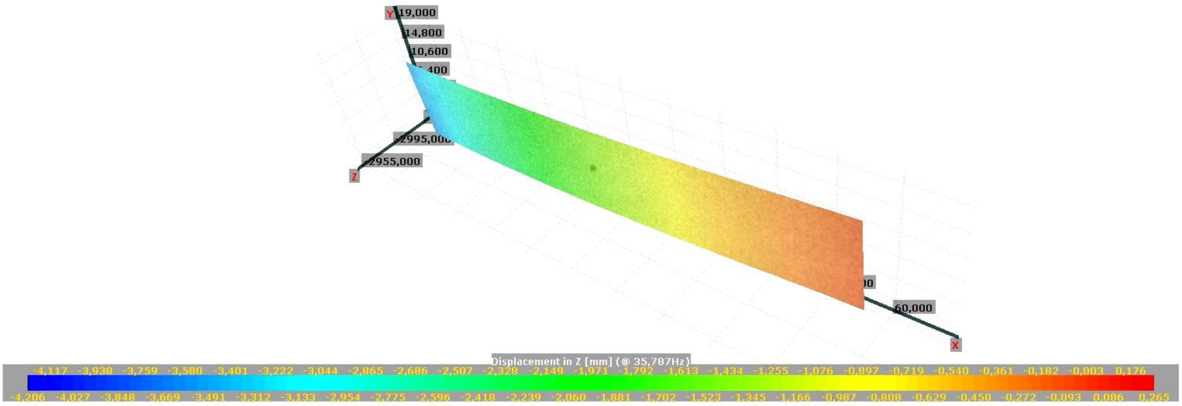

Fig 10: Operational Deflection Shape (ODS) at 36 Hz

Shaker frequency	Resonant frequency - DIC	Deviation
25 Hz	25,1 Hz	0,4 %
36 Hz	35.9 Hz	0,278 %

Key Advantages of Mercury RT for Vibration Analysis

This case study demonstrates the effectiveness of **Mercury RT** for detailed vibration analysis. Key advantages of using **Mercury RT** include:

- **Full-field 3D Displacement Measurement: Mercury RT** provides comprehensive 3D displacement data, capturing the complex motion of the entire surface of the specimen.
- **Operational Deflection Shape (ODS) Visualization:** The software allows for clear visualization of ODS, enabling engineers to understand how the structure deforms at specific frequencies.
- **Vibrography Analysis:** The integrated **Vibrography** tool facilitates in-depth frequency domain analysis, providing valuable insights into the vibrational characteristics of the material.
- **High-Speed Capture:** The use of high-speed cameras allows for the capture of rapid dynamic events, essential for accurate vibration analysis.
- **Non-Contact Measurement: DIC techniques** provide non-contact measurements, eliminating the influence of sensors on the specimen's behavior.

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