Chapter 2

Analytical Material Flow Model for AGV System

2.1 Summary

Manufacturing automation has become increasingly important as the need to remain productive increases. In manufacturing of a product, many processes may be needed. For example, semiconductor manufacturing may include over 400 processing steps involving more than 100 different tools. Furthermore, the process route can include a high level of reentrance in which the same tool or tool types are used. An important aspect in manufacturing automation is material handling. To facilitate material handling, automated transport systems are employed.

A special attention has been given during the last few years to the problem of production control in manufacturing systems (Akella et al., 1990; Gershwin, 1989). Flow models are often used in the intermediate level to represent the inventory balance equation of the production system. The aim is to compute an average production rate for each product type in order to meet the demand with minimum surplus or backlogging costs. During the optimization procedure capacity changes due to machine failures must be taken into account. In (Gershwin, 1989 ), changes in the system’s capacity due to machine failure are described as a function of the state of the system and since machine breakdowns cannot be predicted, capacity is considered as a stochastic set. This means that for the dynamic system representing the flow of parts, a sudden change in the system’s state due to machine failure is transformed to a change (or a jump) for the capacity constraint.

Conventional automated transport systems are used in, for example, a semiconductor manufacturing plant typically comprises a plurality of bays. Each bay includes a plurality of tools which are used to process wafers. Transport vehicles, such as overhead transport (OHT) are provided for automatic transfer of wafers contained in a carrier. A stocker which temporarily stores carriers is provided for each bay. A transport system controller controls the movement of carriers within a bay or between bays. In recent years, the automated material handling system has rapidly developed as an efficient manufacturing system. The AGV (automated guided vehicle) system plays an especially significant role.
and has become more widely used in modern manufacturing environments due to its flexibility and precision. With an AGV system, we can easily respond to changes in production volume, product mix, product routing and so on (Ho and Liao, 2009).

However, due to the continuously increasing size and complexity of the modern manufacturing system, controlling this system has become more difficult. Consequently, various types of research have been conducted to solve this problem. Bozer and Srinivasan (1992) defined the conventional AGV system and proposed tandem configuration based on the “divide and conquer” principle. Multiple vehicles can exist in a traditional AGV system and each vehicle can pick-up, deliver and drop off a load at any workstation. A tandem AGV system is obtained by partitioning all workstations into multiple zones, assuming a single vehicle to each zone. As a result, any potential blocking, congestion or deadlock does not occur. And the performance of the tandem AGV system has been demonstrated (Bozer and Srinivassan, 1992; Laporte et al., 2006; Asef-Vaziri et al., 2001; Kaspi et al., 2002).

The emergence of high performance automated manufacturing systems (AMSs) has lead to the need for methods of modeling these types of system in order to maximize throughput, flexibility and competitiveness. AMSs belong to the domain of discrete event dynamic systems (DEDS) in which the evolution of the system depends on the complex interactions of various discrete events such as the arrival of raw materials, departure of finished goods, failure of equipment etc. The state of DEDS changes only at these discrete points in time. Over the last decade several models have been presented to describe DEDS and these can be grouped into two distinct area (Rajagopalan et al., 2004).

Qualitative models are concerned with the logical aspects of system evolution such as controllability, stability and the existence of deadlocks in system operation, etc. This category also includes Petri Nets, extended state machines and finitely recursive processes (Castillo et al., 2001).

Quantitative models are concerned with the quantitative system performance in terms of throughput and lead time. This category also includes discrete event simulation, min-max algebra, Markov Chains, stochastic Petri nets, queues, and queuing networks (Berman et al., 2009). Quantitative models are a general term including performance modeling which is the area of interest to this article. Within the life cycle of an AMS various decisions are made concerning implementation, design and operation of the system. Typical decisions at the planning stage include number and type of machines, number of material handling devices, number of buffers, size of pallet pool and number of fixtures, best possible layout, tool storage capacity, evaluate candidate AMS configurations, part type selection, machine grouping, batching and balancing decisions, and scheduling policies (Huang et al., 2009)

During the operational phase of an AMS, performance modeling can be used to assist decisions about how to react in the event of a breakdown, removal or addition of resources and parts, optimal scheduling in the event of machine failure