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INFORMATION

STRUCTURES AND MATERIALS PERFORMANCE

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Structures and Materials Performance Laboratory

The Structures and Materials Performance Laboratory of the NRC Institute for Aerospace Research (NRC Aerospace) performs research related to the design, strength, durability, structural integrity and performance of new and legacy aircraft structures and components. The Laboratory develops new design, analysis, and manufacturing technologies for structures and materials, as well as for noise and vibration control. It also investigates technologies to support existing aircraft fleet. Its facilities and expertise are available on a contract basis.

Aeroacoustics and Structural Dynamics

Research and development activities focus on active control systems involving adaptive or "smart" materials to control structural dynamics and vibration. The Group's facilities enable unique test configurations including mechanical, acoustic or aerodynamic loading. A 10,000 lbf (44 kN) electromechanical vibration system and various modal shakers are available to support work in modal analysis and structural durability.

An acoustics reverberant facility provides accurate, high level noise testing (i.e. up to 165 dB) for Canada's aerospace community. The facility includes two reverberant chambers of 80 and 536 m^3 (4.9 x 10^6 and 23.7 x 10^6 in^3) and a 0.3 m x 1.2 m (11.8 in. x 47.2 in.) progressive wave-tube. The noise environment is accurately controlled with an automatic spectrum control system capable of maintaining tight tolerances on noise levels over the frequency range of 25 to 20,000 Hz. The reverberant chamber and high-bay preparation area have a Class 100,000 clean-room capability, with required humidity and temperature control for testing of spacecraft and spacecraft components, acoustic fatigue studies on aircraft components, and research on noise generation concepts and associated consulting.

Composites and Novel Airframe Materials

Research activities focus on the structural performance of advanced composite structures with emphasis on the effects of processing, impact damage, environmental degradation and multiaxial loading. Modelling capabilities have been developed to simulate the processing of composite structures and repairs. New composite processing technologies (such as electron-beam curing, vacuum-assisted resin transfer moulding, and smart tooling) and new materials (such as fibre-metal laminates and high-temperature resins) are investigated.

An autoclave (maximum 1.4 MPa (203 psi), 370°C (698ºF)) is used for adhesive bonding and processing of composites. The chamber is 1.2 m (48 in.) in diameter and 1.8 m (71 in.) long. The Laboratory also has a wide range of standard and specialized servo-hydraulic and mechanical test equipment including a planar biaxial system. Custom tests can be designed for specific applications. Other facilities include:

- Environmental test chambers (temperatures from -150 to +320°C (-238 to 608ºF), relative humidity from 20 to 90%)
- A drop tower for impact damage simulation
- Electrical and optical strain measuring techniques.

Materials and Component Technologies

Research focuses on the design, properties and performance of engine components. This work is supported by microstructural analysis (SEM/EDX, STEM, OM and XRD) and high-temperature mechanical testing (including axial and thermo-

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mechanical fatigue, fatigue crack growth and creep). Two high velocity (Mach 0.8) burner rigs are used to simulate conditions in gas turbine engines to study oxidation, corrosion, erosion and thermal fatigue behaviour of high-temperature alloys and coating systems. Activities include:

- Modelling of deformation behaviour and life prediction of high-temperature parts
- Properties of superalloys, intermetallics and metal matrix composites
- Durability and behaviour of coatings and superalloys
- Thermal fatigue damage modelling.

Non-Destructive Evaluation

Various NDE techniques, such as ultrasonic, eddy current, thermography, X-ray, enhanced optical, liquid penetrant, magnetic particle, and impedance analysis are used to detect manufacturing flaws and service-induced damage. Fully automated ultrasonic and eddy current C-scan systems are available for inspection of composite and metallic components as well as aerospace coatings. These techniques are supported by commercial and NRC Aerospace-developed signal and image processing methods as well as by multi-mode NDE analysis, data fusion and pattern recognition capabilities. Expertise is also available for inspection reliability assessments using probability of detection and confidence analysis.

Aerospace Structures

Research focuses on the development of methodologies, procedures and technologies to reduce the total life cost of aircraft structures, while decreasing the risk of structural failure, ensuring the safety of flight. To accomplish this, a new physics-based risk management framework is being developed that includes the effect of service loads (on the ground and in-flight) and environments (e.g. temperature, humidity, exposure to corrosive elements). Activities include:

- Modeling of structural response to external loads
- Effects of residual stress
- Health and usage monitoring
- Repair technologies for both existing and new structural components.

These activities are supported by both fatigue and static testing on coupons and full-scale structures. A large test bay is equipped with several multi-channel digital test controllers, with a maximum capacity of 64 actuators on a single test, integrated data acquisition for up to 700 strain gauges, and a large selection of hydraulic loading devices complete with protection devices. The facility is unique in its flexibility and its accuracy of applied loading.

Resident expertise exists in all aspects of life cycle management from life prediction to structural testing (including load spectrum derivation) has been developed over the last 30 years.

Summary of SMPL's Competencies

The Laboratory has technical expertise and operates facilities in the following fields:

- Adaptive Control of Structures
- Facilities for Acoustics and Structural Dynamics
- Noise and Vibration Test and Analysis
- Structural Dynamics and Impact Simulation
- Composite Materials and Process Development
- Conductive Heating Technology for Composite Processing Applications
- Novel Metallic and Hybrid Structures and Materials for Airframes and Other Applications
- Gas Turbine High Temperature Materials
  - Burner Rig
  - Spin Rig
  - MTS frames
- Aerospace Protective Coatings
  - ArcPVD
  - EB-PVD
  - Magnetron Sputtering PVD
- Gas Turbine Component Life Cycle Management
- Non-Destructive Evaluation (NDE)
- Experimental Stress Analysis
- Full Scale Structural Test
- Risk/Reliability-Based Life Assessment
- Structural Health Monitoring (SHM)
- Structural Testing and Evaluation Facilities

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