Deutsches Zentrum
DLR für Luft- und Raumfahrt

Handout

Test facility for multiaxial thermomechanical testing

Description of facility
Multiaxial stresses are generated in cooled components by thermal gradients. In case of internal cooling, for example of blades in the first stage of a jet engine, the thermally induced stresses cannot relax by means of macroscopic deformations. The constraints of the component result in multiaxial compressive stresses at the heated surface and multiaxial tensile stresses at the cooled surface. It is not possible to simulate these stress states in conventional thermomechanical testing with a homogenous temperature distribution.

The Institute of Materials Research has developed a thermal gradient mechanical fatigue (TGMF) test facility which allow simultaneous cyclic thermal and mechanical loading with controlled thermal gradients over the wall of hollow specimens. The thermal gradient is obtained by heating of the outer surface with a concentrating radiation furnace and simultaneous internal cooling with pressurized air. A stationary thermal gradient is typically achieved after 20 to 40 seconds.

The high heat flux of the radiation furnace allows heating rates comparable to those in real turbine blades of a jet engine. Realistic cooling rates are achieved by forced air cooling of the outer surface. The cooling vents are integrated in shutters which enclose the specimen during the cooling sequence of the test cycle.

The TGMF testing facilities offer several advantages:
Close to reality testing provides the opportunity of transferring data from laboratory tests to service conditions.
The test cycle can be very short due to the high heating and cooling rates. Thus, the fatigue load of an entire flight mission can be imposed on the specimen within 3 to 5 minutes.

Performance characteristics

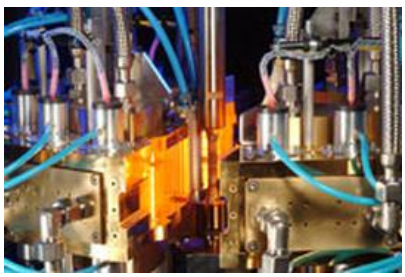
The radiation furnace has a power of 16 kW.
Typical test data for a hollow cylindrical specimen from nickel base super alloy are: heating from 100°C to 1000°C in ca. 20 seconds, cooling from 1000°C to 100°C in ca.15 seconds, stationary thermal gradient of 100°C per mm.
The maximum mechanical load is 25kN .

Application
- Testing of thermal gradient mechanical fatigue
- Heating rates comparable to those in real turbine blades of a jet engine

Contact
- Janine Wischek, DLR Institute of Materials Research, Tel: +49 2203 601 2833, Fax: +49 2203 696480
- Jochen Krampe, Technology Marketing, Tel: +49 2203 601 3665, Fax: +49 2203 695689

This handout, and cross-references to related measurement techiques and facilities are available at: http://messtec.dlr.de/link-261-en.

Open radiation furnace (16kW) with clamped specimen



Deutsches Zentrum
für Luft- und Raumfahrt e.V.
German Aerospace Center

DLR Institute of Materials Research

Janine Wischek
Telephone: +49 2203 601 2833
Telefax: +49 2203 696480
janine.wischek@dlr.de
www.dlr.de