Joint Control of Dynamic Maintenance and Production in a Failure-prone Manufacturing System Subjected to Deterioration

Abstract

This paper addresses the integrated control of dynamic maintenance and production in a deteriorating manufacturing system. The previous literature on the integrated control of production and maintenance usually ignores maintenance opportunities that may arise during machines' failures. Therefore, this paper proposes a dynamic maintenance policy which comprises of corrective, preventive and opportunistic maintenance. Opportunistic maintenance uses the downtime of machines as potential opportunities to perform maintenance on other machines. In this paper, control of dynamic maintenance is integrated with production to achieve the minimal total production cost, which includes costs of inventory, backlog, repair, preventive and opportunistic maintenance. By applying an approximation technique and the value iteration algorithm, the authors obtain a near optimal control policy for the deteriorating manufacturing system. In addition, the authors compare the performance of the obtained control policy with that of a previous control policy reported in the literature. A sensitivity analysis is also conducted to examine the effect of some system parameters on the configuration of the control policy. With the proposed control policy, industry practitioners are able to avoid unnecessary preventive maintenance and fully utilize the opportunistic time window to improve system reliability while achieving minimal total production cost.

Keywords: Integrated control, Preventive maintenance, Opportunistic maintenance, Dynamic maintenance, Corrective maintenance, Maintenance opportunity

1. Introduction

In recent years, global competition has posed demanding requirements on manufacturing industries. Better performances, such as higher system reliability, better product quality, shorter production lead time, etc., are expected in manufacturing industries (Chen & Subramaniam, 2012; Colledani & Tolio, 2012). Production, quality and maintenance are three main issues that affect the performance of manufacturing systems. The control of these three issues becomes indispensable because of the uncertainties in manufacturing systems, such as stochastic demands, random quality and machine failures, etc. These three issues also affect one another and their integration will result in better production performance Pandey et al. (2011). For example, maintenance is usually performed in manufacturing systems to restore machine functions, alleviate deterioration and improve system reliability. However, excessive maintenance will interrupt processing and cause production losses (Yao et al., 2009). On the other hand, higher production rate will speed up machine's deterioration and thus affect maintenance planning. Therefore, maintenance and production control are highly interrelated and should be considered jointly for better production performance.

In the past decade, much research has been directed at the integrated control of maintenance and production (Ayed et al., 2012; Zied et al., 2009). Usually these control problems are formulated as optimization problems which aim at the simultaneous design of maintenance and production parameters to achieve optimal performance criteria such as minimal cost, shortest completion time, etc. The difference amongst the models that are reported in the literature lies in the use of maintenance policies, namely, preventive maintenance (PM) and corrective maintenance (CM). There are different types of PM. Among them are time-based PM, condition-based PM and their variations. Time-based PM is performed on time periods that are either fixed or dependent on machine's age (Jhang & Sheu, 2000). On the other hand, condition-based PM is performed based on system operating conditions and prior statistical knowledge of system lifetime (Deloux et al., 2009). Opportunistic maintenance (OM) is another maintenance policy that is