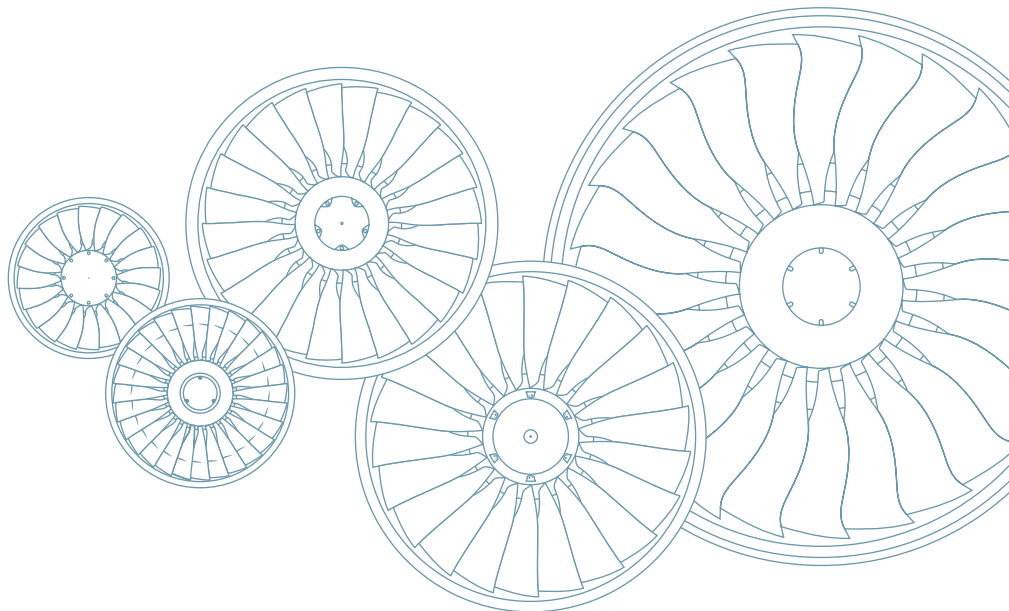




## Component testing



## Our competences

MTU Aero Engines is Germany's leading manufacturer of aircraft engine modules and components.

MTU designs, develops, manufactures, assembles, markets and supports commercial and military engines, as well as industrial gas turbines. Through cooperations with the world's largest engine makers, MTU has been involved in major engine programs for decades and has a presence in all major markets.

MTU's engine control and testing center is mainly responsible for the development of component test programs including planning, assembly and validation for final airworthiness certification.

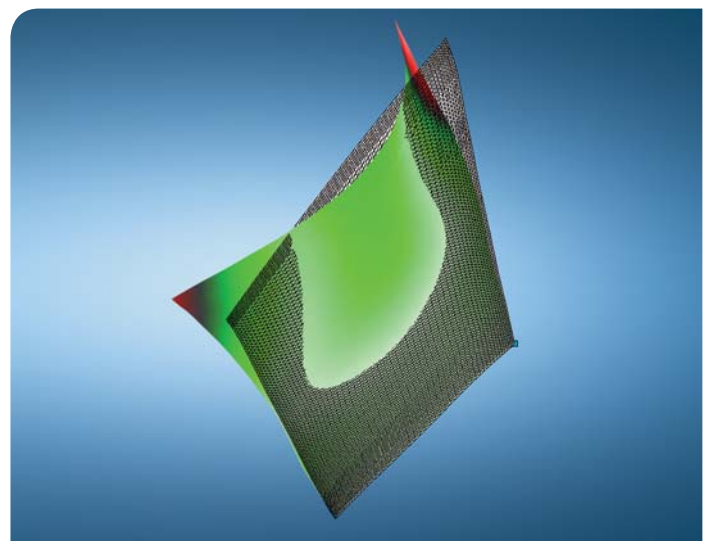
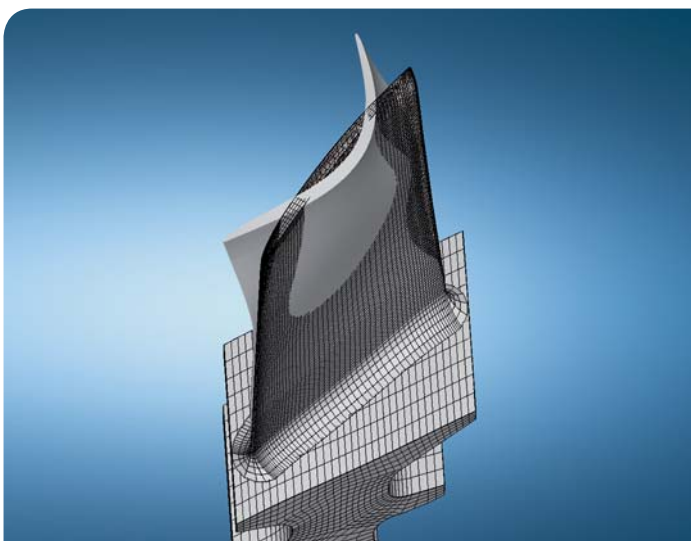
The highly professional staff with its wide range of experience gained over the years ensure solutions specifically tailored to suit the customers' needs.

The department's services are offered either as a comprehensive package or, alternatively, specific areas of concern to the customer are addressed individually, for example:

- Test management
- Hardware planning
- Manufacture of test hardware
- Finite element modeling and simulation of test conditions
- Design of sensors and gages and instrumentation work
- Special measurement techniques
- Spin testing
- Vibration testing
- Vibration identification
- Static and dynamic load testing
- Testing under environmental conditions
- Special heat treatment
- Ingestion testing
- Special test applications
- Non-destructive testing
- Failure analysis



**MTU Aero Engines' advanced technology and unprecedented flexibility provide optimum solutions that meet the most exacting requirements – anytime and anywhere.**



We measure the difference between design and reality.

## Durability testing of engine parts

### Spin testing

Spin tests on vertical and horizontal spin test beds serve to simulate the centrifugal forces acting on rotors, shafts or other rotating parts during engine operation.

Typical tests are:

- Over-speed tests
- Burst tests
- Cyclic tests (low cycle fatigue analysis)
- Combined spin testing with temperature loading (up to 1,400 K)
- Testing with pre-defined thermal gradients possible
- Simulation of operational risks like blade-off, impact or shaft shear

The complete range of measurement devices is available, like:

- Thermocouples
- Pyrometers
- (High temperature) strain gauges
- Non-contact displacement sensors
- Crack monitoring system

The test beds are running fully automatic and ensure highly efficient testing 24 hours a day.



### Vibration testing

The high-cycle fatigue strength and the structure's performance in resonance are determined in vibration testing. In the process, the items under test such as blades, casing parts or electronic components are subjected to pre-defined vibration loading.

Technical details:

- Multiple characteristic vibration loading (sine, sweep, resonance, all kinds of noise, burst, etc.)
- Different electromagnetic and piezoelectric shakers to cover a frequency range from 5 to 50,000 Hz
- Combined vibration testing with temperature loading and/or humidity
- Automatic running test control units allow efficient testing 24 hours a day

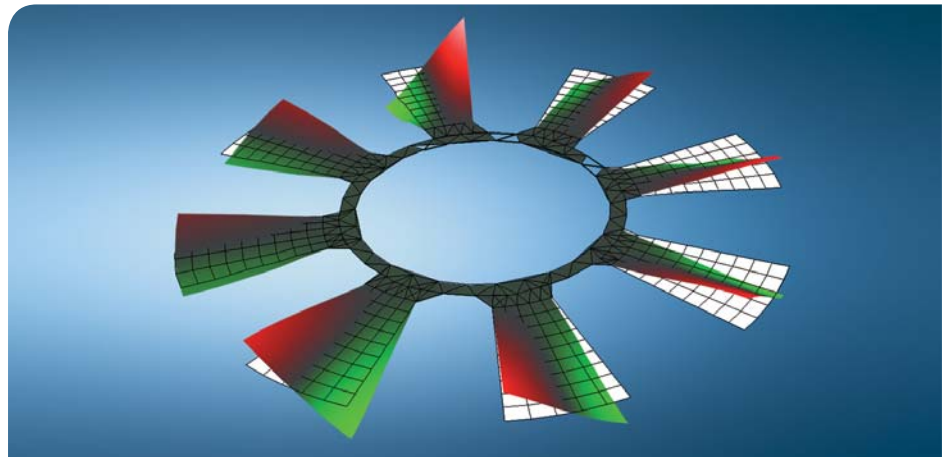


## Vibration identification, modal analysis and model validation

To obtain detailed information on different structural vibration characteristics various vibration identification tools are used. Holographic systems provide quick information about resonant frequencies and mode shapes. Laser scanning units are high-tech instruments to identify structural resonant frequencies and to animate the corresponding mode shapes. A modal analysis system links the experimental test results directly with numerical values and helps develop adapted finite element models by model updating.

Different kinds of measurement techniques are available:

- 1D and 3D holographic systems
- Laser scanning vibrometer
- 3D modal analysis
- High-speed digital imaging
- Thermographic analysis

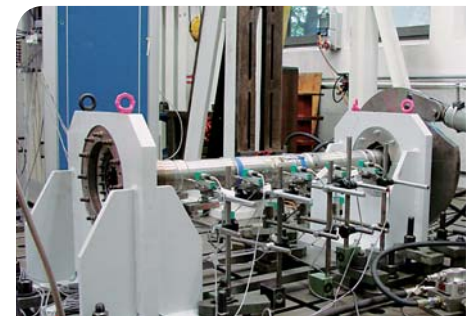


## Static, dynamic and impact testing

Using a customizable structural test setup all kinds of load tests can be performed. A variety of different hydraulic cylinders enables multi-axial testing.

Technical details:

- Static loading
- Dynamic loading
- Measurement of all mechanical properties
- Video documentation
- Direct link to simulation
- Verification of numerical models
- Correlation analysis and model updating



Structural load test

Impact testing is possible from caliber 30 via 1" hail impact up to flocking bird (1 lb.) tests and 4-lbs single bird strike tests.

be effected using digital high-speed video systems with up to six synchronized camera positions.

The customizable test setup can be installed at MTU's or the customer's test site. The use of compressed air permits indoor testing. The test documentation is time-triggered and can

Characteristic values for 1-lb. bird strike tests:

- max. speed Mach 1
- shooting repeatability of 20 min.

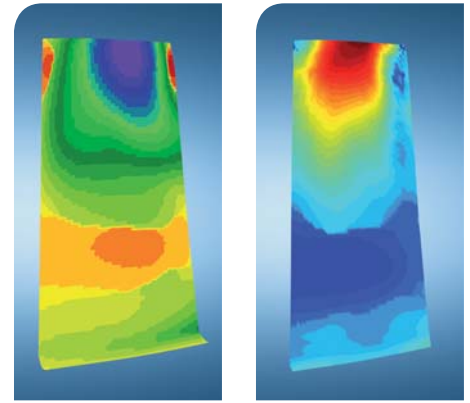


Impact testing

## Component testing – future technologies

### Non-contact 2D surface strain measurements

To improve the capabilities of measuring strains during structural testing, a specific 2D strain measurement device was developed. With this system the surface strains of test specimens can be measured during static and dynamic testing. The maximum strain is no longer limited.

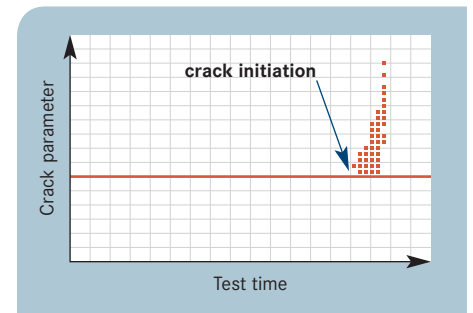


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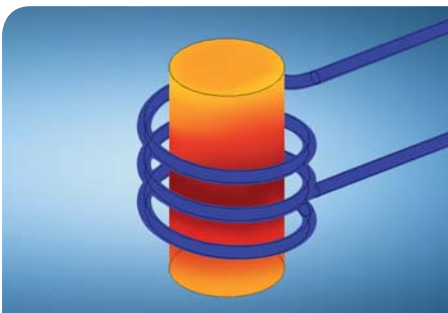
### Online structural condition monitoring

A crack monitoring system is used to permit dynamic tests to be stopped directly at crack initiation. Especially for vibration testing, structural testing and spin testing this structural monitoring unit offers multiple advantages.

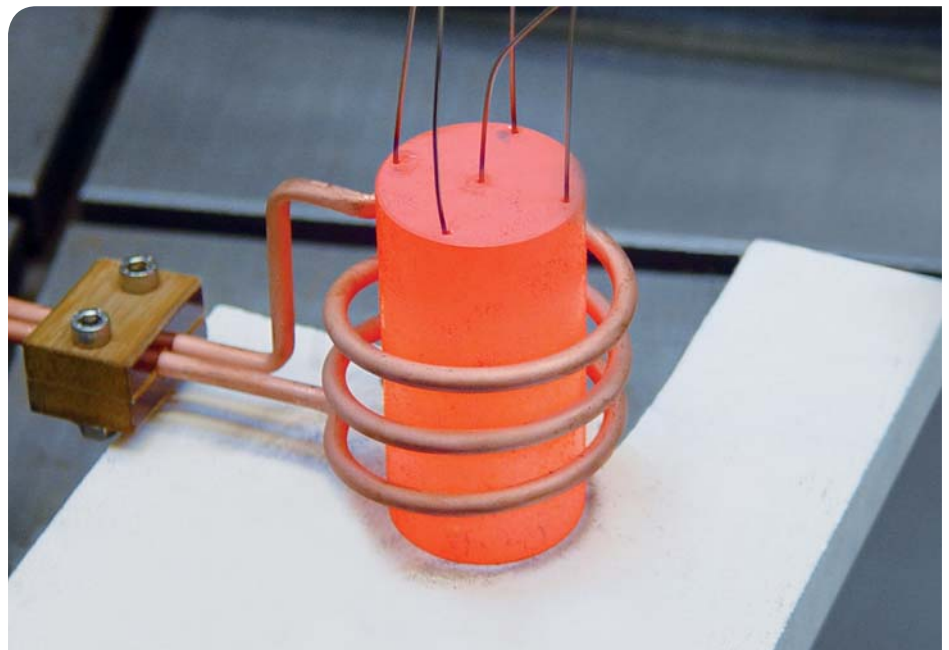


### Inductive heating technologies

The thermal conditions are an important issue in all kinds of tests. The development of adapted inductive heating systems is a big challenge. Numerical design and numerical simulation provide an effective way to manufacture optimized heating systems.



Simulation



Reality



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