Automated Guided Vehicle System (AGVS)

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Abstract - *The automation of transport facilities in the industries, trade and service sector is a key point in optimization. AGVS provides several benefits to fulfill the logistic tasks. This paper presents the research review study about the AGVS technology. It primarily focuses on the design of the Automatic Guided Vehicle System, its types, applications and its efficiency to overcome the day to day problems in industries or industrial warehouses. It also focuses on the issues of designing and installing these systems in a flexible manufacturing system, development, advantages and the future trends of AGVS.*

***Key Words*: Automation, Optimization, Automatic Guided System**

1. INTRODUCTION

An automated guided vehicle or automatic guided vehicle (AGV) is a portable robot which follows marked lines or wires on the ground, or uses radio waves, vision cameras, magnets, or lasers for navigation. They are most frequently utilized in industrial applications to move heavy materials around an outsized industrial building, like a factory or warehouse. Application of the automated guided vehicle broadened during the late 20th century. The AGV can tow objects behind them in trailers to which they will autonomously attach. The AGV also can store objects on a bed. The objects are often placed on a group of motorized rollers (conveyor) then pushed off by reversing them. AGVs are employed in almost every industry, including pulp, paper, metals, newspaper, and manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done. [https://en.wikipedia.org/wiki/Automated_guided_vehicle].

The foremost important aspects of logistics systems are that the handling of goods flows in industrial environments. Despite the high throughput rates realized by steady materials handling technologies such as roller or chain conveyors, the vast majority of industrial applications rely on common lifting or hauling trucks as transportation system. The reasons are manifold: Besides cost related aspects one among the main advantages is that the unmatched flexibility regarding integration in an existing or changing environment. Extending these advantages of commercial trucks by means of automation technology leads increased reliability and reduced operating costs. The outcome is that the so called Automated Guided Vehicle System, abbreviated as AGVS. AGVS are capable of performing transportation tasks fully automated at low expenses. Applications are often found throughout all industrial branches, from the automotive, printing and pharmaceutical sectors over metal and food processing to aerospace and port facilities. The increasing interest in AGVS is reflected within the sales figures which reached a replacement peak in 2006. By now AGV-Systems are known for quite fifty years, a time during which various technical advances are made, starting from improved actuators and energy supplies to completely new sensor concepts. The enormous progress of computer systems induced enhanced control strategies. The following sections introduce the main components of an AGVS and supply a summary of recent achievements in AGVS related technology. [Lothar Schulze et al, 2008]. With the advance of technology, more sophisticated machines are available, which considerably reduce machining and internal setup time [Hassan haleh, Arman Bahari, 2014]. The aim of production planning includes along with fast production, efficient transportation of material between the workstations and in and out of storage. Flexible material handling systems are required to perform an efficient routing of material with random handling capability. In the present study the review was taken as the use of AGVs increases flexibility, since the flow path can easily be selected from number of alternative paths, or, can be reconfigured to accommodate new locations. The design of goods handling guide path features a significant implication on the general system performance and reliability, since it's an immediate impact on the time period, the installation cost, and the complexity of the control system software. [Virendra, Bhatwadekar, 2014].

2. LITERATURE SURVEY

The first AGV was brought to the market in 1950s and at the time it was simply a tow truck that followed a wire in the floor instead of rail. Out of this technology came a replacement sort of AGV which follows invisible UV markers on the ground rather being towed in a sequence. The first such system was developed at the Wills tower in Chicago, llinois to deliver mail throughout its offices. Over the years the technology has become more sophisticated and today automated vehicles are mainly Laser navigated i.e. LGV. In an automatic process LGVS are programmed to speak with other robots to make sure product is moved smoothly through the warehouse, whether it is being stored for future use or sent directly to shipping areas. Today, the AGV plays a crucial role within the design of latest factories and warehouses, safely moving goods to their rightful destination. Several researchers have worked on AGV systems over a period of time. Lothar Schulze et al [2008] stated that automation of transportation in the production, trade and service sector is the key point in the optimization of logistics. Q. Li et al [2011] have studied on design and controlled of AGVS with the focus on quayside container transport in an automated container terminal by setting an event driven model for an AGVS in the zone control framework. Based on this study of zone control model they proposed a traffic control strategy which decouples the motion conflict resolution among the AGVs from the routine problem. The efficiency of the integrated design and control is demonstrated by computer simulations. Manali Pohare et al [2015] have developed intelligent AGV machine for effective transportation of goods on the respective paths and routes. They have stated that AGVs can be widely used in industrial fields and community services as well as dangerous working areas. It works just like a robot as it is able to sense and respond in the given environment. They have developed a prototype of an AGV which follows a given path. On a flat surface with the help of two DC motors and one free wheel. Camera is interfaced with PC for image acquisition and processing is done with the help MATLAB. This unit load AGVs gained widespread acceptance within the goods handling marketplace due of their ability to serve several functions; a bit platform, a transportation device and a link in the control and information system for the factory. Since then, AGVs have evolved into complex material handling transport vehicles starting from mail handling AGVs to highly automated automatic trailer loading AGVs using laser and natural target navigation technologies. Material handling in manufacturing system is becoming easier because the automated machine technology has improved. One of the goods handling methods that has been widely utilized in most industry nowadays is that the Automated Guided Vehicle System or better referred to as the AGVS. It has become one among the fastest growing classes of kits within the material handling industry, Tanchoco and Bilge, [1997]. Until today there are many researchers that have shown interests in improving the system in order to achieve more productivity and flexibility in manufacturing environments. According to Groover, [1987] an Automated Guided Vehicle System (AGVS) is a material handling system that uses independently operated, self-propelled vehicles referred to as the automated guided vehicle or AGV that moves along defined pathways between delivery points or stations. A typical AGV will consist of the frame, batteries, electrical system, drive unit, steering, on board controller and work platform Hinamshu Dudeja et al [2015]. Virendra Patil and Bhatwadekar [2018] highlighted the issues of designing and installing a system of AGVS in a flexible manufacturing system as well as computerized procedure for the optimized vehicle selection.

3. APPLICATIONS, ADVANTAGES AND TYPES OF AGVs

AGVS find their application in any area of industrial production, assembly, trade and service. The main application areas are connection of various work areas, order picking, warehousing and assembly. The realization of the material flow processes in the warehousing and order picking sector is characterized by high volume of traffic from defined sources to defined destinations [Schulze, L.; Zhao, 2006]. This standard application area of AGVS usually demands high loading capacities. The loads are usually standard pallets and therefore the AGVs are equipped with the standard loading devices [Lothar Schulze et al, 2008]. Another vast and important area of application of AGVS or AGVs are the assembly lines. In this, the load is inhomogeneous and changing. Therefore, the loading devices must be fitted to the precise application. The vehicle sometimes not only transports the load from one assembly station to the subsequent, but represents an assembly station itself. In this case the vehicle can be considered as a mobile workbench [Schulze, Zhao, 2007]. New developments at the PSLT are techniques that enable AGVS to follow a delegated person. The basic requirement for human-robot interaction is the system's ability to distinguish between the person and its surroundings and moreover to identify the person. This can be achieved by using sensors like digital cameras or laser range scanners. The main focus is centered on computer vision and its practical integration into an AGV-System. Experimental results show good performances of the system. Logistic operations like order picking would immensely take advantage of such a function. An interesting perspective may be a warehouse with employees focusing on picking while trolleys are following automatically. When they are fully loaded the trolleys will carry their load to the destination point. Empty replacements are provided by the central control in time [Lothar Schulze et al, 2008].

Advantages of AGVS or AGVs:

The advantages of the AGVS or AGVs include Reduction of labour cost, Increased accuracy and productivity, high availability and reliability, modularity, elimination of human error, enhances workplace safety, etc.

Types of AGVs:

Automated Guided Vehicles are classified mainly into three types:

1) Fork Lifts:

The AGVS fork lift truck applications are comparatively newer. These systems are used where there is a need of the automatic pick up and drop off of load from the floor or stand levels and also where the heights of the load transfer vary at stop locations. These systems are able to pick up loads and discharge them to the desired locations without any human interference. The vehicle consists two forks which can rise up to 1-2 meters so that the load from different pallet heights can be serviced.

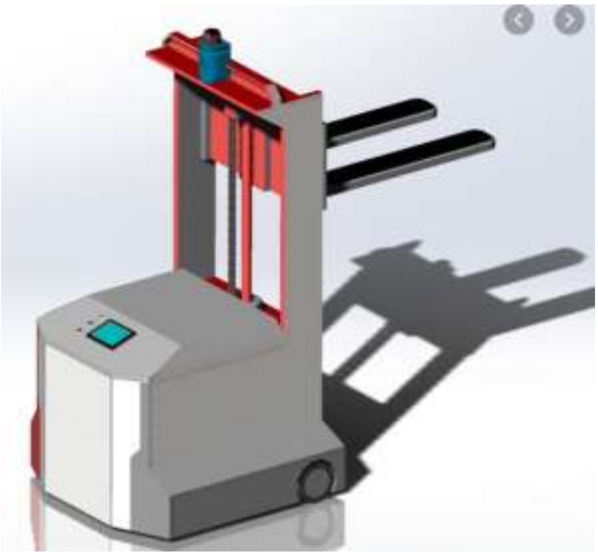


Figure 1: Fork Lift

1) Tow / Tugger or A Driverless train:

Tow tuggers or driverless trains are one of the widely used and applicable AGVS in various industrial sectors. The bulk movement of products / parts / materials in and out of the warehouse areas or directly to the assembly or manufacturing areas. In automobile assembly or manufacturing industries these trucks or trains are efficiently used for bulk movement of the cars. Usually side path spurs are placed in receiving or shipping areas so that trains can be loaded or unloaded off the main line and thereby not hinder the movement of other trains on the main path. Chain movement of product with AGVS trains is also popular. In this case, the AGVS trains are loaded with product destined for specific destinations along the guide path route. The train will make several stops in order for the product to be unloaded at the correct locations. Trains systems are generally used where movement of product is over long distances, sometimes between buildings, outdoors or in very large distributed systems where the runs are long. Since each train can as much as 16 pallet loads at a given time, this becomes a very efficient method and can usually be justified easily based on the elimination of fork trucks or manual trains and operators. [T. Mueller, 1987].

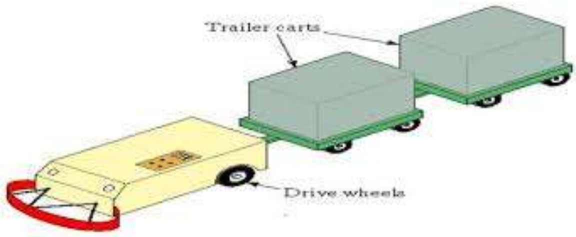


Figure 2: driver less train or tow tugger

2) Unit Load Carrier:

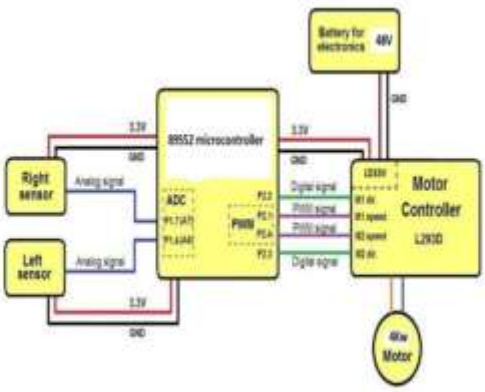
To carry unit load from one station to other, unit load carriers are useful. They usually involve specific mission assignments for individual load movement. Unit load carriers are quite popular in applications integrating conveyors with manufacturing/assembly operations or storage retrieval systems. They are a very efficient means for horizontal transportation between hardware intensive material handling subsystems. The unit load carrier, over moderate distances, can move high volumes of goods linking other automated subsystems during a totally integrated facility. Usually the unit load systems involve an automatic pickup and delivery of product with remote management of the vehicles in the system [Virendra, Bhatwadekar, 2018].

Figure 3: Unit load carrier

System Overview: Design, Navigation and Control Systems

A) Design:

Various technological developments have given AGVs more flexibility and capability in achieving its tasks. Designing an AGV system which will actually move and perform as stated above is not an easy task. Most AGVs in industry are operated using electrical power and moved by utilization of electrical motor. The electrical motor is connected to combination of suitable and appropriate gears, which then further connected to the wheel of the AGVs. Through this mechanism, the AGV are going to be ready to move or navigate with help of appropriate system so as for the AGV to move correctly along path as required [Himanshu Dudeja et al, 2015].



B) Navigation:

The movement task of AGVS requires efficient and intelligent routing. Usually these systems also are capable of handling priorities and time schedules. Static routing is a well-established standard in navigation. This routing technology is predicated on fixed course sections. AGV-Systems with static routing are almost like the railway system with course sections like tracks and therefore the central navigation system same as the railway control center. Sections are marked as occupied when there is a vehicle entering and remain unavailable until the vehicle has left again. This behavior can result in deadlocks, e.g. two vehicles trying to enter the same section on both endings at the same time. With laser navigation flexible paths become feasible. Vehicles can leave their assigned path to perform evasive movements so as to avoid the deadlocks or collisions. The consecutive calculation of the simplest path considering a particular time-frame with reference to the changing environment is understood as dynamic routing. This strategy also can increase the pliability of the whole production system. [Lothar Schulze et al, 2008].

Types of Navigation Techniques:

1) Wired

A slot is cut in to the floor and wires are placed approximately 1 inch below the surface. This slot is cut along the trail the AGV is to follow. This wire is employed a radio signal. A sensor is installed on the base of the AGV near to the ground. The sensor detects the relative position of the radio wave being transmitted from the wire. This information is then used to regulate the steering circuit, making the AGV follow the wire.

2) Guide tape – Magnetic or Coloured

AGVs use tape for the guide path. The tapes can be one of two styles: magnetic or coloured. The AGV is fitted with the correct guide sensor to follow the trail of the tape. One major advantage of tape over wired guidance is that they are often easily removed and relocated if the course must change. Coloured tape is initially less expensive, but lacks the advantage of being embedded in high traffic areas where the tape may become damaged or dirty. A flexible magnetic bar also can be embedded within the floor like wire but works under an equivalent provision as mag tape then remains unpowered or passive. Another advantage of magnetic guide tape is that the dual polarity. Small pieces of mag tape could also be placed to vary states of the AGC supported polarity and sequence of the tags.

3) Laser Target Navigation

The navigation is achieved by mounting reflective tape on walls, poles or fixed machines. The AGV carries a laser transmitter and receiver on a rotating turret. The laser is transmitted and received by the identical sensor. The angle and (sometimes) distance to any reflectors that in line of sight and in range are automatically calculated. This information is compared to the map of the reflector layout stored within the

AGV's memory. This allows the navigation system to triangulate the present position of the AGV. The current position is compared to the path programmed in to the reflector layout map. The steering is adjusted accordingly to keep the AGV on target. It can then navigate to a desired target using the constantly updating position.

- **Modulated Lasers** - The use of modulated laser light gives greater range and accuracy over pulsed laser systems. By emitting a endless fan of modulated laser light, a system can obtain an uninterrupted reflection soon after the scanner achieves line of sight with a reflector. The reflection ceases at the following edge of the reflector which ensures an accurate and consistent measurement from every reflector on every scan. By using a modulated laser, a system can achieve an angular resolution of ~ 0.1 m rad (0.006°) at 8 scanner revolutions per second
- **Pulsed Lasers** - A typical pulsed laser scanner emits pulsed laser light at a rate of 14,400 Hz which gives a maximum possible resolution of ~ 3.5 m rad (0.2°) at 8 scanner revolutions per second. To achieve a workable navigation, the readings must be interpolated supporting the intensity of the reflected laser light, to spot the center of the reflector.

4) Inertial or Gyroscopic Navigation:

Another sort of an AGV guidance is inertial guidance. With inertial navigation, a computer system directs and assigns tasks to the vehicles. Transponders are embedded within the floor of the work place. The AGV uses these transponders to verify that the vehicle is on the track. A gyroscope is in a position to detect the slightest change within the direction of the vehicle and corrects it so as to make the AGV stay on its path. The margin of error for the inertial method is ±1 inch.

Inertial can operate in nearly any environment including tight aisles or extreme temperatures.

5) Vision Guidance:

AGVs are often installed with no modifications to the environment or infrastructure. They operate by using cameras to record features along the route, allowing the AGV to replay the route by using the recorded features to navigate. Vision-Guided AGVs use Evidence Grid technology, an application of probabilistic volumetric sensing, and was invented and initially developed by Dr. Hans Moravec at Carnegie Mellon University. The Evidence Grid technology uses probabilities of occupancy for every point in space to catch up on the uncertainty within the performance of sensors and environment. The primary navigation sensors are specially designed stereo cameras. The vision-guided AGV uses 360-degree images and build a 3D map, which allows the vision-guided AGVs to follow a trained route without human assistance or the addition of special features, landmarks or positioning systems.

6) Geo Guidance:

A geo guided AGV recognizes its environment to determine its location. Without any infrastructure, the forklift equipped with geo guidance technology detects and identifies columns, racks and walls within the warehouse. Using these fixed references, it can position itself, in real time and determine its route. There are no limitations on distances to cover number of pick-up or drop-off locations. Routes are infinitely modifiable.

4. CONCLUSION

Automated Guided Vehicle (AGV) is a set of co-operative driverless vehicle, which is employed on manufacturing floor and coordinated by a centralized distributed computer-based managing system. The main usage is to facilitate automating process of doing manufacturing subjects. After prototype implementation it meets the use of AGVs in industrial fields, warehouses, material fields, etc. Significant technological advancements contributed to increase the alternatives of AGVs for the users. They essentially concern the modularity, standardization and the navigation system, the energy concept, the automation of the safety systems. Efficient, cost effective movement of materials is a crucial and a customary element in improving operations in many manufacturing plants and warehouses, as AGVs can deliver efficient, cost effevtive movement of materials in various industries in standard or customized designs to best suit an industry's requirements such as pharmaceuticals, chemical, manufacturing and automotive industries as well as hospitals and warehouses effectively.

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