Chapter 1
Intelligent Automatic Guided Vehicles

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ABSTRACT

Automatic Guided Vehicles (AGV) based material handling systems have become the most widely used method of transporting pallets and parts between workstations in flexible manufacturing systems. Their primary advantages include increased routing flexibility, space utilization, safety, and reduced overall operational cost. Key issues to address during the design of an AGV system include selection of AGV platform, flow path design, and fleet size determination. During run time AGV system functionality includes: system management, (AGV allocation), navigation (establishing conflict free routes), and load transfer (material pick up and deposit mechanisms). Autonomous AGV systems offer numerous advantages in comparison to traditional systems. The following chapter will discuss the state-of-the-art in AGV systems concentrating on AGV run time functionality and AGV system performance measurement.

INTRODUCTION

Manufacturing Flexibility is the ability of a manufacturing system to respond, at a reasonable cost and appropriate speed, to planned or unplanned changes in external or internal environments. It is accomplished by multidimensional attributes of the manufacturing system. In the global, rapidly changing modern market conditions manufacturing flexibility becomes a necessity in many industrial environments (Tsouveloudis & Phillis, 1998; Roll *et al.*, 1998; Gustavsson, 1984; Zelenovic, 1982). In flexible manufacturing environments product mix, processing requirements, arrival and due times, and job priorities may continuously vary.

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The flow of parts, mobile resources (*e.g.,* tools), and wastes (*e.g.,* machined chips), throughout the manufacturing facility is implemented by the material handling system. The cost of material handling is a significant part of total product cost (Groover, 1987). Therefore, optimization of the material handling system can lead to substantial cost reductions. Material Transport is achieved by systems such as conveyors, monorails, hoists, cranes, and industrial vehicles. Material handling flexibility is an important layer of overall manufacturing flexibility.

Automatic guided vehicles (AGVs) are driverless, steerable, wheeled industrial vehicles driven by electric motors using storage batteries. Some of their primary advantages include increased routing flexibility, space utilization, safety, and reduced overall operational cost (Ganesharajah *et al.*, 1998). An AGV system is material handling system based on several AGVs operating concurrently. An AGV system is highly suited for flexibly manufacturing environments and such systems have become the most widely used method of transporting pallets and parts between workstations in flexible manufacturing systems (Reveliotis, 2000; Hwang & Kim, 1998).

Key issues to be addressed during the design level of an AGV system are: the selection of the AGV platform, flow path design, and fleet size determination. During run time AGV system functionality includes: system management (AGV allocation), navigation (establishing conflict free routes), and load transfer (material pick up and deposit mechanisms). Load transfer between the AGV and the workstation commonly takes place at a designated place next to the station termed the load port or Pick/delivery station. AGV system navigation includes navigation (determining the designated route) and traffic management (conflict resolution between AGVs) (Koff, 1987).

BACKGROUND

AGV Platforms

AGVs, introduced for industrial applications in the 1950s by Barrett Electronics Corporation, are today a commonly applied transportation technology. In 2000 over 20,000 AGVs were used in various industrial applications. The largest consumer of AGVs is the automotive industry, but AGVs are also common in other industries, including warehouses and distribution centers, paper, printing, textiles, and steel industries (Kelly et al., 2007; Vis, 2006).

There are several types of commonly used AGVs (Koff, 1987). Towing AGVs pull a multitude of loads up to 23,000 kg. They are very popular and were the first introduced type. Unit load AGVs are equipped with decks permitting unit load transportation and often load transfer as well. Pallet trucks AGVs designed for palletized load transfer at floor level. Fork trucks AGVs are able to service palletized loads both at floor level and on stands. Light load AGVs generally carry 230 kg and less, though this number is not strictly kept and vehicles with larger load capacity may also be considered light load according to usage (Dunking, 1994). They are used for transporting small parts and designed for operation in limited space. Assembly-line AGVs are basically light load AGVs designed for serial assembly processes. There are also heavy carrier AGVs designed to transport large or very heavy loads (weighing over 100 kg). These are typically used in the primary metal and paper industry. The three most commonly found types of AGV vehicles today are towing AGVs, unit load carriers, and fork trucks (Kelly et al., 2007).

In many industrial facilities reduction of floor space is an important design issue. Consecutively attaining a high degree of AGV maneuverability is important. Omni directional AGVs offer a possible