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Preventive Maintenance and Tactical Production Planning in Multi-State Systems

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***Abstract*—**We propose an integrated model that coordinates preventive maintenance planning decisions with tactical production planning decisions, so that the total expected cost is minimized. We are given a set of products that must be produced in lots on a multi-state production system during a specified finite planning horizon. Planned preventive maintenance and unplanned corrective maintenance can be performed on each component of the multi-state system. The maintenance policy suggests cyclical preventive replacements of components, and a minimal repair on failed components. The objective is to determine an integrated lot-sizing and preventive maintenance strategy of the system that will minimize the sum of preventive and corrective maintenance costs, set-up costs, holding costs, backorder costs and production costs, while satisfying the demand for all products over the entire horizon. We model the production system as a multi-state series-parallel system with binary-state components. Multi-state reliability theory is used to evaluate the production system capacity, and a method is proposed to evaluate the times and the costs of preventive maintenance and minimal repair. We provide illustrative examples to show the value of integrating production planning with preventive maintenance planning.

Key words: Multi-state systems, Optimization, Minimal repair, Preventive maintenance, Production planning.

I. INTRODUCTION

Production planning and preventive maintenance (PM) planning are two areas that have received a lot of attention in both the manufacturing industry, and the industrial engineering and operation research literature. In practice, these activities are typically dealt with and performed independently despite the clear relationship that exists between them. The relationship between production planning and PM planning is conflictual in nature. As PM activities takes time that could be otherwise used for production, production management usually perceives PM in the context of hours or days out of service and fails to realize the importance of maintenance planning. On the other hand, delaying PM for production may increase the probability of machine failure and maintenance management tries to achieve high equipment reliability. Hence, there are trade-offs between PM planning and production planning. Because these activities are performed sequentially in practice, production and maintenance plans are often not optimal with respect to the objective minimizing the combined maintenance and production cost. By integrating these decisions, the system productivity could be improved and the total expected cost reduced. The objective of this paper is to develop an integrated production and PM planning model for multi-state systems (MSS). For production planning, we deal with tactical level. For maintenance, we use multi-state reliability modelling that considers that a system may experience a range of performance levels from perfect functioning to complete failure. This means that MSS are able to perform their tasks with partial performance. The reliability of MSS is a recently emerging field at the junction of traditional binary reliability and performance analysis. A good and extensive review of MSS literature can be found, for example, in [1, 2].

Similar to the situation in practice, the areas of production and maintenance are usually treated independently in the literature. There is a substantial amount of research dealing with tactical production planning. For example, in [3,4] the authors cover the majority of the advancement in the area. Generally, production planning models tend to be deterministic optimization models designed to minimize inventory, production and set-up costs in the planning horizon, regarding

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