APPLICATION OF AUTONOMOUS FORKLIFT FOR UNLOADING OF TRUCK IN AUTOMOTIVE INDUSTRY

Tomáš MALČIC

ŠKODA AUTO University, Mladá Boleslav, Czech Republic, EU, tomas.malcic@savs.cz

https://doi.org/10.37904/clc.2022.4562

Abstract

This article presents the study of the current state of art in the field of application of technology of an autonomous forklift for loading and unloading trucks. The ever increasing need for automatization and robotization of logistics processes in the automotive industry exceeds from inhouse manipulation to various areas of logistics. Recently, the emphasis in terms of automatization in logistics of the automotive industry was placed on the process of loading and unloading trucks, which is crucial for inbound logistics of every automotive company. There are a number of automated systems for unloading and loading trucks on the market. AGV or autonomous forklifts are also one of these technologies. The first part of the article will introduce existing technological solutions, including their advantages, disadvantages and limitations. The second part of the article will be devoted to the assessment of the feasibility of a model case of side unloading of a truck with AGV forklifts in the conditions of the automotive industry. The main goal of this study is to prove if the target logistics process can be done with chosen technology. Also, preconditions which must be met and limitations that must be overcome will be defined.

Keywords: Automated guided vehicle, autonomous forklift, automotive, automatization, truck unloading

1. INTRODUCTION

At present, the customization and differentiation of the offered products is an increasingly important trend in the automotive industry. Another significant trend affecting the automotive industry is the ever-shortening life cycle of products and technologies. All this is the result of customer-centric approach, development and globalization of the automotive market. These trends lead to an increase in the number of products and product variants. This development can be expected to continue as a result of the rise of alternative concepts of mobility, changes in customer behaviour, new materials and technologies, all hand in hand with further individualisation and personalization of cars. The above trends lead to the need to change the principles and characteristics of current manufacturing systems. In addition to the need to adapt manufacturing systems to this development, it is necessary to adapt all related logistics processes and systems in the automotive industry. One of the tools to achieve this is the development of more flexible and adjustable automotive production systems called FMS (flexible manufacturing systems). In connection with FMS, the number of implementations of highly flexible and transformable automated logistics systems with the use of AGV (automated guided vehicles) or AMR (autonomous mobile robots) technologies is growing. AGV technology is becoming more sophisticated, flexible and cheaper. This technology is most widespread in the distribution centres of retail companies, but applications are also increasingly appearing in automated logistics systems in the automotive industry. AGVs are key elements for the efficient operation of FMS, which are characterized by higher requirements for automatic handling systems resulting from their high flexibility and adaptability. Efficient and optimized use of AGV is crucial for increasing FMS performance. The implementation of AGV technology is an ideal choice for the design of all FMS. AGVs are currently used in industry mainly for material handling. However, AGV technology has the potential to address a number of other technical issues. But it is not a universal technology suitable for all material handling requirements [1,2] .

This paper deals with the potential use of AMR forklift technology for loading and unloading handling units from trucks. The subject of research follows from the ever increasing need for automation and robotization of logistics processes in the automotive industry exceeds from inhouse manipulation to various areas of logistics. Loading and unloading trucks is a key inbound logistics process in every company in the automotive industry, and therefore it is a logical effort to automate these processes and utilize the cost saving potential. There are a number of different technological solutions on the market for the automation of the target logistics process. This article aims to examine the potential of autonomous forklift and identify barriers to implementation and shortcomings of technological solutions available in the current market. The second subgoal of the paper is to present the feasibility of a model case of side unloading of a truck with AGV forklifts in the conditions of the automotive industry. The main goal of this study is to prove if the target logistics process can be done with chosen technology and also define preconditions which must be met and limitations that must be overcome.

1.1. Literature review

This chapter contains a literature research in the field of AGV technology. Basic terms will be defined in the search. Also a various types of navigation will be introduced. An automated guided vehicle (AGV) is a device that does not need a human to drive, it is controlled by a computer. This mobile robot is used in logistics for material transport or other specific tasks. It is a very suitable tool for repetitive activities and flows. The truck is powered by an electric motor, which is powered by a battery and is controlled by special software and navigation. In scientific publications, there are a number of different designations for advanced automated logistics robots. Some of these designations are as follows: AGV (automated guided vehicles), AMR (autonomous mobile robots), MAR (mobile autonomous robots), AMV (autonomously moving vehicles), or MAU (mobile autonomous units) [2,3]. Following is definition of mobile logistics robots: *"Mobile robots are a special form of robots that consist of at least the components drive, control and manipulator and are able to move and navigate freely in a given area to fulfil various tasks.* [4]*"* In terms of technological sophistication, autonomous mobile robots (AMR) are at a higher level. The definition of AMR is as follows: *"Mobile autonomous robots are mobile robots that can perceive their surroundings via various sensors and are able to react to changes in their environment. They are capable of solving tasks with higher complexity without every single process step being explicitly taught. Programming of such devices is in general more task oriented and rule based (higher level of abstraction) than jobs of conventional robots. Solutions to problems are generated by algorithms in real time to cope with variations in processes.* [5] *"* All of the above designations are inherently correct. More or less, these are synonyms with only minor differences in meaning. The term AGV can be considered parental to all others, and the designation AMR refers to AGV with the highest level of control and navigation technology [9]. The main way to control AGV is through navigation. This is the basic function that determines its direction, speed, and all in real time. The method of navigation is selected based on the tasks that the mobile robot will perform. The main navigation technologies of mobile robots are as follows (see **Figure 1**) [6]:

- **Wired Type:** Wired-type navigation uses a slot or wire which is cut and placed below the surface.
- **Guide Type:** In Guide-type sensor vehicle follows the path of tape or painted line by the help of camera.
- **Laser Type:** A beam is transmitted and received form sensor, the time taken by the beam to travel and come back helps is determining the distance and angle which helps vehicle in its motion.
- **Gyro based**: The navigation can be performed by the help of computer control system which assigns and directs tasks to vehicle. Such navigation is performed through gyroscopic sensor.
- **Vision Based:** Vision-based AGVs use camera to acquire environment features and made decision based on those features to navigate the vehicle. It uses fixed reference to identify any product within the warehouse and with this help, vehicle navigates itself [8].

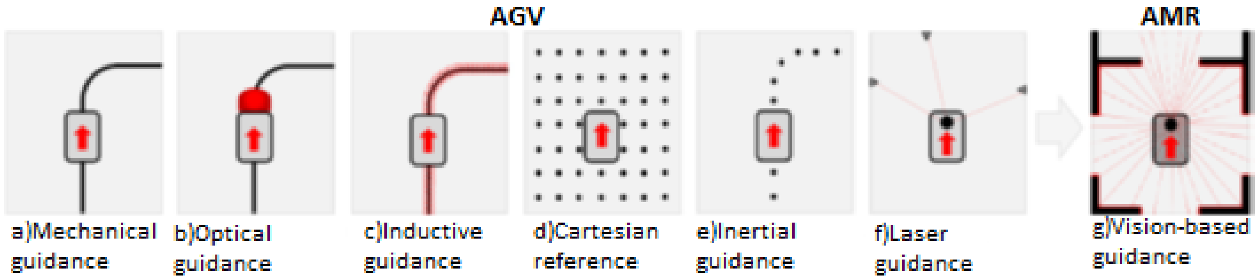

Figure 1 Types of AGV navigation [7]

2. METHODOLOGY

This chapter will describe the methodological procedure for preparing the study. The individual steps that were implemented in order to achieve the objectives of the study will be presented. First, a search of the offered and developed autonomous forklift in the area of unloading and loading of handling units from trucks was performed. The analysis of the market of autonomous forklifts also included an analysis of the technical principles of the functioning of autonomous forklifts and their technological development (navigation, loading / unloading of material). Subsequently, the possibilities of implementing autonomous forklift for unloading and loading trucks in a selected company from the automotive industry were analysed. The next step was to map logistics flows in order to identify current logistics and technological needs. After the market analysis was carried out and the needs of selected logistics processes were identified, the initial addressing of selected suppliers of autonomous forklift took place. Based on the feedback from the tender procedure with selected suppliers, an analysis of the solutions of selected suppliers, their best practices and references to the implementation of autonomous forklift was performed. In the next step, further requirements for the technological specifications of autonomous forklift the needs of automation of the process of loading and unloading trucks emerged. This resulted in KO criteria that the selected technological solution must meet, and thus there was a further filtering of potential suppliers. The result of the study was the elaboration of a set of recommendations for the implementation of autonomous forklift for a selected logistics process.

The source of the presented research was a feasibility study of the introduction of autonomous forklift for unloading and loading of handling units from trucks. At the beginning of the research, the company from the automotive industry required to automate the process of loading and unloading trucks. Due to the current operating conditions and the related logistics and production processes, the introduction of autonomous forklift with the currently most advanced level of navigation using vision technology was chosen as a priority solution. As part of the market analysis of available technologies, 51 manufacturers of potentially suitable autonomous forklift were identified. After a more detailed analysis of selected suppliers, 15 manufacturers were shortlisted, among which a demand procedure was conducted (**Figure 2 and 3** shows examples of autonomous forklift from selected supplier). The outputs of the feasibility study were used to develop the presented general preconditions and limitations of implementation of autonomous forklift.

Figure 2 ATAB & MAX AGV [11]

Figure 3 Elettric80 - CB MONO DRIVE [11]

3. TRUCK LOADING AND UNLOADING WITH AUTNOMOUS FORKLIFT - USE CASE DESCRIPTION

The main goal of the research was to assess the feasibility of automating the side loading and unloading of handling units from the truck in the conditions of the automotive industry. All analyses and research activities were based on the specifics of the selected logistics process. The basic characteristic of the process is the type of unloaded truck. Several basic types of vehicles / semi-trailers were considered for side unloading of standard truck with side entry (canvas). For rear unloading of standard truck with rear entrance (e.g. from a ramp). And alternatively a standard 20 or 40 cubic metres container with a ramp. For simplification only one type of truck and one type of manipulation unit was considered.

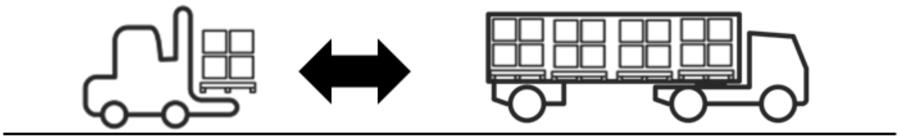

Figure 4 Loading and unloading truck with forklift

The autonomous forklift is to perform the following tasks:

1) Lateral unloading of pallets and storage of pallets on the loading area.
2) Pick up the empty pallet from the consolidation area and load the empty pallet onto the truck. Empty pallets are controlled in a 1: 1 ratio with full pallets.

4. GENERAL PRECONDITIONS AND LIMITATIONS OF IMPLEMENTATON AUTONOMOUS FORKLIFT FOR TRUCK LOADING AND UNLOADING

The following conclusions emerged from a thorough analysis of the autonomous forklift technologies available on the market and from the demand management with selected suppliers for the selected simplified use case. Unloading trucks is currently the most challenging use case for the implementation of autonomous forklift. Unlike logistics processes such as pallet handling, rack storage, etc., there is currently no known and used solution for side unloading. Many suppliers consider this use case to be impossible. Other suppliers claim that the necessary technology has not yet been developed to implement this solution. Due to the current stage of development of the necessary technologies, this application is only suitable for experimental deployment and development cooperation with suppliers, but without guarantee and at high cost. Rear unloading works, but it is relatively slow and demanding. At present, suppliers are still developing the necessary technologies, but nowhere has they been successfully implemented [10,12].

The most important barriers to the effective implementation of autonomous forklift for truck unloading are:

- Very high demands on the accuracy of truck stopping (prolongs parking time).
- Trailer floor height and load placement accuracy in the load compartment.
- Current technology requires very precise placement of manipulated loads and precisely defined target positions (tolerance + - 5-10 mm).
- Current technology can handle loads from exact point A to exact point B with a minimum tolerance of the load position deviation.
- Very high demands on floor quality.
- Very low productivity (slow movement speed).
- Frequent failures, stops and blockages on manipulation areas.

- Emergency need for manual forklift intervention.
- Very long time for unloading (truck drivers delay).
- Most of current technology is unable to cross the outdoor environment (bad weather conditions, lower quality of the outdoor surface and crossings).
- Current technology can identify the pallet by default. Any "search" requirement (moving from place to place and checking the pallet) is feasible, but it is highly time consuming and reduces the efficiency.
- Due to the relatively low speed of autonomous forklift, it is necessary to take into account the implementation of a larger fleet leading to increased traffic density, higher acquisition costs and longer returns.

The preconditions necessary for effective implementation of autonomous forklift for truck unloading are:

- Fixed and precise position of the pallets in the truck with sufficient reserve.
- Precise stopping of a standardized truck.
- Use of standardized handling units and high accuracy of load loading must be ensured.
- Manually controlled material flows preceding the processes provided by autonomous forklift must be standardized (e.g. loading area, loading plan).
- In order to achieve the required accuracy, it is necessary to automate the processes in the transfer points, combine them with other AGV technology or, in the case of connection to manually controlled material flows, use mechanical guide elements.
- Individual negotiations with the manufacturer, pioneering approach.
- It is recommended to focus on the selection of a supplier with advanced software and a user-friendly interface, enabling system self-management.
- Most of the currently available autonomous forklift are technologically at a comparable level in terms of safety, navigation and basic functionalities.
- Decisive criteria for supplier selection should be price, speed, SW solutions, references and services.

5. CONCLUSION

The output of the presented feasibility study of the robotisation process of the truck side unloading in the conditions of the company in the automotive industry by means of the implementation of autonomous forklift is a summary of general recommendations summarized at the end of the article. The general conclusion is that in the current market conditions and at the current level of technological development, this solution is not feasible. Technologically, this process is theoretically feasible, but only in almost laboratory conditions and with very low efficiency. A sufficiently flexible and reliable solution has not yet been developed for real operating conditions. However, robotics is a very fast-growing industry and, given the large rise of AGV technology in industrial logistics and the associated requirements for the development of more advanced technologies, it is only a matter of time before a suitable solution emerges on the market. If, in today's dynamic and turbulent market environment, industrial companies want to maintain the competitiveness resulting from the flexibility and efficiency of their logistics and production processes, they should be involved in the development of this solution. A suitable approach is cooperation with a supplier of AGV technologies in the form of a pilot project.

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