USE OF UNIT LOAD AGVS FOR PICKING CART HANDLING IN AUTOMOTIVE ASSEMBLY LINE

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Abstract

Unit load AGVs are gradually becoming a common part of the internal logistics of industrial companies, especially from the automotive industry. Most often for handling standardized pallet containers. The aim of this paper is to identify the possibilities of using unit load AGVs for picking cart handling. Unlike pallet containers, picking carts are completely non-standardized (both in terms of construction and size). The possibilities were determined and verified in the form of a pilot project in a selected automotive company. Output of the paper is a definition of critical success factors that will enable successful implementation of unit load AGVs for supplying assembly lines by means of picking cart.

Keywords: Unit load AGV, picking cart, material handling, assembly line, automotive industry

1. INTRODUCTION

In the automotive industry, the term internal logistics means the supply of workplaces and assembly lines with materials and parts from warehouses and picking workplaces using suitable handling technology. Transport of material and parts using Automated Guided Vehicles (AGVs) is becoming the standard. AGVs can be categorised into three main types:

- Unit load AGV (see **Figure 1**).
- Forklift AGV.
- Towing AGV.

Unit load AGVs are gradually becoming a common part of the internal logistics in automotive industry and other sectors. They are used for handling standardized pallet containers most often. However, there is many parts that are transported using picking carts (see **Figure 2**). Unlike pallet containers, picking carts are completely non-standardized (both in terms of construction and size). As literature review has shown, current research studies from the automotive industry have so far paid little attention to the application of the unit load AGVs for supplying workplaces and assembly lines by means of picking carts. Thus, the aim of this paper is to identify the possibilities of using unit load AGVs for picking cart handling. The article is divided into five parts. The introduction is followed by a literary review (chapter two), which culminates in a critical assessment of the current state of knowledge. The possibilities of using unit load AGVs were determined and verified in the form of a pilot project in a selected automotive company. The pilot project is described in chapter three. Based on the pilot project, critical success factors that will enable successful implementation of unit load AGVs for supplying assembly lines by means of picking cart are defined in chapter four. The paper is summed up in conclusion.

Figure 1 The unit load AGV designed by Asseco CEIT (1200F) [1]

2. LITERATURE REVIEW

Automated Guided Vehicle (AGV) is a device for moving unit loads of materials from one place to another, within a facility, with no accompanying human operator [2]. AGVs provide competitive advantage for companies in the automotive industry [3]. There is a relatively high number of research studies that confirm this claim and investigate different aspects of AGVs implementation in automotive industry.

Correia et al. [4] demonstrated in a case study from automotive industry that AGV system based on towing AGV type allows to eliminate the transport of heavy loads by the operator and the excess of containers at the workstation, thus contributing to better ergonomics, an increase of safety and greater productivity. Saffar et al. [5] investigated the influence of AGVs application in the specific automotive assembly process based on replacement of manual tugger trains with AGV ones using a computer simulation. Hrusecka et al. [6] showed that AGV technologies provide a great solution to increase the performance of internal logistics using two case studies from the automotive industry. They also suggested selected critical success factors and key performance indicators for the AGV technology implementation phases.

Zuin et al. [7] recommend involvement of designer, safety expert, and worker roles in the design of an AGV system to avoid the need to make changes in the next stages, which would generate higher costs than necessary. Fabri et al. [8] investigated different scenarios of the internal logistics in SEAT and their influence on logistics flows' performance and an assembly lines' aisles utilization using the computer simulation. Three scenarios were simulated: the company's current scenario (towing AGV type), the introduction of autonomous AGVs (enable an AGV to overtake by itself), and introduction of a single flow policy (one flow aisles whenever possible).

Ali and Khan [9] claim that efficient integration of AGVs in flexible manufacturing systems may help industries to face the global and local competition with higher degree of confidence and proposed an integrated framework for that purpose based on systematic literature review. Kern et al. [10] state that new internal logistics concepts in the automotive industry should be based on modular assembly system without a fixed sequence of products. Such system should be supported by means of single transports by AGVs instead of summarized transports and cyclic routes by tugger trains.

Cech et al. [11] consider Autonomous Mobile Robots (AMR) as the highest AGV level that should be used for supplying assembly lines in the automotive industry. They created a comprehensive knowledge base for design, selection and implementation of AMR technology for that purpose. Bauters et al. [12] simulated different transportation systems in the specific internal logistics situation of an automotive factory to compare their performance. One of the transportation systems was AMR. Authors identified the too low AMR speed and congestions as the serious problems of the system.

The following conclusions can be drawn from the realized literature review:

- The main attention is paid to towing AGV (automated tugger trains) with fixed routes (pre-defined path between its origin and destination point) in the automotive industry.
- It is assumed that the future of internal logistics in the automotive industry lies in the application of flexible AGV systems using unit load AGVs with dynamic routes (AMR). One AGV will be able to handle different types of loads and determine its route accordingly.
- Research studies do not focus on the type of loads handled. Problems associated with completely non-standard loads, such as picking carts, are not solved.

3. PILOT PROJECT

The pilot project was implemented in a company from the automotive industry. A side door assembly line was chosen. At present, parts for the line are loaded in rolling picking carts or containers. Examples of picking carts are shown in **Figure 2**.

Figure 2 Examples of used rolling picking carts

Material and parts are transported to the line from the warehouses or with the Just-in-Sequence (JIS) concept. The flow of parts is controlled by requests when the signal stock of parts on the line is reached. There are two picking carts for each part on the assembly line. Assembly parts are taken from the full picking cart. An empty picking cart is exchanged for a full one based on the request system. Picking carts are transported to the assembly line by automated tugger trains (towing AGV with automated C frames), tugger trains with drivers or manually. Manual handling is performed from a warehouse located near the assembly line. The line operates at a rate of 57 s, which represents the exchange of picking carts 173 times per shift. Other handling equipment (forklifts, other tugger trains) and pedestrians that are not related to the given line move in the area of the line and warehouses. There is also a charging station for towing AGV in the assembly line area.

The following parts are transported to the side door assembly line using picking carts:

- Left glass guide – manual transport from the warehouse.
- Right glass guide – manual transport from the warehouse.
- Left side windows – manual transport from the warehouse.
- Right side windows – automated tugger train from the warehouse.
- Door handles – manual transport from the warehouse.
- Door wiring 1 – manual transport from the warehouse.
- Door wiring 2 – manual transport from the warehouse.

- Left door trim – automated tugger train in JIS concept (under the responsibility of the supplier).
- Right door trim – automated tugger train in JIS concept (under the responsibility of the supplier).
- Window launcher – tugger train with driver from the warehouse.

The first seven parts were selected for the pilot project, as well as the removal of empty containers from the assembly line, which is also implemented using rolling carts. The layout of the door assembly line with the marking of loading and unloading places of selected picking carts are shown in **Figure 3**.

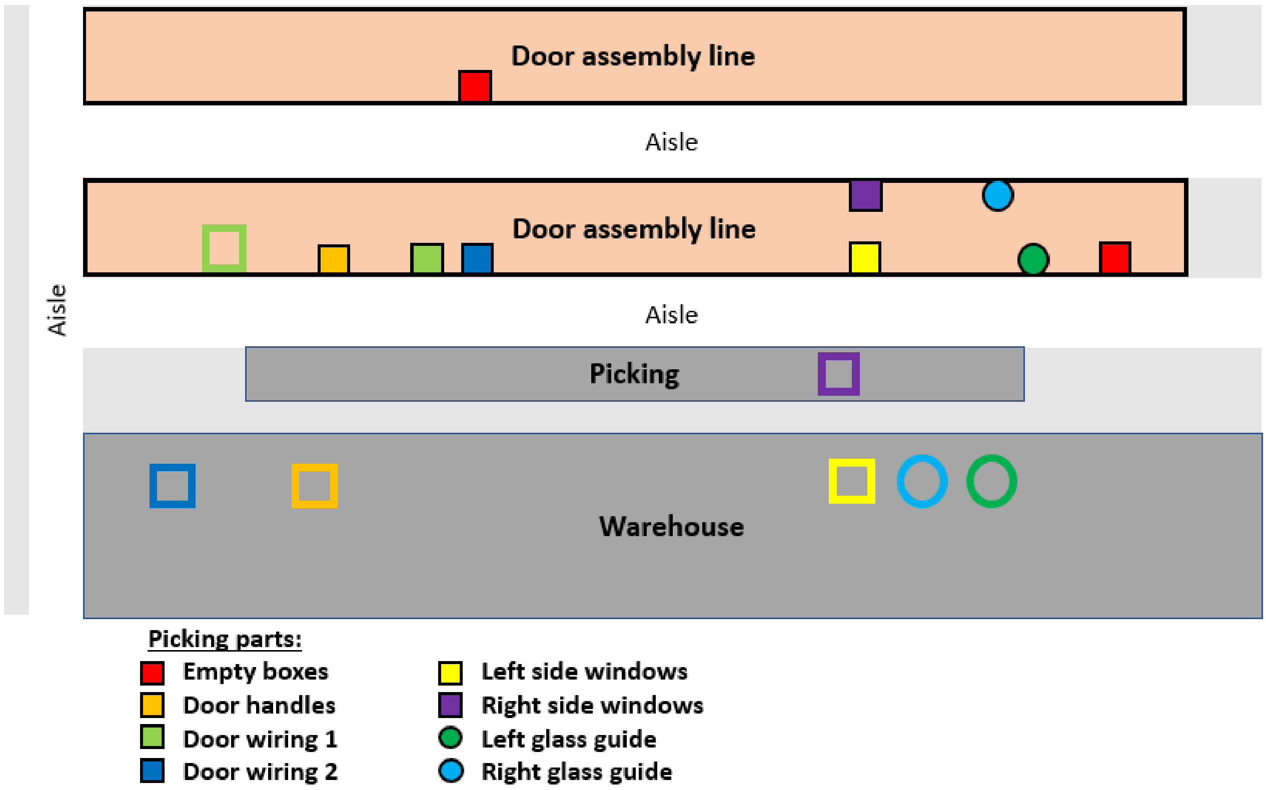

Figure 3 Layout of the door assembly line with marking of parts for the pilot project

For the pilot project, Asseco CEIT was selected as the unit load AGV supplier because it is the main supplier of towing AGV for the entire assembly plant. Due to the required functionality, the AGV 1200F was chosen (see **Figure 1**). Asseco CEIT conducted a computer simulation of the pilot project. Based on the simulation results it determined the required number of AGVs is six. Unlike standard AGV systems, unit load AGVs do not have fixed parts and routes assigned. The most suitable AGV is selected in terms of its availability and distance to load a full picking cart or to remove an empty one.

4. CRITICAL SUCCESS FACTORS

Based on the planning and implementation of the pilot project, the following critical success factors for successful implementation of unit load AGVs for supplying assembly lines by means of picking carts were identified (see **Figure 4**):

- Selection of suitable AGVs – AGVs of various parameters and functionalities are available on the market. It is possible to buy a robust and advanced AGV, which will be unnecessarily expensive and will have parameters and functionality that will be used only sporadically. For each AGV, it is advisable to consider the following parameters: size, load capacity, speed, turning radius, movement mode, stroke, accuracy, operating time, charging time, type of navigation, safety.

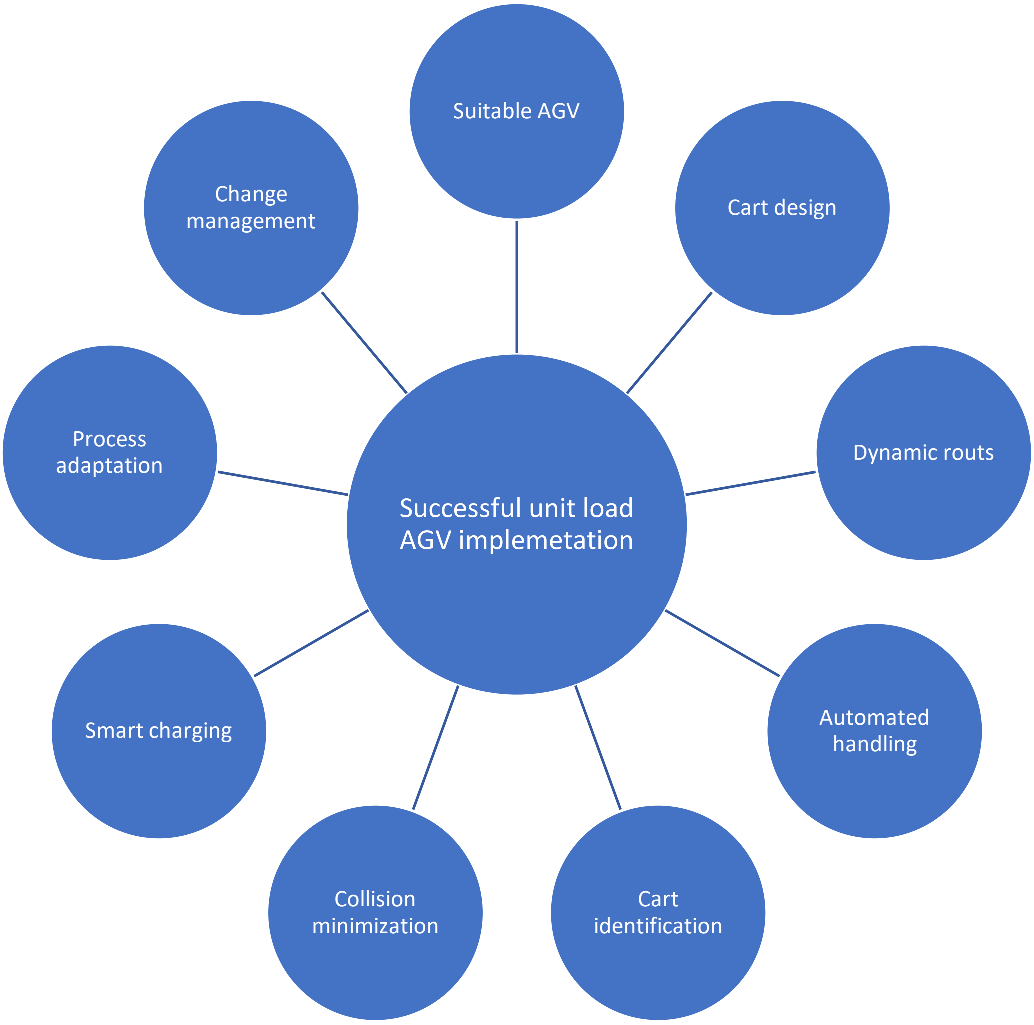

Figure 4 Critical success factors to implement unit load AGVs for picking cart handling

- Changing the picking carts design – the introduction of unit load AGVs is not possible without modifying the picking carts. At a minimum, it will be necessary to raise the cart chassis to match the height of the AGVs used. Furthermore, it is necessary to deal with the fact that picking cart are often high. For their stable transport, it is therefore appropriate to use AGV with mandrels. Again, it is necessary to adapt the cart chassis. Chassis should be as unified as possible. In the case of very non-standard cart dimensions (e.g. too long or high) a complex change of cart design will be necessary.
- Switching from fixed circuits to dynamic routes – replacing tugger trains that can carry more picking carts with unit load AGVs would lead to the need for more AGVs while maintaining fixed circuits. Therefore, it is necessary to choose a supplier with quality fleet management that allow to assign missions to individual AGVs dynamically and efficiently according to AGV availability. In this way, it is possible to maximize the use of unit load AGVs without unnecessarily increasing their number.
- Automation of handling operations on the assembly line – a full picking cart is inserted on the line and an empty picking cart is pulled out. Picking carts usually have a rectangular floor plan with large differences in the width and length of the cart. If they are supplied by tugger trains, they are transported in width (shorter side) due to the permeability of aisles. However, a significant number of carts must be placed lengthwise on the line. This is solved either manually (by the tractor driver or the line worker) or automatically (e.g. using automated C frames). This problem is schematically illustrated in **Figure 5**.

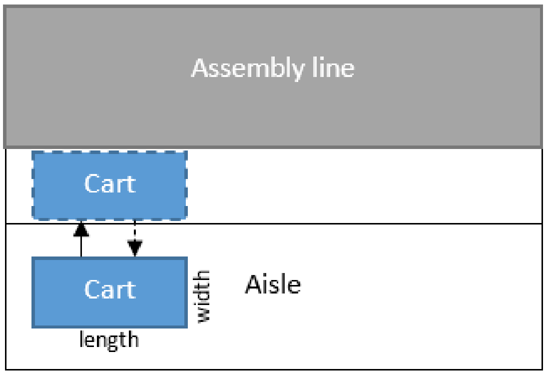

Figure 5 Method of handling picking carts on the assembly line

In the case of the unit load AGV, it is assumed that the picking cart will be delivered to the line completely automatically. This can be achieved in different ways, each of which will be differently expensive and will have its pros and cons:

- Loading the picking cart to length – this solution is only possible if the difference in width and length of the cart is not large. Otherwise, the aisle permeability would be significantly reduced, or it would not even be possible.
- Changing the picking cart design – reducing the difference between the width and length of the cart. It can be problematic from an ergonomic point of view or will require a reduction in the number of picked parts and thus greater AGV capacity requirements.
- AGV with omni wheels – however, this solution is practically unavailable on the market.
- AGV with rotating lifting module – the picking cart is transported in width, in front of the line the lifting module rotates the cart to its length and thus goes to the line. In this case, however, the aisle permeability will be significantly reduced during the handling in front of the line.
- Automatic carousel at the assembly line – the picking cart is inserted into the assembly line in width, placed on the carousel and turned to length. However, this solution will require additional assembly line production space.
- Turning the AGV under the picking cart – the picking cart is transported in width, the AGV places the cart in front of the assembly line, rotates 90 ° below it, lifts the cart and insert it into the line. This solution requires a change in the safety zones of the AGV and a slight increase in handling operations.

- Automatic identification of picking carts – the AGV must be equipped with automatic identification of transported picking carts to be able to dynamically change its safety zones. Otherwise, the AGVs would have to have the safety zones set to the dimensions of the largest picking cart, which would significantly reduce the aisle permeability.
- Minimization of collisions with other handling equipment and pedestrians – in most cases, other handling equipment and pedestrians move in the aisles in addition to the AGV, which leads to blocking of the AGVs and loss of their capacity. In these cases, it is appropriate to regulate traffic:
  - Set traffic rules – especially for intersections and bottlenecks. In the case of handling equipment operated by people and pedestrians, the setting of the system of keeping the rules is critical.
  - Consider the degree of AGV autonomy – in practice it turns out that the use of autonomous AGVs, which are able to get around other handling equipment and obstacles, does not lead to increased aisle permeability and utilization of AGV capacity in busy traffic.

  - Consider one-way aisles – this solution is suitable for short aisles. In the case of long aisles, it leads to an increase in the number of AGVs needed.
- Minimize the loss of AGV capacity by charging – charging accounts for up to 25% of the available time of AGVs and therefore it is necessary to look for solutions that would minimize this loss:
  - The standard solution should be the decentralization of charging stations in the warehouse and assembly line, thus eliminating the AGV travel time to centralized charging stations.
  - An innovative solution is to replace the batteries, which can ideally take place completely automatically (robotically).
- Adapting processes to the new loading concept – in most operations where unit load AGVs are implemented, production and logistics processes are historically set to the original logistics concepts (e.g. forklifts or tow tractors). If the implementation of the unit load AGV concept is to be effective, it is necessary to consider the modification of assembly lines, warehouses, and aisles both in terms of space and technology. The minimum is to meet the requirements for floor quality. Current assembly lines for car production are undergoing radical changes in connection with the onset of electromobility. A new internal logistics concept should also be part of the design of these new assembly lines.
- Efficient change management – the implementation of unit load AGVs is a fundamental innovation change in internal logistics processes. Every major change encounters a number of problems, the most pressing of which is people's resistance to change. Therefore, it is necessary to use the best practices of change management already in the planning phase of the mentioned concept.

5. CONCLUSION

The ambition of the article was to eliminate the research gap consisting in the lack of a comprehensive knowledge base for successful implementation of the unit load AGVs for supplying workplaces and assembly lines by means of picking carts in automotive industry and similar sectors. This purpose was fulfilled through the planning and implementation of a pilot project in a selected automotive company. Based on this project, the following critical success factors were identified: suitable AGV, cart design, dynamic routs, automated handling, cart identification, collision minimization, smart charging, process adaptation, and change management. Further research will focus on the verification and supplementation of these factors from the widespread deployment of unit load AGV in the company.

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