National Aeronautics and Space Administration

Overview of Prognosis Health Management Research at Glenn Research Center for Gas Turbine Engine Structures With Special Emphasis on Deformation and Damage Modeling

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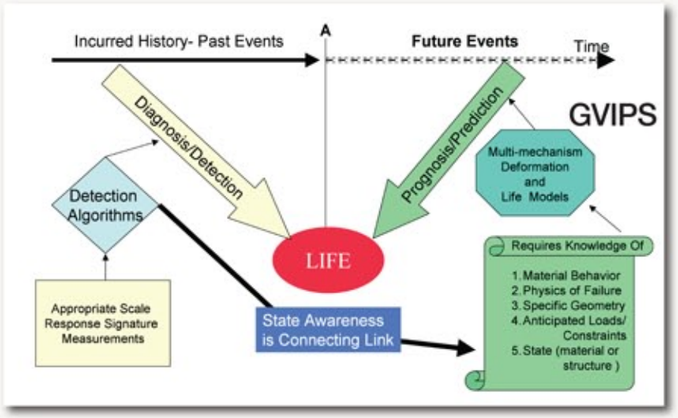
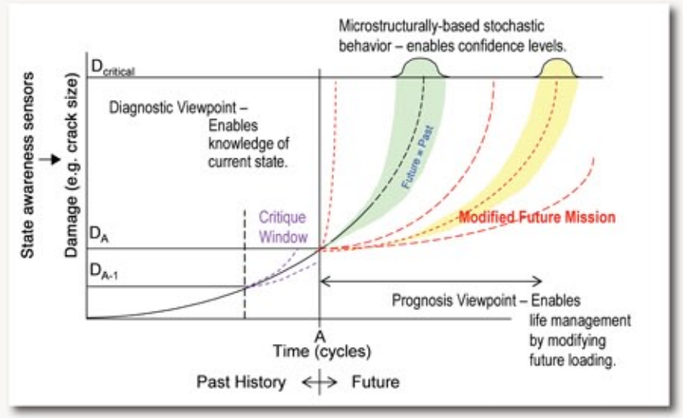
Background on FILMS: Fully Integrated Life Management System

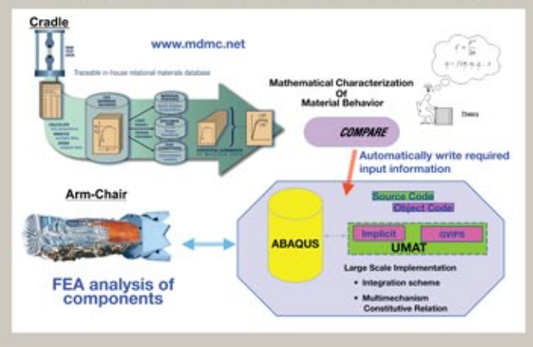


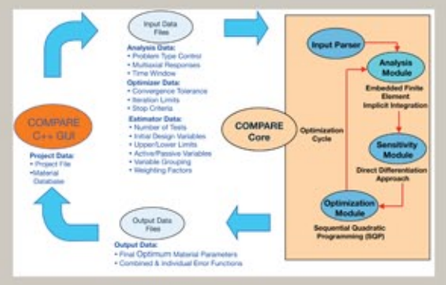
A general, multimechanism, physics-based viscoelastoplastic model is presented in the context of an integrated diagnosis and prognosis methodology, which is proposed for structural health monitoring, with particular applicability to gas turbine engine structures. In this methodology, diagnostics and prognostics will be linked through state awareness variable(s). Key technologies, which comprise the proposed integrated approach include (1) diagnostic/detection methodology, (2) prognosis/lifing methodology, (3) diagnostic/prognosis linkage, (4) experimental validation and (5) material data information management system. A specific prognosis lifing methodology, experimental characterization, and validation and data information management are the focal point of current activities being pursued within this integrated approach. The prognostic lifing methodology is based on an advanced multimechanism viscoelastoplastic model, which accounts for both stiffness and/or strength reduction damage variables. Methods to characterize both the reversible and irreversible portions of the model are discussed. Once the multiscale model is validated, the intent is to link it to appropriate diagnostic methods to provide a full-featured structural health monitoring system.



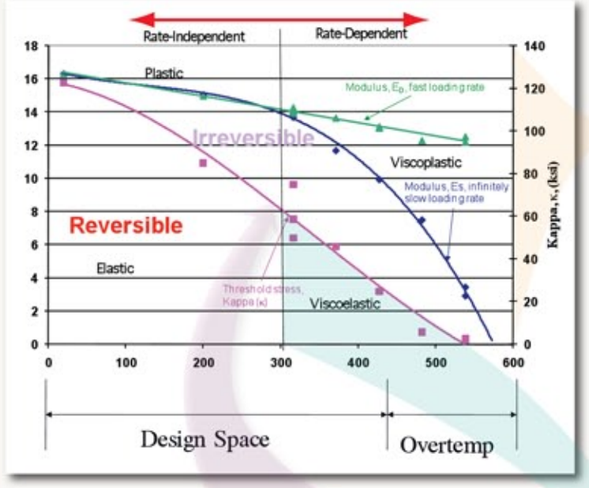
Experimental Characterization/Validation Program Using Ti-6-4 and Generalized Viscoplasticity with Potential Structure (GVIPS) Deformation and Damage Model

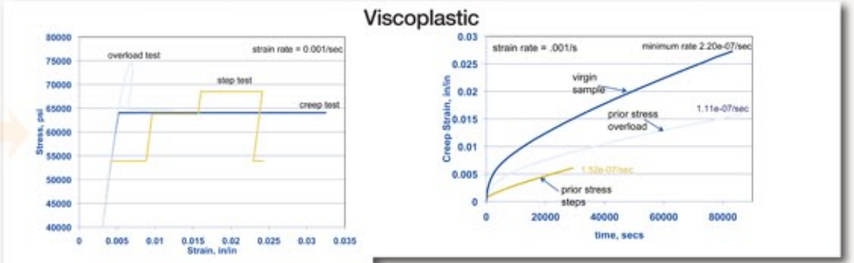
Integrated Toolset for Design and Analysis at Elevated Temperature

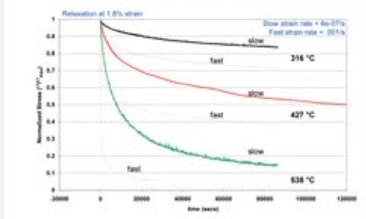




Model Characterization With COMPARE







Experimental Observations

- Reversibility (Viscoelastic)
  - Rate-dependent instantaneous stiffness
  - Transient creep/relaxation
  - Limit equilibrium state
- Theoretical demarcation (Experimentally Verified)
- Irreversibility (Viscoplastic)
  - Strain-stress dependent
  - Nonlinearity
  - Strain rate dependent
  - Creep with steady state
  - Relaxation with finite residual state
  - Creep/plasticity interaction
  - Thermal recovery
  - Nonlinear kinematic/isotropic hardening
- Anelastic recovery during reversal in both quasilinear and fully developed inelastic regions

GVIPS Constitutive

Viscoelastic Material Parameters

2+2M number, i.e., E_∞, ν, $(M_{(a)}, \rho_{(a)})$
+ 4 stiffness reduction constants
cs, $\bar{Y}_{sb}$, μ_{sd}, n_{sd}

Viscoplastic Material Parameters

- Flow k, m, n
- Hardening H_b, k_b and b,
- Recovery: R_b and m_b
- Strength Reduction

c, $\bar{Y}_o$, μ_d, n_d

3 + 5N irreversible material constants + 4N strength reduction constants