

Definition

Components may fail prematurely under cyclic loading (fatigue fracture). Therefore, the behaviour of materials under cyclic mechanical loading is an important design criterion. Data required for fatigue life modelling are determined in laboratory tests.

Two cases are distinguished:

- High cycle fatigue (HCF)
- Low cycle fatigue (LCF)

LCF tests are characterized by high amplitudes with plastic deformation and a number of cycles to fracture $<10^4$.

Loading (uniaxial, tension-compression) can be strain or stress controlled, fluctuating (only tensile or only compression) or alternating (in tension and compression) at constant temperature.

LCF testing

LCF tests require standardized sample machining (geometry tolerances, surface quality), low bending grips and a constant testing temperature.

Strain is measured directly on the sample by high temperature extensometers, having ceramic edges which detect the distortion in the parallel section of the specimen.

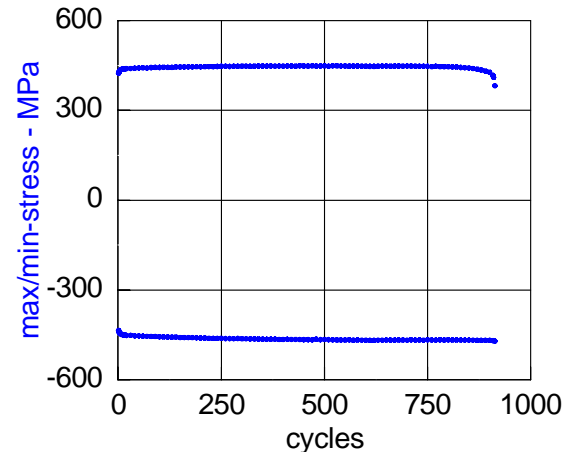
Temperature is measured by three thermocouples in the centre of the specimen as well as in the transition radii.

To check the testing system the Young's modulus is determined at room and at testing temperature as well as the coefficient of thermal expansion.

If these values meet the requirements, mechanical load is applied to the specimen. Load is applied mainly strain controlled with constant strain rate, sometimes with holding time.

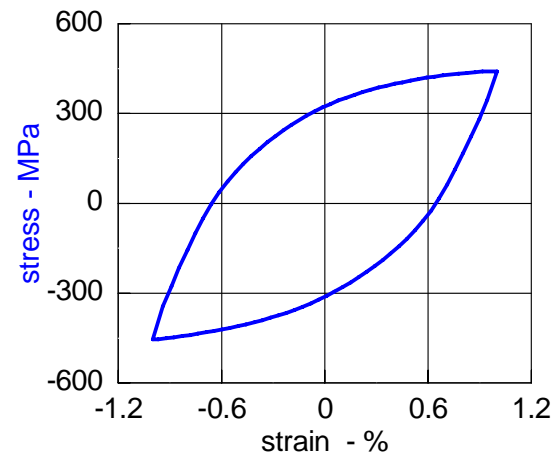
During the test, load, strain, and temperature data, the load maximum and minimum is measured by time based data acquisition (200 data per cycle). A real time data reduction reduces the data to a reasonable amount.

A representation of the data as max./min. stress vs. number of cycles provides important information of an LCF test; e. g. the fatigue life (i. e. number of cycles to fracture) under the chosen test parameters.

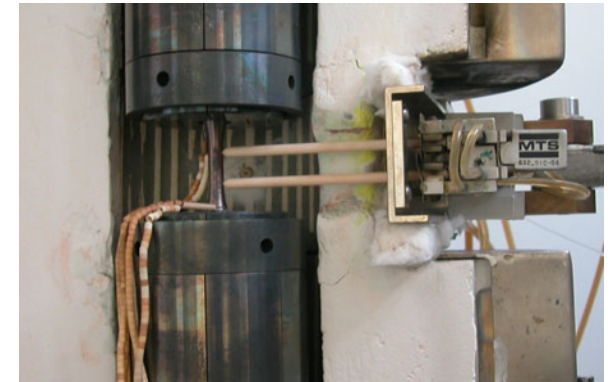


Maximum/minimum stress vs. no. of cycles;
913 cycles until fracture

The stress vs. strain diagram shows a complete loading cycle at half fatigue life.



Stress-strain curve after 460 cycles.



Experimental set-up of a LCF-test

Objective

Characterization of the mechanical behaviour under cyclic loading at constant temperature.

- Shape of stress-strain curve
- Hardening and softening
- Fatigue life

Standards

ISO 12106: Metallic materials – Fatigue testing – Axial-strain-controlled-method

DIN EN 3988 (draft standard): Aerospace series – Test methods for metallic materials – Constant amplitude strain-controlled low cycle fatigue testing

DIN EN 3874 (draft standard): Aerospace series – Test methods for metallic materials – Constant amplitude force-controlled low cycle fatigue testing

Test equipment

All LCF tests are conducted on servo hydraulic or electro mechanic testing machines. Heating is realized preferentially by resistance furnace or for special applications (strain field measurement, tests in vacuum) by inductive heating.

In addition to axial tests, torsional or combined axial/torsional loading is also possible.

Activities of the working group
„Mechanical Behaviour of Metals“

The following working scope is covered mainly in national or international cooperation with partner in industry, universities or other research institutes:

- High temperature materials for gas turbines
- Fibre reinforced light metals for aero engines
- Grey cast iron for break disks
- Development of new testing procedures in mechanical testing
- Collaboration in development of technical standards
- Customized mechanical testing
- Optimization of testing techniques by loading simulation
- Analysis of damage caused by loading
- Education of materials testing personnel
- Supervision of engineering student projects
- Failure analysis

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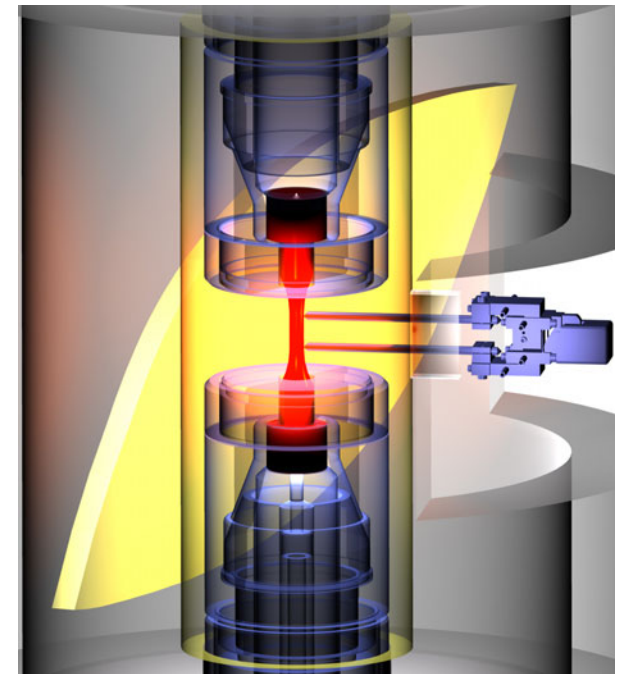
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Low Cycle Fatigue (LCF)



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„Mechanical Behaviour of Metals“

BAM, division V.2 is approved by DAP Deutsches Akkreditierungssystem Prüfwesen GmbH according to DIN EN ISO/IEC 17025:2000 as an accredited testing laboratory.



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