

TECHNOLOGY & AUTOMATION

Factors to Consider when Using AGVs for Pallet Movement

When considering the right type of AGV system, a number of issues come into play, such as type of vehicle, guidance system, drive configuration, power and communication.

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The use of automated guided vehicles (AGVs) has played a pivotal role in facilitating process and throughput efficiency in manufacturing and distribution operations. Interfacing with multiple auto-transfer devices, AGVs can provide reliable raw material and product handling, with less potential for product damage, compared to manual methods of transport.

Utilizing a combination of logic software and wired or wireless navigation, AGVs can perform tasks that are not possible with other transport systems—such as the uniform movement and positioning of loads to within a fraction of an inch of their designated targets, without rush and noise, and with a high degree of safety for workers and the operational environment.

Transporting these heavy loads, however, imparts huge forces upon these vehicles, resulting in significant maintenance and power requirements to keep AGV fleets functioning. Newer models incorporate design, navigation, sensor and power improvements that can significantly streamline their operational performance, cost of maintenance and ROI, over and above prior AGVs.

Many types of AGVs exist for use in different industries, including those vehicles designed for extremely heavy or oversize loads. But for a large number of applications in manufacturing and distribution, AGVs are utilized for pallet movement.

AGV SYSTEM TYPES FOR PALLET MOVEMENT

For pallet movement, four types of AGVs are commonly employed. Basic differentiating factors that need to be considered for each type of AGV system are as follows:

1. Fork AGV System

- Outrigger, counterbalanced or under-rigger
- Pantograph or traversing-mast reach
- Single- or double-fork
- Side-shift forks

- All-wheel steer, omnidirectional.

2. Lift Deck/Unit Load AGV System

- Turning radius
- Electric lift versus hydraulic lift
- Differential steering versus single-steer drive.

3. Conveyor Deck AGV System

- Single- or dual-conveyor
- Off-board power requirements
- Payloads up to 60 tons
- Dual-steer drive, quad movement.

4. Tugger AGV System

- Braking—negative g-force to stop vehicle safely
- Grades—much more torque required to go up grades
- Automatic coupling and hitching
- Floor flatness critical.

WEIGHT

There is a linear relationship between the run time of an AGV and its weight. Given any battery size, if 10% of the weight is taken off of the vehicle, it will travel 10% longer. Commensurately, if 20% of the weight is reduced, it will travel 20% longer.

When considering a forked vehicle system, for example, this weight-to-travel ratio will have considerable implications. A counterbalanced vehicle will need to add 40-50% of the vehicle's weight for the counterbalance. With an outrigger design, or under-rigger design (for European-style pallets), the extended wheels support the load, so that vehicle design is 40-50% lighter.

Other factors come into play with weight as well. The implications of a vehicle of this size that has a 40-50% weight reduction are of enormous consequences. Lighter weight vehicles will need less frequent battery charging, therefore, fewer battery chargers will be needed to support a fleet. Maintenance and wear requirements for these lighter weight vehicles are commensurately diminished. Energy draw needed from AGV batteries is reduced. And repairs required for plant floors, caused by the AGVs and their load weights, are also significantly lessened.

Although the outrigger and the under-rigger avoid the counterweight, the counterbalanced vehicle is a more narrow truck, which will permit movement in more narrow aisles, allowing for denser pallet storage and a smaller floor footprint.

AGVs have typically been designed so that the weight of the AGV is 40-60% of the expected load. This 40/60 ratio has been the conventional AGV design practice for decades. This has now changed with the introduction of lighter, more efficient AGVs, which weigh considerably less than conventional AGVs, and are engineered to reduce wear and energy usage. They not only match the payload requirements of contemporary heavier models, but match or exceed those vehicles' structural stress thresholds.

WHEEL STEERING

Many AGVs in operation within manufacturing plants, and many of those first put into operation before 2000, were often equipped with Ackermann steering links. This arrangement of linkages, commonly used for steering automobiles and trucks, remedies the problem of setting wheel angles in a turn, given that each wheel needs to trace out circles of a different radius. The problem is that Ackermann steering geometry only approximates the required steering angles, allowing inaccuracies which result in wheel scrubbing. With such heavy loads in transport, the end result creates considerable repair and maintenance requirements. The wheel scrubbing not only increases amp draw, but can also cause concrete and tire wear.

Newer AGVs may also be engineered with electronic independent-wheel steering, which has considerable implications for AGV operability, vehicle maintenance and repair requirements, and damage to plant floors.

Electronic independent-wheel steering does away with Ackermann steering geometry completely, and the issues it creates. The vehicle can now drive sideways or in any direction, enabling shorter trips, thereby reducing the fleet size. The four-wheel independent steering provides tight maneuvering and smoother cornering.

BATTERY PERFORMANCE

Options for battery power in AGVs are predominantly lead acid and Lithium chemistries. The most conventional power source used in AGVs has been, and still is, lead acid. But lead is heavy. Since battery run time is directly proportional to vehicle and payload weight, reduction in vehicle weight on AGVs directly impacts the run time of its batteries. Therefore, any weight reduction exhibited by AGVs translates into longer run time from the batteries before requiring recharge.

New battery technology also contributes to weight reduction. A Lithium ion solution, for example, with the capability of putting out 140 amp hours of power would weigh about 150 pounds. Compare this to a lead acid battery putting out the same power, but weighing 700 pounds. For the same power, 550 pounds have been removed from the vehicle.

The recharge time for Lithium ion solutions is approximately 4X faster than lead acid. And typical lead acid recharge cycles are about 1,000, while Lithium ion phosphate is closer to 4,000 cycles. In short, the Lithium ion phosphate battery is charging 4X faster and delivering 4X the life compared to lead acid.

NAVIGATION

AGV systems are equipped with navigation systems, based on laser and/or inertial guidance. Each system varies in performance, flexibility and cost.

Laser navigation

Laser navigation systems are based on target triangulation to keep the vehicles on course. The vehicle is equipped with a rotating laser beacon, which scans 360 degrees around the vehicle for laser targets mounted on columns, walls and stationary machinery. The reflections from these targets are measured relative to angles from the vehicle, and triangulated to allow the vehicle to determine its position. This position is compared to a CAD-type map stored in the vehicle's memory.

The system uses positive-positioning feedback in real time, computing algorithms hundreds of times per second. The targets are typically located 20 to 50 feet apart, on both sides of the path to provide sufficient navigation resolution. The steering is adjusted accordingly to keep the AGV on track. It can then navigate to a desired target using the constantly updating position. Laser navigation can obtain tracking accuracy of about $\pm .75$ inch on vehicles of this size.

Inertial navigation

Inertial navigation systems use a gyroscope onboard the AGV to detect changes in vehicle direction and attitude. Each vehicle has a CAD-type map of the system layout in its memory. The vehicle steers by comparing information from the gyroscope and odometry sensors (which estimate change in position) to the map, and making necessary course corrections each time it passes over a magnet or transponder.

Typically, the tracking of inertial navigation systems is $\pm$ one inch of the true path. Magnets or transponders are embedded in the floor every 30 to 60 feet to maintain the tracking accuracy.

Multi-navigation

Both navigation methods can be seamlessly combined in a concept called multi-navigation, which switches back and forth from laser to inertial guidance without stopping the vehicle. This allows the AGVs to move throughout a plant and outside, where one system alone may not have access to the physical surroundings or weather conditions necessary to support that system.

AGVs travel nominally 2 mph, and are equipped with outboard laser bumper sensors for object detection. Covering the vehicle 360 degrees including upwards, the sensors are designed to cause the vehicles to adjust their speed, or stop if necessary, if an obstacle is detected in their path. Once the path is clear, the AGVs will automatically continue their mission.

Some bumper sensors have a range starting at about 1,500 lux (the SI unit of illuminance and luminous emittance). These new AGVs use the latest in safety laser technology, incorporating 15,000 lux systems, with a 10 times higher tolerance to light.

REAL-TIME CONTROLS

The smooth functioning of AGVs is dependent on their controls system, which has the task of coordinating the orders received from the plant's process system or warehouse management system, or ERP, then directing the work for the automated guided vehicles.

More advanced controls systems may be using a Windows and SQL database architecture that is able to uniquely operate within a single platform.

Communication is provided by two-way radio transmissions between the vehicles and the computer. The controls provide real-time management of the system's operation, including management information, load prioritization, load status, productivity statistics and reports, and workload analysis. It allows associated functions to be automated—such as with receiving, raw materials storage, hot line processes, roll mill processes, cold mill processes, finished product storage and shipping.

The positional status of each AGV is continuously being updated through the controls system, at least once per second, regarding such factors as whether it is loaded or unloaded, emergency stopped or soft stopped, operating in manual mode and battery level. A simulation module simulates the AGVs in the system. An HMI graphical interface gives the operator a graphical overview of the AGV locations in the system and monitors each in real-time.

Operational flexibility is a key factor with newer controls systems—not just in its capability to direct and manage the fleet of AGVs, but also in its expandability. Any number of AGVs can be added to the network, at any time plant production or distribution needs require.

MAINTENANCE

AGVs, with weight reduction and electronic independent-wheel steering, can deliver a sizable reduction in maintenance and repairs. Realistically, as much as a 60% reduction in annual maintenance, per vehicle, can be achieved.

Contributing to this is the accessibility of the AGV to perform maintenance or repairs. With conventional AGVs, access to wheels, gears and other moving parts is for the most part unexposed, requiring the vehicle to be hoisted or moved into a pit to be serviced. This is an inherent difficulty which has been resolved in some recent AGV models.

SIMULATIONS

AGV system simulations can provide excellent system development guidelines for perfect conditions. But such conditions seldom exist in manufacturing and logistics facilities. What-if conditions need to be factored into the simulation, such as the variable of human interaction on the floor where AGVs are in motion.

Fleet size is monitored by: a) volume of product transported per move; and b) length of route. The bigger the AGV system, the more important is the need for simulation. In a system larger than five or six vehicles, simulation would be a requirement, as mathematics calculations alone cannot adequately profile vehicle-to-throughput ratios.

ENVIRONMENTAL FACTORS

Also influencing the performance of AGV systems is temperature and humidity, wi-fi coverage over the area of transport, *electromagnetic interference* (EMI), conductivity of the floor coating, and flooring drains, slopes and grades. These factors must be considered when determining the most optimum approach for an AGV system.

FLEXIBILITY

AGVs enable significant efficiencies to manufacturing and distribution. They improve production flow by bringing material to the operators, thereby cutting cycle times, and eliminating wait, walk and search time. They reduce work-in-progress inventory. They cut labor costs by eliminating simple jobs related to material and movement, and permit reassignment of those workers to areas where they can add more value to the facility. In some cases, AGVs can virtually eliminate product damage with gentle handling of loads, and provide flexibility of process flow and throughput, as needs change.

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