OPTIMIZATION OF SUPPLY CHAIN PRODUCTION SYSTEM USING THE CONCEPT OF PICKING AND AUTOMATED GUIDED VEHICLES

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Rezumat. *În acest articol sunt analizate conceptele de picking şi Vehicul Ghidat Automat (AGV). Picking-ul este un proces de selectare şi de colectare a pieselor mari şi constă în aprovizionarea şi ordonarea fiecărei piese în cadrul unui sistem bine definit. Scopul acestui articol este de a îmbunătăți fluxul de aprovizionare a unei linii de asamblare reală, cu piese din zona de picking. Distanța dintre zonele de picking este o componentă importantă a costurilor. În studiul nostru de caz, cărucioarele sunt transportate la linia de asamblare cu ajutorul unui tractor electric, deservit de un operator logistic. În această lucrare este analizată posibilitatea de a înlocui mijloacele de transport existente cu un AGV. Conceptul de picking şi utilizarea AGV-urilor pentru transportul între zonele de picking pot fi considerate ca fiind metode de optimizare a planului de amplasament pentru liniile de asamblare.*

Abstract. *In this article, the concepts of picking and Automated Guided Vehicle (AGV) are analysed. Picking is a process of selecting and collecting large pieces and consists in the supply and the ordering of each piece in a well-defined system. The purpose of this article is to improve the flow of supply of a real assembly line, with pieces from the picking zone. The distance between the picking zones is an important cost component. In our case study, the trolleys are transported to the assembly line using an electric tractor, operated by a logistics operator. In this paper the possibility of replacing the existing means of transport with an AGV is analysed. The picking concept and the use of AGVs for transportation between picking zones can be considered as methods to optimise the layout for assembly lines.*

Keywords: picking, automated guided vehicle, simulation, route optimization

1. Introduction

In recent times companies in the automotive industry face fierce competition. Thus, companies must make quick decisions concerning the strategies to supply workstations.

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In this sense, this article provides strategies to improve the flow of supply with pieces in an assembly line. One of the supply methods is *picking*, a method consisting in the selection and collection of pieces.

Another important component of the supply chain is the distance between the picking areas. Let us analyse a real case study. We want to replace the existent means of transport (electric tractor) by an AGV.

The use of AGVs in supply systems has the following advantages:

- saves labour: no human operators are involved in the transport of materials between warehouses and manufacturing systems, which leads to increased productivity;
- space is saved: the long transfer performed by the AGV is ongoing, there is no need for intermediate storage to create reserve stocks to continue the manufacturing activity between two transports, as it is done in a classical system of internal transport;
- increases the quality of products, items carried automatically are less exposed to damage than in the case of manual transportation (the human operators used for this purpose are usually unqualified);
- allows an easy adaptation of the system to changing requirements, meaning that the routes on which the automated guided vehicles move are usually easily exchangeable.

2. Picking Methodology and AGV

Picking and AGVs (Figure 2.1) are two alternative systems to supply materials that are common in assembly systems.

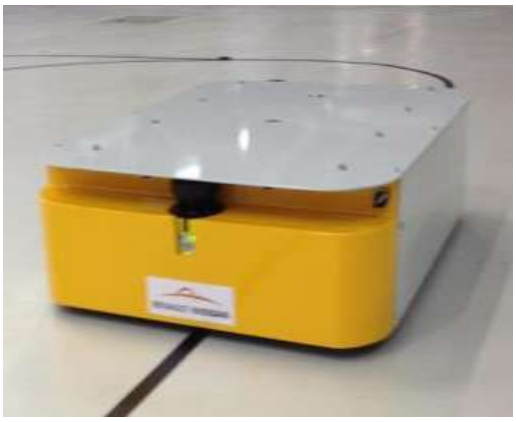

Fig.2.1.AGV -Automated Guided Vehicle [5]

The schematic representation of picking is exhibited in Figure 2.2: the pieces for the same position are arranged and stored on a support bracket and the support is inserted into the workstation.

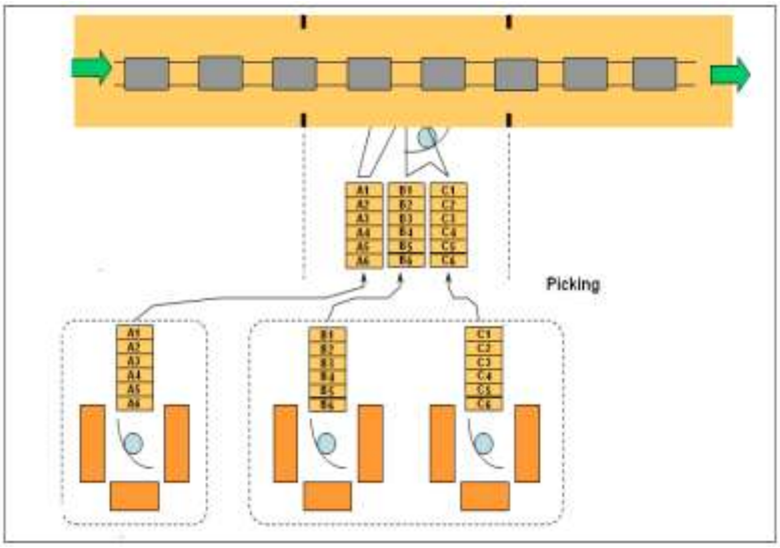

Fig.2.2. Schematic representation of picking [12]

Picking is the process of selecting and collecting large pieces, showing diversity in delivering, performed within a well-defined system.

The picking operation can be performed in several ways and in order to increase the efficiency in most cases automatic variants are used [1,11].

The AGV can be described as a mobile robot that follows markers or wires in the floor, or uses vision or laser to move on the industrial flooring in order to handle materials, including storage, retrieval and exchange between machines. Over the last few decades AGV systems have been widely used in manufacturing processes [1].

The role that these machines played cannot be underestimated because in 1953 they were first introduced in shifting materials. The first AGV was built in 1953 by Barrett Electronics Corporation, designed and used as a modified tow truck, moving from one point to another, following a wire on the ground [2].

AGVs must make decisions in selecting the road. This is done through various methods: by selecting the frequency (wired navigation) and by selecting the route (just wireless navigation) or via a magnetic strip affixed to the floor not only to guide the AGV but also to issue steering and speed commands [3]. AGV is an independent mobile vehicle; therefore, the power comes from the battery, instead of alternating current.

The battery capacity is limited, hence it is recommended to consider the amount of energy consumption during the design phase. As the battery is used, the voltage will also change. When the voltage reaches a certain level, some elements of the AGV will be unable to function normally, which will produce error messages. It is recommended to implement a system of voltage control, so that different actions can be taken in response to voltage changes [4].

AGV makes work easier, reduces damage to materials transported, increases efficiency and reduces costs by helping to automate a production or storage unit [5-14].

3. Case Study

3.1. Describing the Assembly Line

The assembly line produces three types of engines. The production capacity is of 450,000 engines / year with a cycle time of the line of 0.76 min. The surface of the assembly line area is of 1427 m², organised as an "*O*" and has a total of 88 workstations.
The synchronous supply is made in three picking areas. The survey is conducted on picking zone 3.
The assembly line is supplied with pieces from the picking area. In the area of picking type logistics preparation is conducted on trolleys, in the order of the manufacturing film and sets of pieces: cylinder head cover, distributor, turbo manifold and catalytically can.

The manufacturing film consists in planning production based on firm orders sorted according to the data received from customers, structured in the order of manufacturing.

The trolleys are transported to the assembly line using an electric tractor, operated by a logistics operator.

3.2 Identifying the Problem

This research aims to optimise the manufacturing flow by supplying the picking areas using new means of transport.

In the current situation, the transport of trolleys with pieces is performed by an electric tractor. In this study we want to remove this tractor because it generates costs both in the commitment of the operator who drives the trolleys and in the operating time of the tractor.

The flow of pieces supply to the workstations will be improved by replacing the existing means of transport by an AGV and the solutions proposed to achieve this improvement are shown in Figure 3.1.

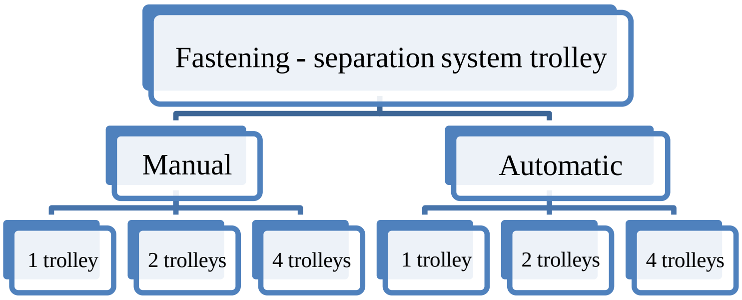

Fig. 3.1. Situations proposed.

4. Results

First of all, we shall determine the commitment of the operator and the working time of the electric tractor. A time analysis sheet will be used. This sheet describes the activity performed by the operator, depending on the distance and frequency to perform the activity, therefore the resulting the time needed to carry a trolley with pieces to the workstation. The length of the route travelled by the electric tractor for supply will be determined with the help of the layout of the line implantation.

The data collected will give the result that the commitment of the operator who transports the trolleys to the assembly line is of 43.26 [%], entailing a cost of 18170.07 [€] (for all 3 shifts).

The operating time of the tractor is of 7.59 minutes and the resulting cost is of 3388.41 [€] / year.

Further, we shall present the results obtained for the optimisation solutions proposed, as well as the comparisons made between the two means of transport.

The cost of the investment for the solutions proposed is presented in the following table.

Table 1) Cost of investment

Investment	Manual			Automatic		
	1 trolley	2 trolleys	4 trolleys	1 trolley	2 trolleys	4 trolleys
Number of AGVs	2	2	1	2	2	1
Cost of AGVs, [€]	13045			15045		
Total cost of AGVs, [€]	26090		13045	30090		15045
Implementation cost, €]	3170	3010	2610	9170	12010	17610
Total investment, [€]	**29260**	**29100**	**15655**	**39260**	**42100**	**32655**

The following table highlights the period over which the investment for the solutions proposed will be amortised.

Table 2) Period of amortization of the investment

Cost of use	Situations proposed						Current situation
	Manual			Automatic			Electric tractor
	1 trolley	2 trolleys	4 trolleys	1 trolley	2 trolleys	4 trolleys	
, [%]	18.55		21.18	-			43.26
, [€]	7791		8895.60	-			18170.07
, [€]	-						3388.41
“AGVs supplies”*, [€]	1200	1200	600	1200	1200	600	-
Total cost of use, [€]	8991	8991	9495.6	1200	1200	600	21558.48
Amortization, [years]	2.32	2.31	1.29	1.92	2.06	1.55	

* The battery of the AGV must be changed every year.

In the following figure, it can be seen that for the automatic fastening - separation system the operator cost is zero because the action is done automatically using a device that is purchased simultaneously with the AGV.

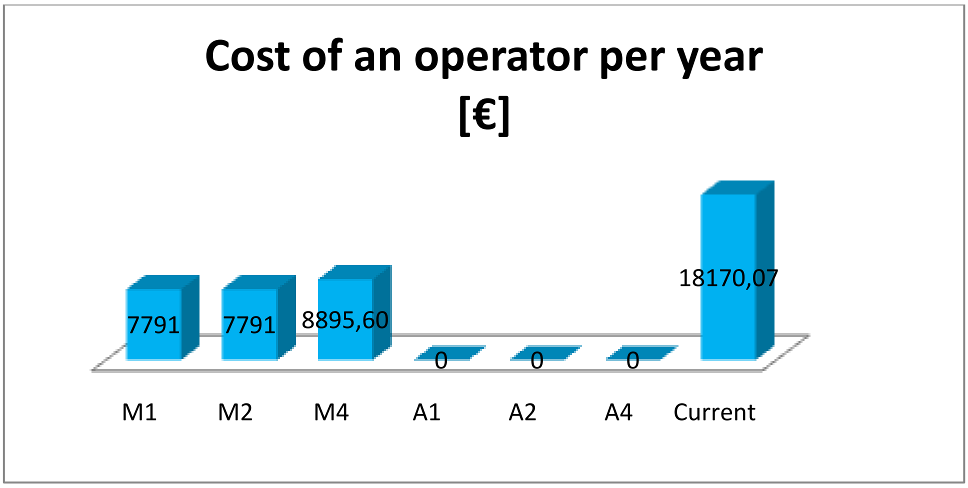

Fig. 4.1. Cost of an operator per year.

In Figure 4.2, it can be seen that for the current situation the tractor must be paid because it is rented, therefore it is necessary to pay the rent.

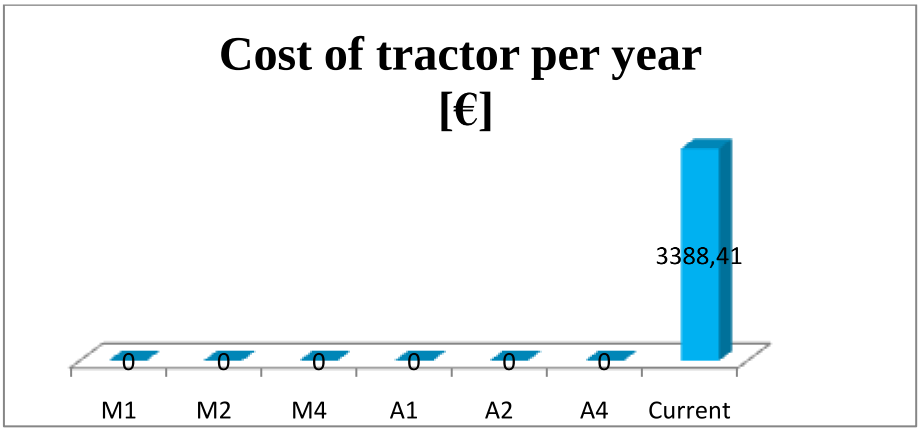

Fig. 4.2. Cost of tractor per year

The “AGV supplies” category for each situation proposed is shown in Figure 4.3. The “supplies” refer to the fact that the battery of the AGV must be changed every year.

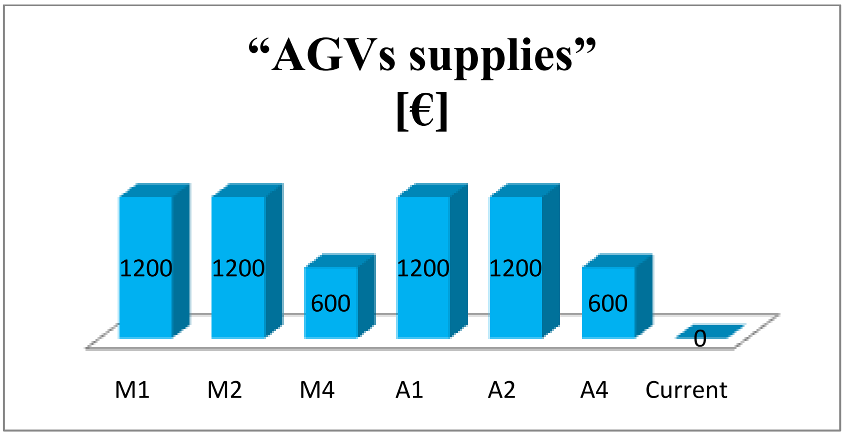

Fig. 4.3. AGVs supplies

It can be seen that, for the manual fastening – separation system with 4 trolleys, only one battery is required to achieve the transport of trolleys with pieces in the workstations, because only one AGV is needed for each situation proposed. And, in the case of manual and automatic fastening – separation systems, which carry one trolley, two trolleys, respectively, two supplies are required, because 2 AGVs are needed for these situations.

The total cost of use for the current situation and for the situations proposed is exhibited in Figure 4.4. In the current situation this cost consists of the cost of the operator per year plus the cost of the electric tractor, and in each situation proposed it is composed of the cost of operator per year plus the "AGV supplies".

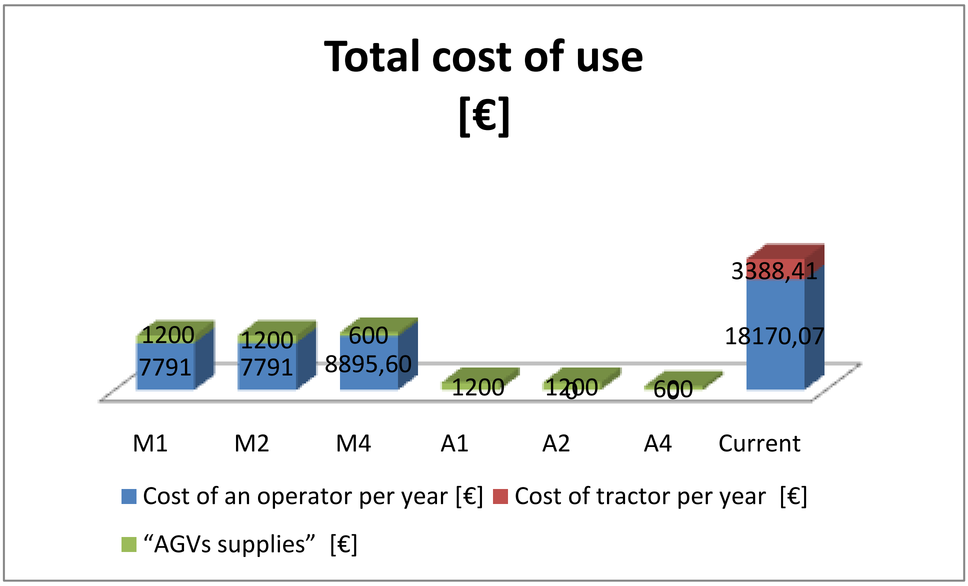

Fig. 4.4. Total cost of use.

Conclusions

In this article is studied the improvement of the process of supplying workstations in an assembly line.

The optimization methods used in this study were the following: picking and introducing AGVs as a means of transport. Several comparisons were made between transport with the electric tractor and the AGV.

Many situations have been proposed to improve the flow of supply and then an analysis of investments and costs was made.

In terms of depreciation of investment and running costs, the best option obtained is when it uses an AGV, which has a manual fastening – separation system and carries four trolleys (Figure 5.1).

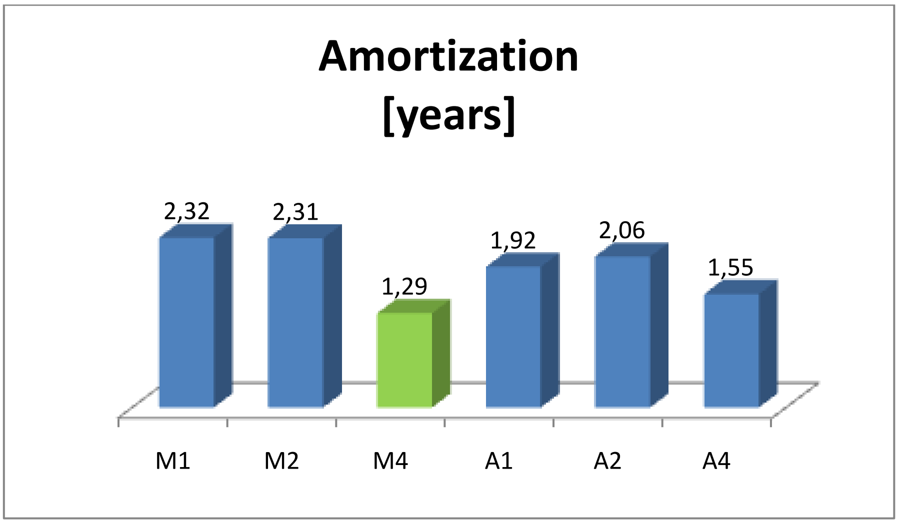

Fig. 5.1. Analysis of the situations proposed.

Further research directions will be channelled to study the supply method, called *kitting*, a method by which pieces individually separated are grouped, packaged and supplied together as a whole (a set) in order to be used in an operation (Figure 5.2.) [15-16].

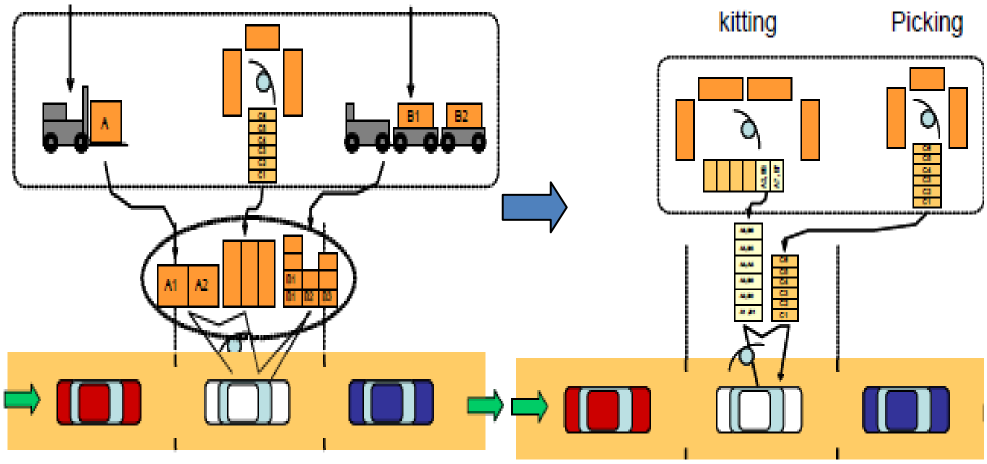

Fig. 5.2. Kitting and Picking

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