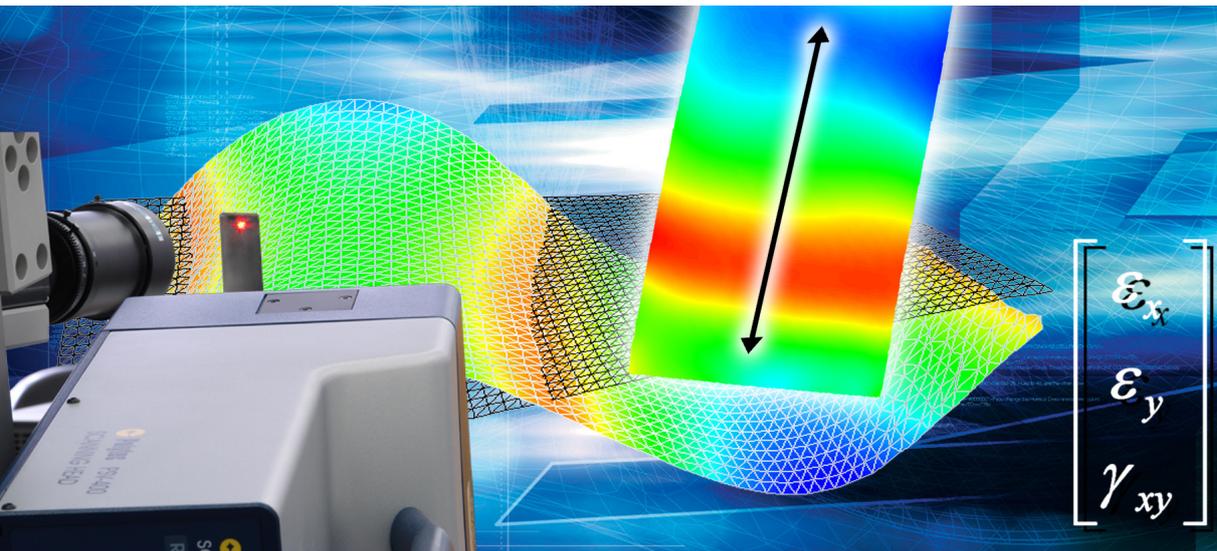


# Optical Measurement of Dynamic Stress and Strain



## Polytec Scanning Vibrometers

- PSV-400 Scanning Vibrometer
- PSV-400-3D Scanning Vibrometer
- RoboVib Structural Test Station
- MSA-500 Micro System Analyzer
- PSV Software
- Scanning Vibrometer Options and Accessories

Understanding the origin of the stress and strain distribution is crucial to increasing the durability of components under dynamic load. Numerical simulations based on finite element (FE) models help with this understanding but must be validated by real component data. Polytec's 3-D Scanning Laser-Doppler Vibrometer provides an advanced, non-contact optical test solution that provides accurate 3-D vibration mapping, sets up quickly and interfaces with geometry models based on FE data.

### Laser Vibrometry Measures Dynamic Stress and Strain

Polytec's StrainProcessor is a measurement extension developed for easy finite element model (FEM) updating and for comparisons to calculated stress and strain distributions. It comprises a set of hardware and software components enabling a PSV-400-3D Scanning Vibrometer – a well established tool for full field non-contact vibration mapping – to measure and analyze the dynamic strain and stress distribution on surfaces with high resolution and low noise.

### Eliminates Installation of Strain Gauges

The Scanning Vibrometer makes a series of non-contact deflection measurements on a predefined grid using the laser probe to characterize strain at each point instead of attaching individual strain gauges. Thus, the test setup is fast and very repeatable with no mass loading from an attached transducer. Tests are fast and avoid the high cost of preparing and instrumenting the sample with strain gauges.

### Features and Benefits

- Quick setup and fast results: perfect for repeated measurements
- Non-contact probe simplifies setup
- No mass loading, stiffening and damping to reduce measurement accuracy
- High spatial resolution at no additional cost
- Variable field-of-view accommodates different object sizes
- Measure using arbitrary points or FEM geometry for model validation
- Laser probe eliminates sensor wear and fatigue
- Precision placement of laser probe eliminates surface patterns and alignment marks

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The ability to use geometries directly from the FEM to automatically define the measurement locations is a unique feature of this system. An alignment procedure matches numeric surface geometry models with the actual object under test. Manual grid creation is supported by an integrated geometry measurement system. The interferometric measurement technique does not require patterns on the surface and delivers outstanding resolution, surpassing image processing approaches.

### Working Principle

The PSV-400-3D Scanning Vibrometer measures the spatial distribution of three-dimensional vibration data on the surface of a component under test (Fig. 1, 2).

The measurement is performed on a grid (Fig. 3) which consists of points and triangular elements. This grid can be either user defined or imported from an external source. The non-contact measurement technique directs three lasers simultaneously to one grid point. Each laser measures the vibration along its incident direction.

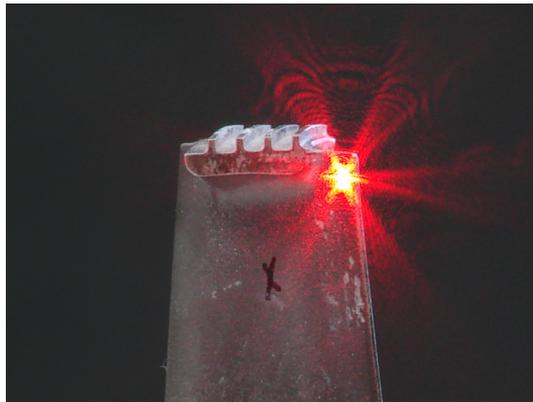


Fig. 2: Turbine blade with laser spot.

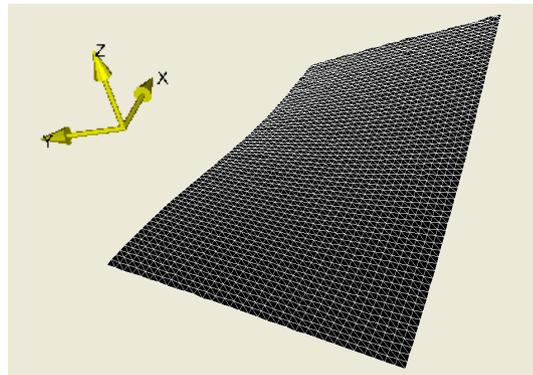


Fig. 3: Measurement grid of the turbine blade under test.

The PSV software calculates the three-dimensional vibration vector from the raw data. The resultant vibration data can be displayed as displacement, velocity or acceleration. Simply put, the PSV-400-3D acts as a full field vibration measurement system (Fig. 4).



Fig. 1: Dynamic strain measurement on a turbine blade mounted on a shaker.

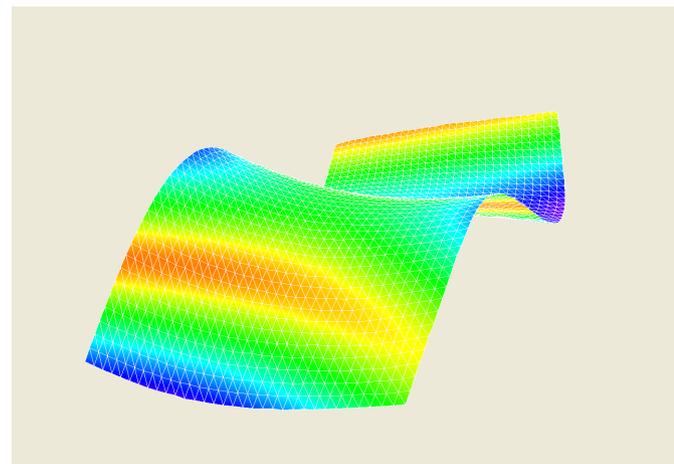
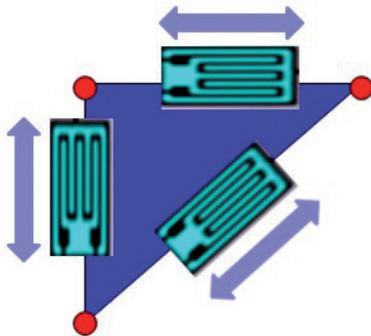


Fig. 4: Operational deflection shape (ODS) of the turbine blade.

Strain is processed from the displacement data using the StrainProcessor software package. The strain is calculated by placing simulated strain gauges at each edge of each triangle (Fig. 5).

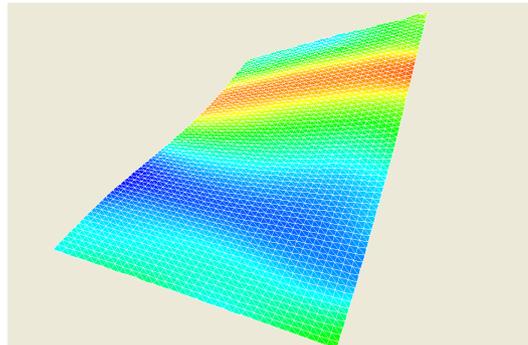


**Fig. 5: Principle of strain calculation.**

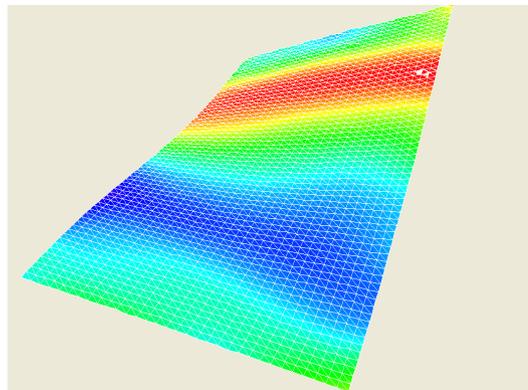
Strain for each triangle edge can be calculated from the difference in displacement along the edge divided by the length of the edge.

For the actual strain calculation, the displacement data is transformed into two in-plane components and one out-of-plane component for each surface triangle. Thus, three surface strain values are calculated, two linear strain values and one shear strain value. The surface strain values are then transformed back into the global coordinate system. The distribution of the strain values is displayed and animated as a color coded map (Fig. 6).

Stress distributions are calculated from the strain distributions (Fig. 7).



**Fig. 6: Strain distribution of the turbine blade in x-direction calculated from displacement data.**



**Fig. 7: Stress distribution of the turbine blade in x-direction.**

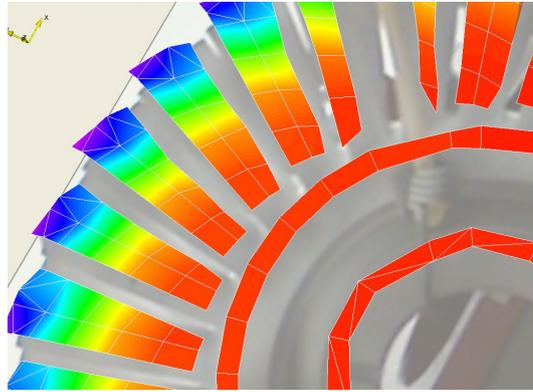
## Specifications

The PSV StrainProcessor Measurement Extension requires a PSV-400-3D or PSV-400-3D-M Scanning Vibrometer running PSV Software version 8.81 or higher. For detailed specifications refer to the relevant PSV-400-3D data sheets available on [www.polytec.com/psv3d](http://www.polytec.com/psv3d).

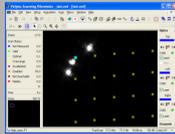
Software	Description
PSV StrainProcessor	Post processor for PSV-3D vibration data (*.svd) generated with PSV Software version 8.81 or higher.
Input file format	*.SVD (Scanning Vibrometer Data) files
Parameters	Young's Modulus, Poisson's Ratio, spatial filter settings
Output	Strain and stress results stored in User Defined Data Set (UDDS) of the original *.SVD input files. Batch processing possible
Strain processing	<ul style="list-style-type: none"> <li>Strain in global coordinates (linear and shear)</li> </ul>
Stress processing	<ul style="list-style-type: none"> <li>Stress in global coordinates (linear and shear)</li> <li>Worst principal stress</li> <li>Von Mises stress</li> </ul>
Filtering	Advanced spatial filtering
Additional features	Calculation for all frequency bands defined in the *.SVD file, automatic removal of outliers, batch processing
Visualization	Visualization of dynamic strain and stress in PSV Software 8.81 or higher

### Application Fields

- Turbine blades
- Engine components
- High frequency tensile test
- High temperature strain measurements
- Small sized objects in medical applications and mechanics



Feature	Description
Field of view	Diameter of <10 mm to >1000 mm
Resolution	Better than 1µm/m (< 1µε)
Max. velocity	500 mm/s typical
Max. displacement	1/1000 of the field of view
Bandwidth	80 kHz with PSV-400-3D 350 kHz with PSV-400-3D-M; depending on measurement conditions

Accessory	Description		
PSV-S-TRIA	Software optimizing the 3-D geometry for enhanced resolution	●	
A-CAZ-1000	High resolution camera with zoom lens	●	
PSV-A-450	Reference object for laser beam alignment and geometry matching	●	
PSV-A-T34	Near-field PSV-3D stand. Provides optimized positioning for small sized objects. Horizontal measurement direction	○	
A-MIR-2030	Mirror set for vertical measurements with PSV-A-T34	○	

- required
- optional

For more information please contact your Polytec application/sales engineer or or visit our web site at [www.polytec.com/strain](http://www.polytec.com/strain).

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