Accelerated Aging Studies

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Statistical Methodology for the Assessment of Aging and Lifetime Prediction

BACKGROUND & MOTIVATION

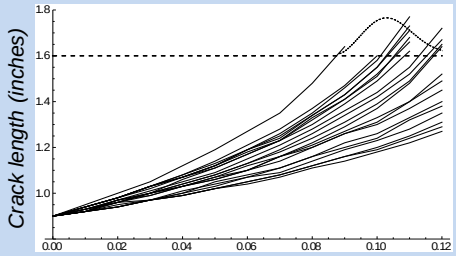
Factors such as temperature, pressure, or radiation are used to accelerate aging of materials in order to predict future conditions

INNOVATION

Statistical Modeling of the aging processes allows assessment of future conditions/responses of the materials and prediction of material lifetimes

- If failure is caused by a well understood physical aging process, this can be measured to predict reliable lifetime

Critical crack length (failure point)



DESCRIPTION

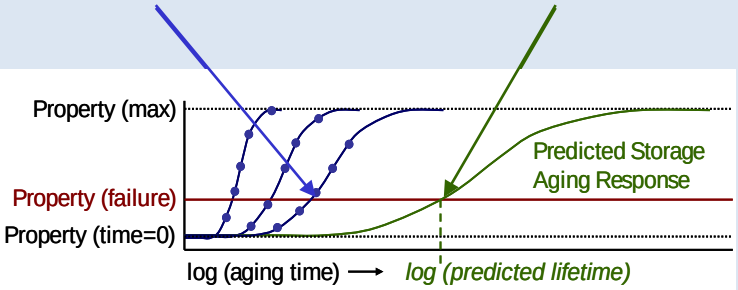
Develop empirical, semi-empirical, or science-based models of time-temperature aging response

A model example for property P as measured at time t:

$$f(t) = \frac{P(t) - P(t=0)}{P(t = \text{peak age}) - P(t=0)} = 1 - \frac{1}{[1 + \exp(A(\log(t) - B)]}$$

Arrhenius Equation for Time-at-Temperature Conversion:

$$\log_{10}(\text{time at } T_1) + \frac{Q}{2.303R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] = \log_{10}(\text{time at } T_2)$$



Lifetime Prediction Requires:

- Model of Accelerated aging response as f(aging time, temperature, etc.)
- Extrapolating the model to lower temperatures (using, for example, Arrhenius equation)
- Failure criterion in terms of a property threshold such as tensile strength, corrosion depth, etc.

Current Technology Readiness Level (TRL) 5

- On several projects, model has been validated with field data

ANTICIPATED IMPACT

Provides a rational basis for decision-making on materials and components subject to aging

- Decisions based on a model that represents the aging process
- Bounds on the model can provide bounds on the prediction, thereby incorporating uncertainty into the decision-making process
- Helps mitigate the potential for costly errors associated with invalid conclusions

Temperature (°C)	Lower Bound Lifetime (Years)
30	278
35	224
40	187
45	142
50	112
55	83
60	45

PATH FORWARD

Advance the use of statistical methodologies for experimental design and modeling of aging data

- Optimize the design of accelerated aging experiments to minimize cost and maximize information
- Validate models against actual field data
- Compare model results with experimental data from literature reviews

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