Markovian Reliability in Multiple AGV System

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INTRODUCTION

Traditional manufacturing has relied on dedicated mass-production systems to achieve high production volumes at low costs. As living standards improve and the demands for new consumer goods rise, manufacturing flexibility gains prominence as a strategic tool for rapidly changing markets. Flexibility, however, cannot be properly incorporated in the decision-making process if it is not well defined and measured in a quantitative manner. Flexibility in its most rudimentary sense is the ability of a manufacturing system to respond to changes and uncertainties associated with the production process (Miettinen et al., 2010; Kumar & Sridharan, 2009; Das et al., 2009). A comprehensive classification of eight flexibility types was proposed in Browne et al. (1984). Automated Guided Vehicle System (AGVS) becomes popular in many industrial fields because of its flexibility, reliability, safety, and contribution to the increase of productivity and to the improvement of housekeeping. But, the performance of the material handling system is significantly influenced by several operating policies. Since the manufacturing systems experience different failure states, therefore considering these states in modeling a reliability problem is of importance. The best way for considering system states in modeling is to employ Markovian property. Reibman (1990) stated the problem in estimating the probability of failure in different state is vital for reliability computations. The increasing demand for the reliability assessment in manufacturing systems under several random parameters has been investigated by several approaches facilitating the computations of probability estimations. As a significant merit for availability of an automated material handling system, studying on the reliability of the system is effective. The importance rises while several devices configure a multiple handling system. State transition in FMS is substantially effective on reliability computations. Therefore this research helps readers to find out more about different aspects of reliability computations in various manufacturing system configurations including machines and AGVs.

BACKGROUND

Flexible manufacturing systems (FMS) are crucial for modern manufacturing to enhance productivity involved with high product proliferation. As one of the critical components of the FMS, the flexible material handling system (MHS) plays a strategic role in the implementation of the FMS. According to Tompkins et al. (2002), about 20–50% of the total production cost is spent on material handling. This makes the subject of material handling increasingly important. In addition, all the complexity of manufacturing are passed on to the MHS. Therefore, the flexible MHS has been vital for improving the FMS to fulfill the requirements of high product proliferation (Zhao et al., 2011).

Automated manufacturing systems (AMS), which are equipped with several CNC machines and AGV-based material handling system are

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designed and implemented to gain the automation and efficiency of production. To make use of all features of AMS, the planning in the AMS decision making process is critical because the planning decision has influence on the subsequent decision processes such as scheduling, dispatching, etc. The planning in automated manufacturing systems can be characterized as being online and short-term nature to respond to frequently changing production order. Given a production order, manufacturing planning function is responsible to establish a plan by decomposing the production task into a set of subtasks. An analysis of AMS dealing with changing demand can be found in (Terkaj et al., 2009). An extensive review of the loading problem for an FMS can be found in (Grieco et al., 2001). An early stochastic programming approach to address the short-term production planning for an FMS can be found in (Terkaj & Tolio, 2006).

In most manufacturing systems, decision making is worked out at several stages of design, planning and operation. The role of performance modeling is significant in advanced manufacturing systems from economic viewpoints (Yang, 2011). However, events such as machine breakdown, changes in part type and volume, tool replacement, raw material and other short interruptions are effective on the desired performance of a manufacturing system. This problem is critical due to its impacts on the capacity of the system. Researches on the automated manufacturing systems imply that the machine failure is the major problem in analyzing system performance in comparison with other factors like raw material, equipment, software and workers. Therefore, reliability considerations should be taken into account for manufacturing system analysis. Researchers who studied this problem include Liberopoulos (1993), Viswanadham and Narahari (1992), Perkins et al. (1994), Choi and Lee (1998).

MAIN FOCUS

The system under study is a jobshop manufacturing system having multiple AGVs for material handling purpose. In each shop several machines perform the part processing according to a pre specified process plan. To transfer the parts among different shops AGVs are employed. The reliability of the whole manufacturing system is concerned with the reliability of the machines in shops and the reliability of the AGVs. The schematic of the system is shown in Figure 1.

The failure of the machines and AGVs could be considered in different states. The failure causes for machines are:

- Amateur operator
- Equipment deficiency
- Inappropriate part specifications

Figure 1. Schematic of the multiple AGV manufacturing system