Abstract: HAYNES® 718 is a nickel-based superalloy important in aerospace applications, due to its high strength, corrosion resistance, and operating temperatures. To meet industry standards, time-dependent deformation, known as creep, is crucial to understand and effectively quantify. Specifically, AMS 5596 requires a minimum stress rupture life and elongation above 23 hours and 4%, respectively, at 1200 °F and 95-100 ksi. In this study, we investigate the addition of microstructural features to predict creep properties using machine learning.

Background

Microstructure and thermo-mechanical processing influence creep properties of Ni-based superalloys.

**Phases:** γ matrix, γ', δ, carbide

**Strings:** - Remaining slag after production processes - Affects ductility

Objective: Based on experimental data, utilize machine learning to predict creep properties of HAYNES® 718.

Model Predictions

**HAYNES® 718 Dataset**

- 42 descriptors
- 2 target features:
  - SR Elongation
  - SR Life

**Regression Models**

- Random Forest
- Neural Network
- Gradient Boosting
- XG Boost
- Gaussian Regression

**Model Evaluation**

- Mean Absolute Error (MAE)
- Mean Squared Error (MSE)
- Root Mean Squared Error (RMSE)

- *Selected model, exhibited lowest mean absolute error

Dashed Line = Perfect Accuracy (slope = 1)

Solid Lines = Two Standard Deviations Away

Model exhibits reasonable predictions within the median ranges, but noticeable underpredictions for larger values.

Feature Importance

Conducted SHAP (SHapley Additive exPlanations) analysis to extract importance of features to the model.

Conclusions

1. The addition of phase volume fractions had no noticeable impact on model predictions.
2. The processing parameters remain the descriptors with highest correlation.
3. Data relating to stringer content can be extracted from micrographs for use in the model.
4. Obtaining more descriptors related to heat treatment and test conditions might help improve the model in the future.

References


