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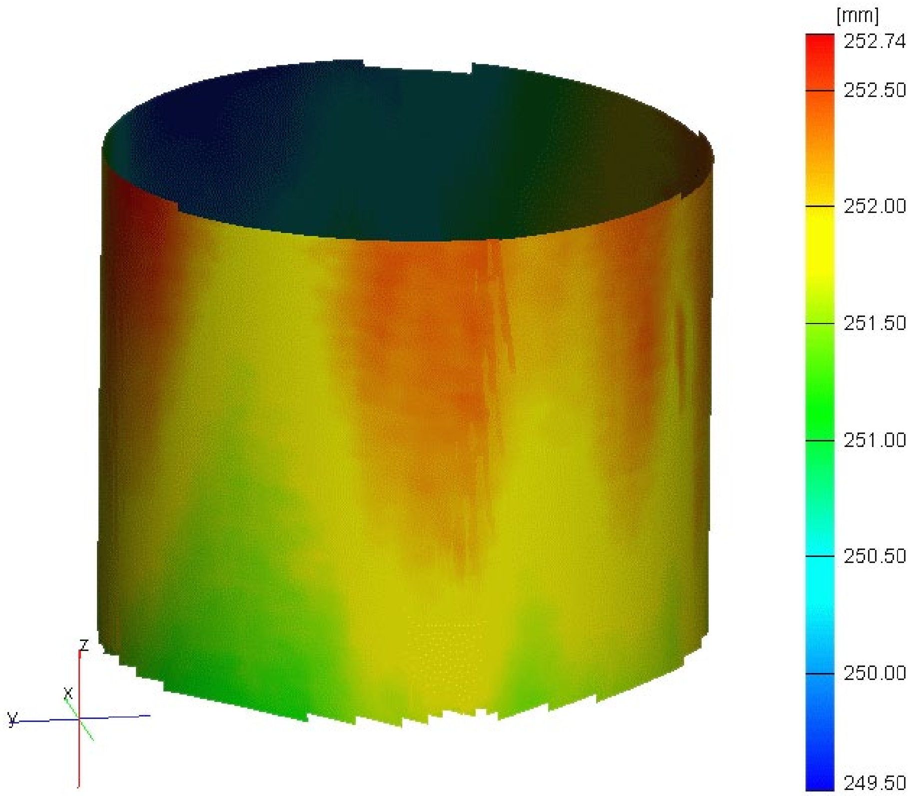
Application Example: Material Testing

Numerical Simulation: Complete deformation measurement using multiple ARAMIS sensors

Measuring Systems: ARAMIS, TRITOP
Keywords: cylinder measurement, buckling

Multiple high speed ARAMIS sensors are used to measure the buckling and post-buckling behaviour of a thin walled CFRP cylinder at DLR (German Aerospace Center).



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Material Testing / Material Analysis

Grating Method used with Composite Shearing Panels

Multiple high speed ARAMIS sensors are used to measure the buckling and post-buckling behaviour of a thin walled CFRP cylinder at DLR (German Aerospace Center - www.dlr.de). In this experiment, the complete surface of the cylinder is observed simultaneously and the resulting deformations are captured in synchronized views. The result is displayed in the coordinate system defined by the object under test to allow an easy verification and optimization of the numerical calculations made to predict the behaviour of thin walled structures. More detailed information about the DLR Institute of Structural Mechanics, their goals and facilities can be found at: http://www.dlr.de/fa/en/

The cylinder with a diameter of 500 mm is loaded with axial compression and torsion in the test system (Fig. 1) This test center applies axial compression, torsion and internal pressure simultaneously to the object under test. During the loading, the four ARAMIS sensors capture synchronized image series from all four sides to cover the full surface of the cylinder (Fig. 2).

Fig. 1: Testing facility

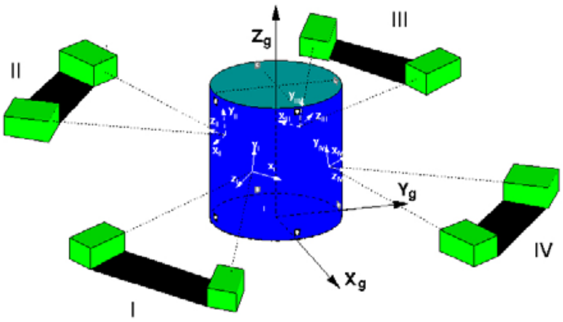

Fig. 2: Set-up of the test cylinder and the four ARAMIS sensors to capture the deformation of the object under load

Each sensor consists of two measuring cameras with 1280 x 1024 pixels and a maximum full frame rate of 485 images/sec (higher for reduced image size) and covers typically 100 degrees of the cylinder's surface. The individual sensors capture the images synchronized in their own local coordinate system.

To transform the individual data into a global coordinate system defined by the cylinder, the proven concept for digitizing with ATOS XL is used. In case large and complex objects need to be digitized, the ATOS system is used in combination with the TRITOP photogrammetry system. For digitizing reference point markers are applied to the object.

In this case, the cylinder is equipped with two rows of reference point markers, one on the top and one on the bottom as well as with some individual reference points (see Fig. 3).

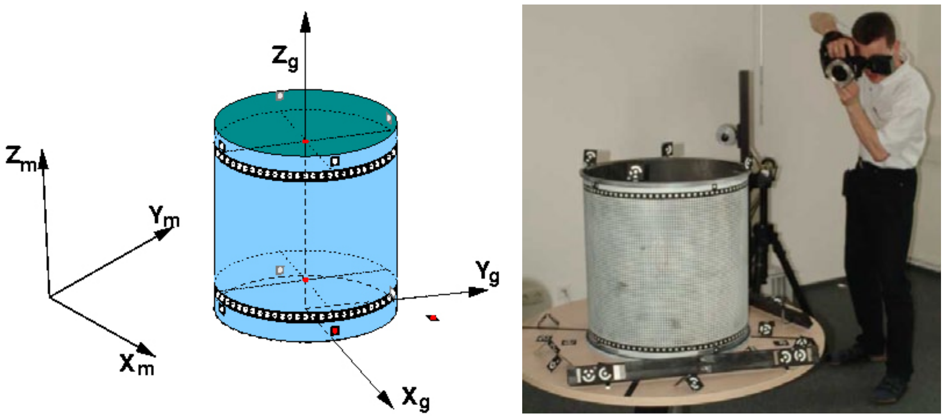

Fig. 3: Test object with attached reference point markers and additional coded markers to define the exact positions of these markers using TRITOP

Then, using a rigid digital camera, multiple images are recorded from various views. Using these images, the software of the photogrammetry system TRITOP calculates the precise 3D positions of the reference point markers. Based on these markers, the position of the cylinder and the positions of the ARAMIS sensors during the capturing of the image sequences is defined. In addition the coordinate system of the measurement set up is aligned to the cylinder axis. The measurement data of the individual ARAMIS sensors are transformed into the object coordinate system of the cylinder, using a minimum of three reference points. Thus, the ARAMIS software is able to process and visualize the four measurement sets as one complete set of data. The available results show the 3D coordinates of the object surface (Fig. 4), the 3D deformation (Fig. 5) and the planar strain in each stage of the load.

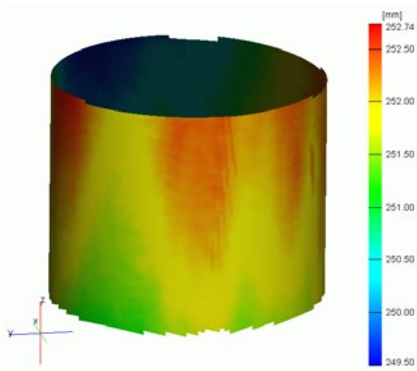

Fig. 4: Graphical display of the local distribution of the cylinder radius captured simultaneously by the four individual ARAMIS sensors

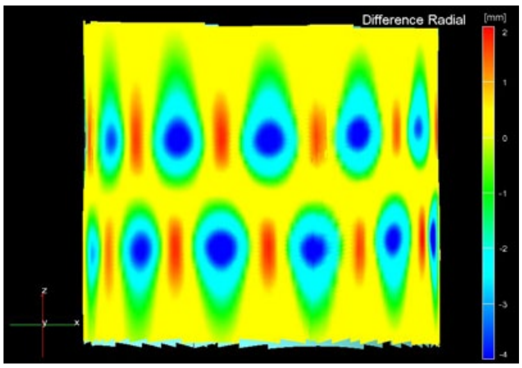

Fig. 5: Graphical representation of the buckling of a thin-walled cylinder under axial load

Based on the recorded geometry data (Fig. 4), the sensors capture the deviations from the cylinder shape under load and calculate the deviation values of the cylinder radius. The measuring values of the different sensors can be combined in a common coordinate system. In addition, the measurement data can be clearly illustrated and show the user how the test object behaves under load (Fig. 5).

The measuring based on multiple ARAMIS sensors has been proven beneficial for multiple applications, for example for measuring the exact thickness-reduction in tensile test situations with two ARAMIS sensors, but also for the synchronous capturing of the complete object or multiple areas, typically if inhomogeneous materials are involved or complex loading situations have to be captured. For capturing fast sequences, multiple ARAMIS sensors can be adjusted to observe the same area and can be triggered in sequence to capture data with high local resolution and fast data rates. The possibility to combine the data captured by multiple ARAMIS sensors and the transformation of these measurement data in customized coordinate systems gives a clear view about the object behaviour. In addition these data can easily be integrated or compared with data generated by numerical simulations.

By courtesy of the DLR, Institut of Structural Mechanics.