REMAINING USEFUL LIFE ESTIMATION (RULE) FOR ROLLING BEARINGS VIA RANDOM VIBRATION SIGNALS AND A FUNCTIONAL MODEL BASED METHOD

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General Problem

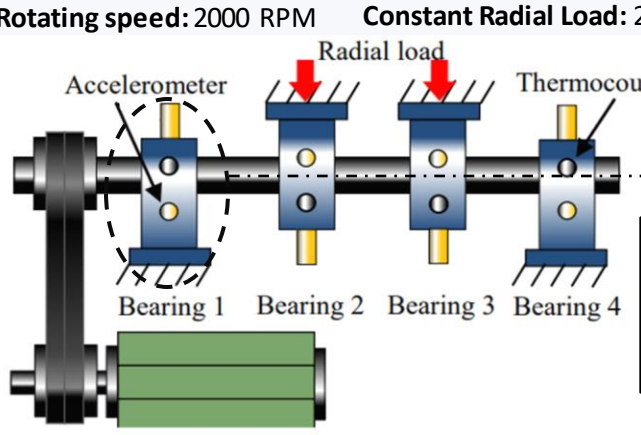
Remaining Useful Life Estimation (RULE) for rolling bearing under normal operating conditions via random vibration signals and FP-AR model.

Study Goal

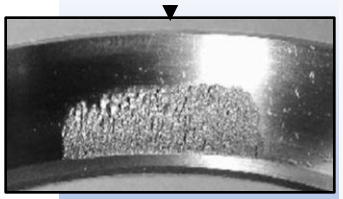
- Identification of an FP-AR model capable to represent system's dynamics
- Damage detection via PSD based method and RUL estimation
- Comparison of RULE by different methods

Run-Till-Failure Experiment

Rotating speed: 2000 RPM **Constant Radial Load:** 27 kN **Duration:** 7 days



Outer Ring Damage



Training Phase

82 out of 984 signals are used

Step 1

- BIC/RSS Criterion
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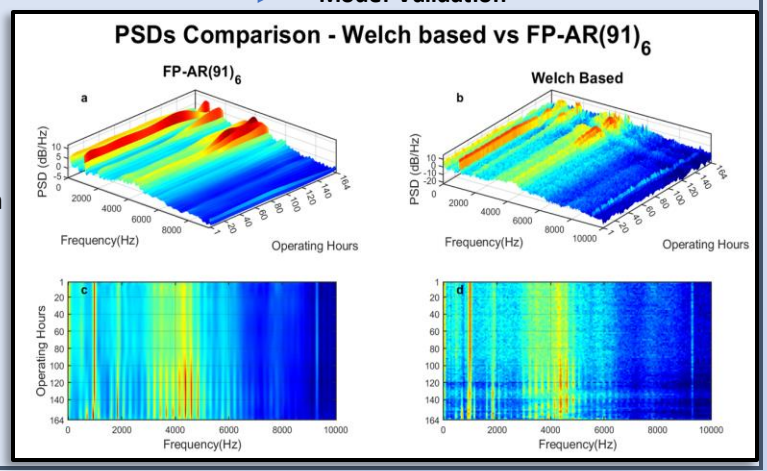
- Genetic Algorithm

Identification of *FP-AR(91)$_6$*

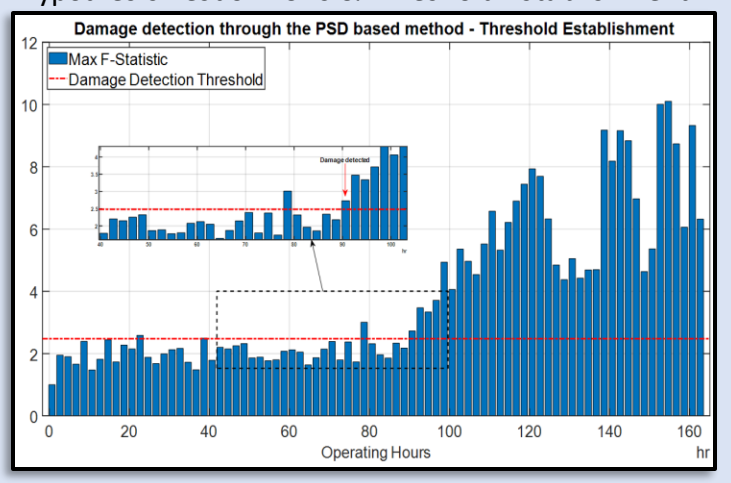
- Selection of an **operating parameter** k representing the RUL in hours

Model Validation



Step 2

- **Degradation** Time **Detection** via Hypothesis Test on PSDs & Threshold Establishment



Inspection Phase

Step 3

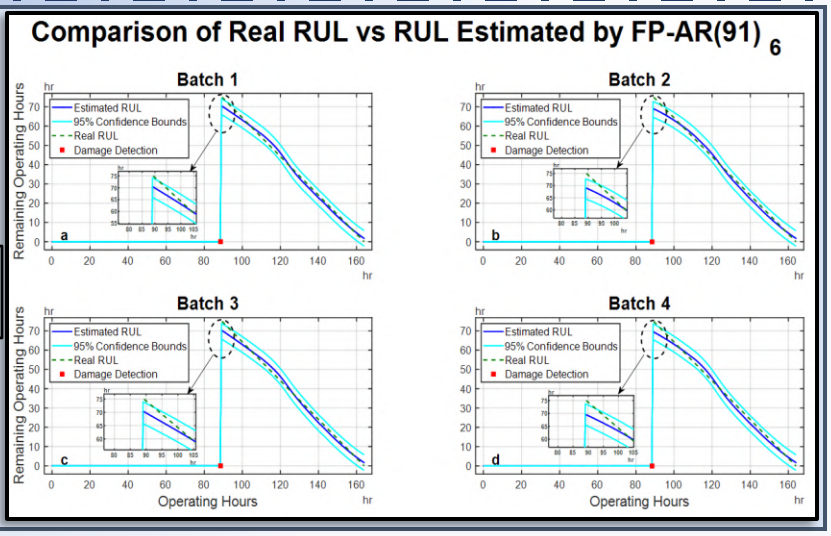
$y_u[t]$ → Hypothesis Test on PSDs → Degradation is detected → $y_u[t]$ → FP-AR model re-parametrization based on $y_u[t]$ → ***k* (RUL) estimation** ($\hat{k}$)

Signal $y_u[t]$ from unknown state is selected

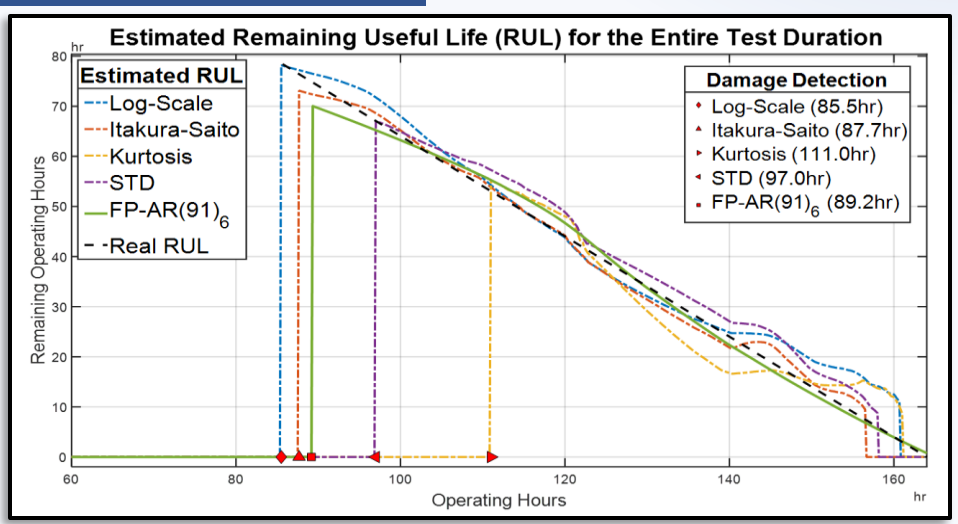
Degradation is not detected

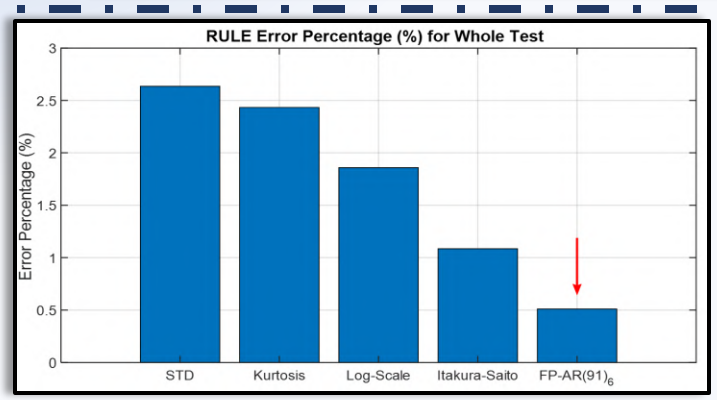
$e_u[t, \hat{k}]$

- $\hat{k}$ Validation via Pena Rodriguez Test on residuals
- Construction of $\hat{k}$ confidence intervals



Comparative Results





Concluding Remarks

- **Successful modelling** of **system's dynamics** via FP-AR model using RUL as an operating parameter.
- Comparative analysis of the performance of the method based on FP models vs the Wiener models based on time and frequency domain features, with the **FP model-based method** emerging as the **most efficient** and **reliable method** for **RUL estimation**.