INFORMATION

STRUCTURES AND MATERIALS PERFORMANCE

Aeropropulsion Materials Engineering

The NRC Institute for Aerospace Research (NRC Aerospace) offers unique expertise and comprehensive facilities for evaluation and qualification testing of new engine materials. Research and development in aeropropulsion materials engineering focuses o n issues related to the structural integrity, durability and reliability of aero engine components. Related activities are also carried out to evaluate new materials and processes, life extension technologies (coatings and specialised repairs), and emerging concepts for life cycle management of engines and their components. These arrangements, which can be carried out to support Canadian manufacturers, overhaulers and users of gas turbine engines, are available through collaborative research or fee-for-service contracts.

Key facilities and equipment

Mechanical property evaluation
A variety of testing systems are available for evaluating mechanical properties of materials and subcomponents using standard or customer-specified procedures and testing conditions. Capabilities include:

- tensile and compressive testing from room temperature to 1100°C
- high-cycle rotating bending fatigue, load or strain controlled axial fatigue testing from room temperature to 1100°C
- room temperature and elevated temperature axial fatigue crack growth rate and creep crack growth rate testing at high temperatures, with alternating or direct current potential drop (AC/DC PD) monitoring capabilities
- axial load or strain controlled thermomechanical fatigue testing in air
- high-temperature creep-rupture testing in air
- axial corrosion fatigue testing in air; salt fog environmental exposure testing
- fretting fatigue testing up to 600°C in air
- spin rig facility for rotating component durability studies. The facility is programmable for mission simulation, with a maximum rotation speed of 100,000 rpm and elevated temperature capability (information available on request).

Durability evaluation
A variety of apparatus are available to evaluate the durability of materials, components or protective coatings under specific conditions using standard or customized test techniques. Capabilities include:

- high velocity (Mach 0.8) burner rigs with capabilities for salt injection; special hardware available for component level testing (information available on request)
- cyclic oxidation testing of alloys and coatings at elevated temperatures
- erosion test rig using particles entrained in a gas jet: up to 750°C and 300 m/s to ASTM G76 specifications
- pin-on-disk, scratch testing and wear rigs for coating degradation studies
- nanoindentation tester for determining nanomechanical properties of thin films, coatings and bulk materials at room temperature, with depth and spatial resolutions of 0.03 and 250 nm respectively, and with a load capacity of up to 300 mN and a load resolution as low as 1mN. The tester is also equipped with a load cell for micro-hardness and micro-scratch tests, and an atomic force microscopy objective to reveal nano-scale images, indents and other surface features
- thermogravimetric analyser for evaluating high-temperature oxidation/corrosion behaviour of alloys and coatings in vacuum or controlled atmospheres.

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Non-destructive evaluation

- Eddy current techniques for detecting/sizing cracks in bolt holes, dovetails, and oxides in thermal barrier coatings
- Pulsed thermography for detecting debonding in thermal barrier coatings
- Liquid penetrant and magnetic particle inspections
- Radiography, including micro-focused real-time x-rays for defects and damage in turbine blades
- Ultrasonic methods (conventional longitudinal, shear-waves, guided waves, leaky waves) for flaw detection and thickness gauging
- Electrical impedance and conductivity measurements for material sorting and coating inspections
- Edge-of-Light for detection of wear and surface flaws
- Boroscope, video microscope, replication apparatus, portable instruments, probes and manual scanning devices for in-situ inspections
- Multi-mode NDI Analysis software for data analysis, interpretation and presentation
- Probability of detection and confidence analysis to determine safe inspection intervals.

Stress and fracture mechanics analysis

- State-of-the-art computational facilities with extensive graphic capabilities
- FEM commercial software: MSC.NASTRAN, MSC. PATRAN, MSC.MARC, ABAQUS, in addition to inhouse-generated software to create finite element models for stress, strain, thermal and fracture mechanics analysis of gas turbine engine components.

Materials and components processing

- Hot isostatic pressing (HIPing): up to 2000°C and 200 MPa (30,000 psi) with 26 cm long x 12 cm diameter working zone for processing, rejuvenation and repair of materials and components
- Vacuum heat treatment: up to 2000°C, 10 -5 torr, 0.3 x 0.3 x 0.3 m work zone for sintering, brazing and heat treatment of materials and components with gas quenching capability; various atmosphere heat treatment furnaces.

Microstructural analysis

- Standard optical me tallographic equipment and image analyser
- Scanning electron microscopes: Hitachi S 570 and Philips FEG, XL-305 SEM's interfaced to Link AN10 EDX system with light element detection and image analysis capability
- Scanning-transmission electron microscope: Philips EM 430 with goniometer stage and dark field capability
- X-ray diffractometer: Rigaku Model D/MAX 2B, with a wide-angle and small-angle capabilities, residual stress analysis attachment, computer-controlled measurements, data acquisition and plotting.

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