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Introducing a Dynamic Factor-Based Predictive Maintenance Model for Optimizing Resource Allocation in Complex Systems

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Abstract : Instead of relying on predetermined schedules or calendar intervals, Usage-Based Maintenance (UBM) is a proactive maintenance method that initiates maintenance operations based on the actual usage of the equipment. This is in contrast to traditional maintenance methods of corrective maintenance and time-based preventive maintenance. The precision and applicability of a usage-based model rely on its exactness when modelling the actual system. However, excessive simplification of usage-based maintenance models may omit all active failure modes that arise during equipment use, leading to inaccurate predictions and ineffective interventions. This paper presents a unique exponential-based predictive maintenance model that simultaneously considers the impact of multiple failure modes during equipment usage. The model integrates time-dependent deterioration dynamics and operational thresholds derived from basic principles. The proposed model integrates a growth-modulating factor governed by a baseline parameter against a system-specific usage threshold, which calculates the time to failure of the component under usage. Within the context of a chemical processing facility, a case study application of the formula is applied to data from the operating history of essential components subjected to four (4) different failure modes. These failure modes include fatigue, corrosion, erosion and wear. The study's findings demonstrate the formula's practical implementation and illustrate the impact that numerous failure modes working simultaneously on a single component might have due to operational stress on the time to failure. This technique provides a dynamic framework, allowing for predicting failure probability, optimizing maintenance schedules, and improving resource allocation in critical systems such as those in the chemical, aerospace, energy, and manufacturing industries.

Keywords : usage-based maintenance (UBM), failure modes, predictive maintenance model, operational thresholds, and maintenance optimization
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