Recent Developments in Unified Mechanics Theory

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Abstract

Newton's three universal laws do not account for, dissipation, degradation, or damage in the system. However, the laws of thermodynamics govern dissipation, degradation, and damage evolution. The unified mechanics theory unifies the universal laws of motion of Newton and the laws of thermodynamics at the ab-initio level. Therefore, the dissipation, degradation, and damage mechanics of any system are included directly in the governing partial differential equation. However, to be able to unify these two sets of laws the Newtonian space-time coordinate system must be modified. Therefore, a new linearly independent fifth axis is introduced into the space-time coordinate system. The new axis is called the Thermodynamic State Index (TSI) axis which can have values between zero and one. When the entropy generation rate is maximum TSI coordinate is zero. When the entropy generation rate is minimum the TSI coordinate approaches the maximum value of one. The TSI axis is linearly independent, hence, the information represented on the TSI axis cannot be represented on the space-time coordinates. Moreover, the derivative of displacements with respect to entropy is no longer zero, as in classical continuum mechanics. The damage evolution along the TSI axis follows Boltzmann's formulation of the second law of thermodynamics. Therefore, the entropy generation rate must be calculated at each time increment at each material point. The entropy generation rate can be calculated directly from the thermodynamic fundamental equation of a material, which includes all entropy-generating micro-mechanisms that contribute to the failure criterion chosen.

Recently, thermodynamic fundamental equations for very high cycle fatigue, metal corrosion, and metal hydrogen embrittlement have been derived analytically and verified experimentally. They will be also presented.

The presentation will be at the fundamental level to accommodate all engineering students at the first-year undergraduate engineering level and above.

Reference: Introduction to Unified Mechanics Theory with Applications, 2nd Edition, 2023, Springer.