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A cost effective degradation-based maintenance strategy under imperfect repair

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Abstract

An optimization model is developed to minimize the total cost of imperfect degradation-based maintenance by determining an optimal interval of condition monitoring and the degradation level after imperfect preventive repairs. The decision model is based on a novel cost model that considers functional relationship between the expected degradation reduction and the cost of preventive repairs. The decision model is applied to simulated vibration signals with a variety of specifications of cost values and degradation model parameters. This study has initiated a new area for the research of cost effective maintenance strategies. The results clearly indicate the significance of the proposed model and the decision variables under the objective of minimal cost. For instance, the results indicate direct relationship between the optimal length of monitoring interval and the monitoring cost. However, longer monitoring interval increases the risk of failure, and therefore, more degradation reduction is needed. By increasing the slope of cumulative degradation, the cost effective strategy advocates taking more frequent monitoring. The optimal degradation level after each preventive repair is not so sensitive to the change in the degradation slope due to the uncertainty associated with degradation patterns.

Keywords: Imperfect maintenance; Degradation process; Preventive repair; Optimization

Notations

X_p	Degradation threshold for potential failure
X_f	Degradation threshold for functional failure
ζ	Optimal degradation monitoring interval
x_r	Degradation level after repair
$D(t_i)$	Cumulative degradation model up to time t_i
Φ	Initial degradation value (a known constant)
$\varepsilon(t_i)$	Error term that follows a Markov process
θ	Lognormal random variable
β	Normal random variable
$L(t_i)$	Log form of the cumulative degradation to time t_i
Δ_i	Increment of log degradation
C_p	Cost of preventive repairs
C_s	Fixed (set up) cost for preventive repairs
M	Proportional constant (known)

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