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Production control of unreliable manufacturing systems producing defective items*

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Abstract

This paper addresses the production control problem of a failure prone manufacturing system producing a random fraction of defective items. Our main objective is to extend the Bielecki and Kumar theory under which the machine considered produced only good quality items, to the case where the items produced are systematically a mixture of good as well as defective items. We first show that for constant demand rates and exponential failure and repair time distributions of the machine, the Bielecki-Kumar theory adequately revisited provides new and coherent results. For the more complex situation where the machine exhibits non exponential failure and repair time distributions, a simulation based approach is then considered. The usefulness of the proposed models is illustrated through numerical examples and sensitivity analysis.

Keywords: Stochastic optimal control, manufacturing, integrated production and quality control.

1 Introduction

In the eighties Akella and Kumar [2], and subsequently Bielecki and Kumar [1] developed an optimal stochastic control analysis of a model of a failure prone machine facing a constant rate of demand of a single part type, and with both storage and backlog costs. The main conclusion of their analysis was that there exists an optimum, typically positive level of finished parts inventory one should aim at maintaining whenever possible in meeting the demand. This type of production policy became known as a hedging policy, and was subsequently shown to be susceptible to generalizations in multi state [3] and multi part failure prone manufacturing systems [4]. In hedging policies, the critical inventory one aims at maintaining is associated with a cost per unit time, and this cost acts much like an insurance policy one pays upfront so as to hedge against future machine failures which may induce shortages and ensuing large backlog costs. The Akella - Bielecki - Kumar (AKB) theory has come to be regarded as an after the fact analytically founded justification of the ideas behind Kanban and related manufacturing production disciplines.
One of the main conclusions of the mathematical analysis of manufacturing systems under uncertainty is that it is optimal for production to get sufficiently ahead of demand, or equivalently, that there is a need for storing inventory or work in process at a level consistent with the level of uncertainty, and both the costs of storage

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