Chapter 11
Intelligent Integrated Maintenance Policies for Manufacturing Systems

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Abstract Nowadays, the fierce competition between enterprises has led many of them to revise their maintenance and production or service strategies. Satisfying customer demand in a timely fashion has become difficult due to the demand’s random nature, a problem compounded by machine failures and low system availability. Much of the literature addressing this situation describes models and methods to optimize maintenance policies. By contrast, the research presented in this chapter is geared toward the development of a set of intelligent maintenance policies, which optimize integrated maintenance, inventory and production elements while satisfying random demand over future periods. This is a complex task due to the various uncertainties involved, which are due to external or internal factors. For instance, the variations in the environmental and operational conditions can be considered as external factors whereas the variations in the material availability can be considered as internal factors. The approach described in this chapter demonstrates the significant influence these factors have on the system failure rate, which is in turn important in the determination of an optimal intelligent maintenance strategy. We also emphasize that, on the one hand, high machine availability is an underlying assumption of just-in-time production control policies, and on the other hand, the traditional approach, which dissociates maintenance and production, is no longer satisfactory.

Keywords Preventive maintenance (PM), failure rate, simulation, optimization, reliability, availability, sequential PM, periodic PM

11.1 Introduction

Problems treating jointly maintenance and production plans have recently attracted the attention of several researchers. The basic thrust of our research is in
devising an intelligent aggregate optimal production and maintenance plan, which minimizes the total cost of production, inventory and maintenance, and satisfies the random demand over future periods. The complexity of this task stems from the various uncertainties associated with the decision process, due to external and internal factors. While the randomness of the demand, which inhibits knowledge of the demand behaviour during future periods, can be considered as an external factor, the variation in material availability can be considered as an internal factor. An intelligent optimal maintenance strategy considering the deterioration of the manufacturing system according to the production rate was studied by Hajej et al. (2009). On the other hand Silva and Cezarino (2004) considered a chance-constrained stochastic production-planning problem under the assumption of imperfect information on the inventory variables.

The traditional maintenance policies proposed in the literature mainly seek the critical age of a machine or a set of machines at which preventive maintenance (PM) is to be carried out. These policies are based on models describing the deterioration law of the equipment. Valdez-Flores and Feldman (1989) distinguished four classes of models: inspection models, models of minimal repair, shock models and replacement models. The cost/time of maintenance/repair is assumed to be known and consequently the impact of a maintenance/failure cannot be analysed easily. Under these conditions, it can be shown that the optimal policy is one of critical age. In this context, Wang and Pham (1996) suggested that maintenance can be classified according to the degree to which the operating conditions of an item are restored by maintenance. They proposed four categories: perfect repair or perfect maintenance, minimal repair or minimal maintenance, imperfect repair or imperfect maintenance and worse repair or worse maintenance.

Obviously, maintenance becomes even more important in a just-in-time production environment, which requires the uninterrupted availability of machines. An integrated approach of maintenance and production control hence becomes necessary. In this context, Buzacott and Shanthikumar (1993) proved the importance of the choice of the maintenance policy for the minimization of the total cost, while Cheung and Hausmann (1997) considered the simultaneous optimization of the safety stock and the maintenance policy of the critical age type. Rezg et al. (2004) tackled the global optimization of PM and inventory costs in a production line made up of N machines. In the same context Rezg et al. (2008) presented a mathematical model and a numerical procedure, which determine a joint optimal inventory control, and age-based preventive maintenance policy for a randomly failing production system. Maintenance/production strategies taking into account a subcontractor are considered by Dellagi et al. (2007).

Traditional PM models assume that the action is perfect, i.e., it restores the system to the as-good-as-new state. However, it is more realistic to assume imperfect PM actions, where the system following the PM activity is in a better condition than before, but cannot be considered as new. Many models have been developed to represent the effect of an imperfect maintenance. An early such model, devel-