APEM journal

Advances in Production Engineering & Management
Volume 21 | Number 2 | June 2026 | pp 239–253
https://doi.org/10.14743/apem2026.2.571

ISSN 1854-6250
Journal home: apem-journal.org
Original scientific paper

An integrated framework for production lot sizing and predictive maintenance based on Remaining Maintenance Life and Proportional Hazard Models

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ABSTRACT

Equipment reliability is critical to maintaining production efficiency and controlling manufacturing costs. Predictive maintenance (PdM), based on machine condition prediction, can effectively reduce the risk of machine failure; consequently, machine degradation assessment and the prediction of remaining maintenance life (RML) are crucial for maintenance decision-making. Moreover, because equipment condition affects production planning, PdM should be integrated into the traditional economic production quantity (EPQ) model. The main contribution of this study is the introduction of RML as a decision-support metric linking equipment degradation prediction with production lot-sizing decisions, thereby enabling the joint optimization of EPQ and PdM policies. To minimize expected average cost, maintenance decisions are integrated into the production lot-sizing model to determine the optimal production lot size and maintenance policy. This study considers a single-machine production process in which the ARMA method is used to forecast the machine degradation index. Cox's proportional hazard model (PHM) is then employed to estimate machine reliability based on the predicted degradation index. Based on this reliability assessment, remaining maintenance life (RML), rather than the traditional remaining useful life (RUL), is employed to link degradation prediction with the EPQ model and to characterize the machine deterioration process. An integrated EPQ–PdM model is developed to jointly determine the optimal production lot size and maintenance policy while minimizing the expected average cost (EAC) over the production cycle. Finally, a case study of an automotive bumper factory demonstrates the effectiveness of the proposed framework. The results show that the framework reduces EAC by 19.6 % relative to the current production strategy and identifies an optimal maintenance threshold of R_{safe} = 0.4 with six maintenance cycles.

ARTICLE INFO

Keywords:
Economic production quantity (EPQ);
Predictive maintenance;
Proportional hazard model (PHM);
Machine degradation;
Remaining maintenance life (RML);
Production lot sizing;
Reliability assessment;
Maintenance optimization;
Condition-based maintenance (CBM);
Integrated production-maintenance optimization

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Article history:
Received 24 September 2025
Revised 22 June 2026
Accepted 25 June 2026

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