Opportunities and Challenges for AGV-Technology in Material Supply for Automotive Final Assembly

Sten Björn ANDERSSON  Master Thesis MSc Mechanical Engineering

AGV – Automated Guided Vehicle

An AGV is a driverless industrial vehicle used in manufacturing plants and warehouses to transport material. The first AGV was introduced in 1953 using tactile safety sensors and simple wire guidance. Since the mid-1990s, the industry has boomed, now offering multiple navigation technologies and sophisticated software controls.

Objective
- Examine the available and relevant AGV technology
- Identify the opportunities and challenges to implementing AGVs for material supply on the manufacturing floor in Volvo Cars Final Assembly

Manufacturing industries are moving towards increased automation and digitalisation under the Industry 4.0 paradigm with more decentralised control, modularity and real-time capabilities. Whilst AGVs can be considered "intelligent but not autonomous", AGVs are increasingly becoming autonomous enabling the vehicle fleet to reconfigure to the needs of the production system. The future of the AGV industry is conjectured to be enhancing the vehicle and fleet ability to share traffic information and redistribute transportation assignments to ultimately provide flexibility and logistical efficiency.

Navigation
- Fixed-path navigation
- Inductive wire
- Magnetic/Optical track
- Open-path navigation
- Magnetic Spot
- Laser (Artificial landmark)
- Natural/Contour laser

Personal detection: the vehicle must be able to detect pedestrians and plant infrastructure and avoid collision by braking. Laser sensors, see Fig. 2b, is the industry standard with different protective fields set as shown in Fig. 2a.

Industry standards limit the operating speed to 1-2 m/s. The AGV path should also feature a 0.5 m margin on either side.

Energy Supply:
- Virtually all indoor AGVs are electrified. The most common solution for logistic AGVs, as opposed to assembly-flexure AGVs, is a battery solution. The battery can either be replaced or charged on-board.
  - Manual battery exchange: suitable for smaller fleets in continuous operation.
  - Automatic battery exchange: suitable for larger fleets in continuous operation.
  - Automatic on-board charge: scheduled charging, suitable for cyclic applications
  - Opportunity on-board charge: non-scheduled charging, suitable for applications with varying workload.

Case Studies & Simulation:
3 specific case studies were selected and analysed further including the supply of windshields, dashboards and engines.

A sophisticated simulation model was developed, using Flexsim and their AGV-module, to model the engine material flow. This was done to discover how AGV application could handle a varying workload using a simple dispatching algorithm essentially assigning transportation assignments in the order of appearance. The conclusion drawn from this simulation is that for varying workloads the AGV system must be granted a maximum lead time.

Moreover, it was concluded that for certain processes some modification to existing loading and unloading station layout configuration may be required.

Based on the case studies, the conclusion was made that it should be possible to rationalise one manual truckdriver with 2-3 AGVs.

Based on the site visits, interviews and case studies, it was estimated that an AGV system could be implemented with the initial investment offset by the reduced labour cost in 3-4 years.

Conclusion:
- It is recommended to use open-path navigation as it permits smaller modifications to the route network to be done virtually. The most relevant technologies were judged to be laser navigation, using artificial or natural landmarks, and magnetic spot navigation because of their high reliability and flexibility. These technologies could advantageously be used in hybrid as their flaws complement each other.
- The most relevant energy supply option was seen to be automatic or opportunity on-board charging to eliminate manual intervention and take advantage of often naturally occurring idle times.
- The main opportunities were identified as reducing labour costs and improving plant safety. The key challenges were identified as operating in an environment shared with manual traffic, identifying suitable processes, where de-facto rationalisation can be made, and setting an adequate level of automation.

Author:
Sten Björn ANDERSSON
Academic Supervisor EPLL: Prof. Philippe Wieser
Industry Supervisor: Kristoffer Mann, Volvo Cars

Acknowledgements:
Volvo Cars: Manufacturing Engineering Department Mats Hultman, Vekkos Turunen, Morgan Ericsson, Ola Fogelmark & Jonathan Legal-Odin, Volvo Cars
Yang Yaqing, Lynk & Co. Jakob Dammemark, AGVE Par Knutsøn, Jemko FlexSim