Editorial

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Maintenance modelling concerns methods of improving asset reliability and availability with consideration of relevant cost through maintenance, including corrective, preventive and predictive maintenance.

This special issue contains 32 papers studying different aspects of maintenance modelling. A small proportion of the papers are extended versions of some papers presented in the 9th International Conference on Modelling in Industrial Maintenance and Reliability (MIMAR), held in London, UK, 12–14 July, 2016.

The contents of the papers distributed as shown in the following figure.

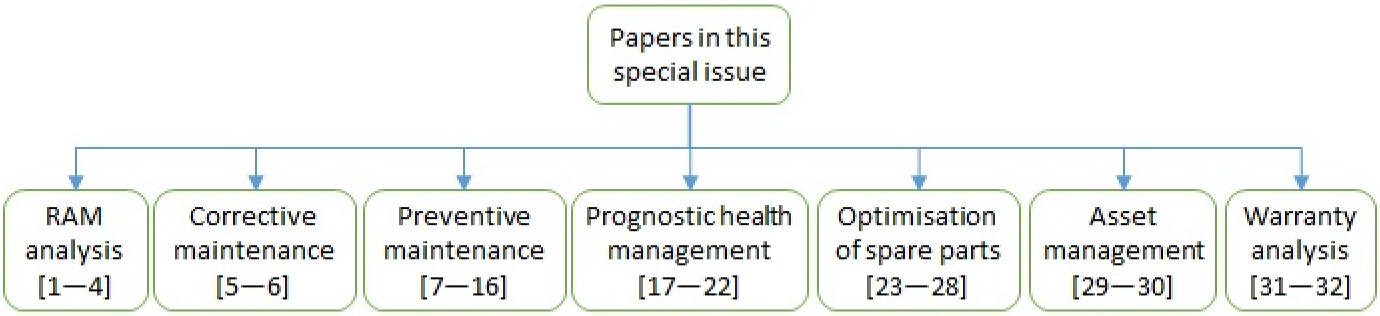

Fig. 1. Papers in this special issue.

RAM (Reliability, Availability and Maintainability) analysis aims to analyse the reliability indexes, such as reliability, availability and maintainability, of a system. It has long been a topic of major concern. In this special issue, [1] proposes a general modeling and decision framework for linking PHM (Prognostics and Health Management) metrics of literature to the component reliability. [2] introduces two new interval availability indexes for a Markov repairable system. [3] proposes a new model for the demand failure probability of a safety component, taking into account the effect of demand-induced stress (mainly test-induced stress), maintenance effectiveness and test efficiency. [4] investigates the impact of the statistical uncertainty of the lifetime distribution of offshore wind turbine systems on system availability.

Corrective maintenance carries out after fault recognition and intends to put an item into a state in which it can perform a required function * . Estimation of maintenance effectiveness and optimisation of maintenance cost have been main focuses, which are discussed in [5] and [6] for different settings, respectively. [5] investigates the possibility of building equivalent models with a geometric reduction of age or intensity and present several ideas leading to different possible models. [6] proposes an approach to building a process for understanding the trade-offs within corrective maintenance activities at the equipment level.

Preventive maintenance carries out at predetermined intervals or according to prescribed criteria and intends to reduce the probability of failure or the degradation of the functioning of an item*. Research relating to preventive maintenance (PM) mainly focuses on optimisation of maintenance intervals, considering the complexity of industrial systems and the operating dynamic conditions. Many PM models have been introduced in the literature. [7] develops a delay time model for a one-component system with postponed replacement to analyze situations in which maintenance might not be executed immediately upon discovery of a defect in the system. [8] proposes a method for optimising maintenance policy of a multi-component system with different maintenance modes. [9] considers PM of a repairable item under an operating environment that can be modeled by a Poisson process of shocks. [10] proposes a cost-based importance measure to prioritise PM for components in a system. [11] proposes a maintenance model for a single machine system working under piecewise constant operating condition by combining an age-based hybrid imperfect maintenance model and an accelerated failure time model. [12] proposes an opportunistic PM scheduling for serial-parallel multistage manufacturing systems with multiple streams of deterioration. Economic dependence between components is studied for joint PM on several components. [13] introduces a PM model for software rejuvenation in a deteriorating job processing system. In the proposed model, the number of queued jobs is used to represent the system state and the decision of rejuvenation is made upon the completion of a foreground job. [14] presents a framework for optimal maintenance of power distribution systems subjected to hurricane hazard, timber decay and climate change. The framework was demonstrated using a virtual city as a case study and considering periodic chemical treatment of the poles and repair of decayed poles using fiber reinforced polymer. [15] develops a framework to select tests to identify errors made whilst the maintenance is underway. [16] compares replacement polices that are carried out at some periodic times and that are done at a predetermined number of repairs.

Predictive maintenance Prognostic health management techniques have emerged as promising solutions for cost effective maintenance planning. The connection between prognostics and maintenance enables updating maintenance plans with up-to-date system health indicators. The integration of predicted health indicators into maintenance strategies for complex industrial systems operating under dynamic environments is still an open research issue. [17] proposes a dynamic grouping maintenance planning using an online predictive diagnosis algorithm, which can distinguish between critical and non-critical assets and predict the system health based on dynamic dependability model. [18] reports on experience using PFP-SubSim algorithm (Particle Filter-based Prognostics with the technique of Subset Simulation) for making predictions for the end-of-life and remaining useful life in the challenging application of fatigue damage propagation of carbon-fibre composite coupons using structural

* British Standard, Glossary of terms used in terotechnology, BS 3811, 1993

health monitoring data. [19] proposes a method to integrate the degradation information into the maintenance planning. Their main idea is to consider that the degradation itself does not directly lead to system failure, but increases the failure risk of the system. [20] proposes a data-driven prognostic method to obtain accurate results on the high-level degradation states. [21] presents a maintenance optimization strategy for a multi-component system and uses local prognostic control to improve the health status of the system at component-level. [22] uses the survival signature, a generalization of the system signature allowing for multiple component types, to predict the distribution for the system survival time, also known as residual life distribution.

Optimisation of spare parts The demand for industrial plant spare parts is driven, at least in part, by maintenance requirements. It is therefore important to have enough stock on hand. However, overstocking of spare parts is usually costly. Since balancing this trade-off poses a challenging problem, there has been a lot of research on spare parts inventory control and optimisation. [23] proposes incorporating degradation state information in the spare parts inventory control policy and use three heuristic policies to seek optimal solutions. [24] proposes a joint predictive maintenance and inventory strategy for systems with complex structure and multiple non-identical components and jointly use an prognostic condition index and the structural importance measure of components to build the thresholds for PM and spare part provisioning. [25] studies the impact of the maintenance policy on the inventory requirements and the corresponding costs for a setting that is realistic at an OEM (Original Equipment Manufacturer) in the compressed air industry. [26] develops a method to use simulation for predicting failures in the army equipment and then use the genetic algorithm to optimise the maintenance policy. [27] presents a hierarchical coloured Petri net (HCPN) model of a fleet operation and maintenance process including maintenance scheduling and spare inventory management. [28] studies the joint optimisation of the inspection interval and the spare parts inventory. A number of simultaneous periodic review and continuous review replenishment policies are compared. It can be seen from [24,26,28] that maintenance and inventory optimizations are two interrelated processes and should be jointly integrated into a global model.

Asset management is a systematic process of deploying, operating, maintaining, upgrading, and disposing of assets cost-effectively. To guarantee the cost-effectiveness, the Life Cycle Cost (LCC) estimation and optimisation are the keys of success. That is the reason why they have been extensively studied in the literature. In this special issue, [29] assesses the potential cost savings of introducing a maintenance option in railway wheelset maintenance in Great Britain, develops a life-cycle cost model and puts forward a Monte Carlo simulation procedure to assess the life-cycle costs of different maintenance strategies. [30] focuses on the problem of LCC estimation. A high level Petri net model is proposed to simulate the degradation, failure, inspection and maintenance of the main overhead line equipments and to calculate various statistics, associated with the cost and reliability of the system over its lifecycle.

Warranty analysis Warranty is a contractual obligation incurred by a warrantor in connection with the sale of a product. For the warrantor, there are many challenges due to the failure uncertainty, discounting in future costs, client behaviors and their characteristics, etc. [31] analyses interaction among hospitals and their OEM. An optimal extended warranty setting which maximizes the OEM's expected profit has been proposed in considering two classes of hospitals (large ones and small/medium ones). [32] investigates warranty cost forecasting with taking into account its discounting, which depends on the product sales, failure processes, and customer behavior (failed-but-not-reported phenomenon).

Acknowledgments

We are grateful to Professor Philip Scarf for co-chairing the 9th International Conference on Modelling in Industrial Maintenance and Reliability. We are also greatly indebted to the editor-in-chief of the journal, Professor Carlos Guedes Soares, for his time and efforts on this special issue. We thank all authors for their excellent contributions to this special issue. Of course, sincere thanks go also to all reviewers for their careful (and voluntary) review work, which has helped to improve the quality of the papers published and thus the significance of the special issue.

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