Advanced Logistic Systems – Theory and Practice, Vol. 17, No. 4 (2023), pp. 41-50.
https://doi.org/10.32971/als.2023.029

AUTOMATION FEATURES OF MATERIAL HANDLING MACHINES

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Abstract: *Industrial, service and other processes applying more and more automated devices, there are many smart solutions in the homes and robots are standing at the gates. However, the situation of handling processes is a little bit special, because of the operation specifications of the handling machines. Most of the automation tasks and problems related to discontinuous handling machines, their application requires much more planning and operation tasks. This paper gives an overview about the application and specifications of automated material handling machines, especially focusing to those features, which can influence the handling processes and many parameters of the material handling machines. The objective of this research is to uncover the specifications of material handling machines. The results can help to build more effective handling systems and automated handling equipment.*

Key words: *material handling machines, automatic operation, automation problems.*

1. INTRODUCTION

This century is the century of the automation. Industrial, service and other processes applying more and more automated devices, there are many smart solutions in the homes and robots are standing at the gates [1]. Nowadays, as in every field of the industry, there are many automated devices in materials handling. However, the situation of handling processes is a little bit special, because of the operation specifications of the handling machines. Near the half of the handling equipment has continuous operation (e. g. conveyors), which does not require too much automation activities. Most of the automation tasks and problems related to discontinuous handling machines, their application requires much more planning and operation tasks.

This paper gives an overview about the application and specifications of automated material handling machines, especially focusing to those features, which can influence the handling processes and many parameters of the material handling machines.

2. EQUIPMENT USED IN MATERIAL HANDLING SYSTEMS

During material handling processes, different goods are moving among technology or other objects located in given places, to fulfil the requirements of any production, service or consumer systems. The goods can be living or lifeless elements, the moving direction can be horizontal, vertical or other (simple or complex). The moving process can be realized by human operators or material handling machines [2].

There are many material handling machines in industrial and economic processes [3], which are significantly different each other, at first sight. However, we look deeper into their detailed structure and functional operation, many similarity can be found, which enables to put them into different types. In the aspect of the main structure and principal

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operation characteristics, 15-20 main types can be defined (e. g. cranes). Fig. 1 presents a possible structure of material handling device types.

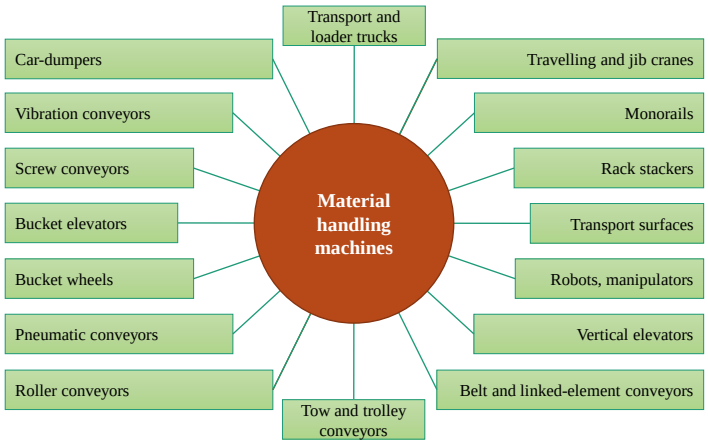

Figure 1. Main types of material handling machines [2]

The differences among the machine types are based on three important factors:

- the required handling operation elements,
- the handling characterisations of the tasks and
- the handling methods.

During material handling different activities are realized, which consist of the next elements:

- horizontal movement,
- vertical movement,
- goods picking up,
- goods releasing,
- fixing,
- waiting.

The solutions applied for the handling are determined by the parameters of the handling tasks and handling machines, where 4 main characterisations can be described [4]:

- goods type (units, bulk solids),
- operation character of the machine (continuous, discontinuous),
- guidance method (along track, free),
- operation method (manual, automatic).

Based on the realization of the moving of the goods, four goods handling methods can be applied in material handling [2]:

- mobile handling units,
- fixed loading arms,
- transport channels,
- moving by towing elements.

The above-mentioned factors and their actual parameters influence the structure, operation and application possibilities of the individual machine types. If we want to apply automated handling solutions, the above-mentioned factors have important effects to the applicability and the automation procedure.

3. AUTOMATION IN MATERIAL HANDLING

Traditional machines and processes are operated by human workforces, but there are many advantages of the automated operation of machines and systems.

3.1. Automation

During automated operation, machines work with computer control, without human interactions. The main automation objectives (Fig. 2) are the **s**afety, productivity, operability, control, human resource reduction, etc.

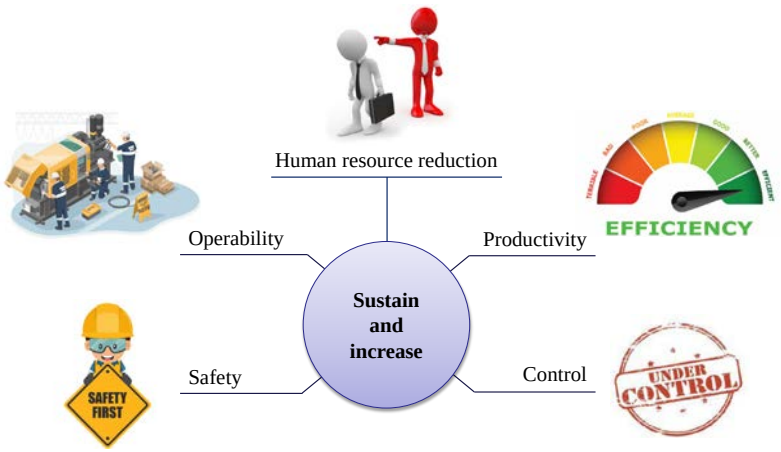

Figure 2. Automation objectives

At manual control, the operator realizes all required tasks. In automated machines, all task needs individual, independent execution. The main tasks related to automation are the moving, commanding, observation, monitoring, information handling, data transfer, identification, tracking, etc.

3.2. Automated material handling devices

At material handling, the automation of discontinuous machines is much more complex and problematic, because their operation contains several elements and movement sections. In some cases, the handling system consist of different independent units (e. g. automated guiding vehicles), which require individual commanding and central control [5]. Independent automation areas are the goods handling, lifting, moving and other additional tasks (e. g. overload checking, automated waiting solutions).

Most important types of discontinuous automated material handling machines are the automated guiding vehicles (AGV), lifting AGVs, semi-automatic AGVs, automated cranes, automated monorail systems, automated storage-retrieval machines, robots, etc.
Moving of the goods on continuous material handling machines is traditionally an automatic operation. Beside it there are different traditional solutions for the uploading and releasing of goods at the different machine types.

Automated uploading and releasing used at bulk solids handling machines (belt conveyors, elevators, bucket wheels, etc.) and at tow conveyors.

Because of the above-mentioned characterisation, the automation of continuous machines is much easier task than the discontinuous ones [6]. Main fields of their general automation process are the handling operations (uploading, releasing, transfer) and some simple additional tasks (starting, stropping, load limit checking, unit or trolley alignment, etc.).

The most important automated continuous handling system types are the roller conveyor systems, trolley and power and free conveyors, belt conveyor systems, bucket elevators, pneumatic conveyor systems, etc.

4. SPECIAL FEATURES OF THE AUTOMATED OPERATION OF HANDLING MACHINES

Material handling processes are usually complex, so automation must involve all movements and process elements. During the automatic operation, the different elements require usually individual solutions, and high-level coordination. Some simple manual elements (e. g. gripping) cannot be easily solved in automated processes. In some cases, there are no advantages to apply full automated machines, so the semi-automatic operation can be applied.

4.1. Control of automated handling machines

Automated machines are commanded by a control device (PLC, computer, etc). At material handling machines, commanding can be different, depending on the machine types, central control or distributed control can be applied.

Central control (e. g. conveyor systems) uses one central computer which controls the whole transport system.

In case of distributed control (e. g. AGV system) the control system has two levels: central computer and onboard computers on every autonomous unit [4]. Tasks of the central computer are the distribution of the handling tasks, controlling the autonomous units, coordination of the individual units, etc. Tasks of the onboard computers are the communication with the central computer, accepting and executing commands, controlling of command execution, local observation, collecting and transfer of data, etc.

4.2. Observation tasks at automated handling processes

Taks of observation devices (sensors, cameras, etc.) to notice the effects (internal and external) which can influence the operation of the automated machine to avoid any problems and errors. Observation has three different areas:

- process supervising (e. g. end of a process element),

- notice environmental effects (e. g. disturbing objects),
- notice errors during operation (e. g. wrong direction).

As material handling machines are moving objects, so the observation of environmental effects has further tasks during the automated operation: tracking, collision avoidance, accident prevention, etc. At along-track-moving machines only the track area must be observed. At free-moving devices the whole used area must be observed, and it has important role in the route planning process (Fig. 3).

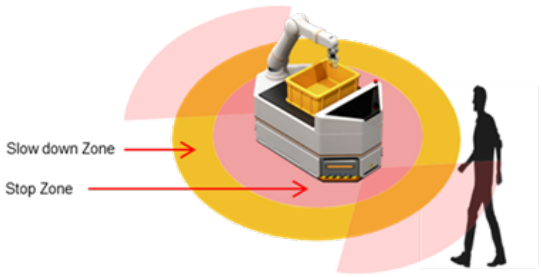

Figure 3. Example for the observation areas of an AGV [7]

4.3. Identification

Identification means the identifying process of any objects in all parts of automated processes. In material handling systems the next objects must be identified:

- goods, units, unit loads,
- handling objects (machines, operators, etc.),
- storing places, etc.

There are different solutions for the identification, but in material handling the most often used types are the optical identification (e. g. barcodes – see Fig. 4) and radiofrequency identification (RFID).

Figure 4. Example for the location of optical readers [8]

4.4. Tracking solutions

Tracking means the online position tracking of any objects. During material handling processes online tracking can be used for

- goods, units, unit loads in intern logistic systems,
- material handling machines (intern or extern),
- human operators for efficiency analysis (see Fig. 5), etc.

Most often used tracking solutions are infrared, RFID, WIFI, BLE (Bluetooth Low Energy), UWB (Ultra Wideband), GPS, etc.

Figure 5. Example for the tracking of human workforces [9]

4.5. Guidance of mobile units

Automated mobile units (e. g. AGV) transport or loading goods among uploading and releasing points at floor level, guided along a given line system or by virtually.

Direct guiding is simpler, usually contains starting, moving and stopping phases mainly in horizontal direction (Fig. 6). The line of the moving can be

- optical lines painted on the floor,
- underfloor electric cables or
- physical tracks (rails).

Figure 6. Example for direct guidance [10]

Using direct guidance is much effective solution, its specifications:

- tracking is the hardest task (moving, starting, stopping are easy),
- easily avoids blocking (restricted moving zone),
- precision of the tracking depends on the line system, etc.

If mobile units do not use direct guidance, they can change their way depend on the moving conditions. Automation of virtual-guided units is much more complex task than guided ones, selection of optimal routes requires complex route planning devices and algorithms. Too much disturbing object in the moving area can cause non-effective transport.

Application of virtual guidance (Fig. 7) is not so frequent in the practice, except in special cases, when the disturbing effects (humans, other machines, etc.) are not significant in the handling zone (e. g. cold storage).

Figure 7. Example for virtual guidance [11]

4.6. Semi-automated handling machines

Semi-automatic devices are controlled by computer, but at least one of the operation elements are realized manually. Cause of the manual process element (e. g. gripping) can be

- hard to solve by automated process,
- too expensive,
- low efficiency, etc.

Example for semi-automatic operation is the order picking procedure (Fig. 8). In this case the handling is too complex, because of the large differences among the goods (in size, shape or mass), so an operator is used for picking of the units, the other operation elements are automated.

Figure 8. Example for semi-automatic order picking machine [12]

4.7. Automated crane grippers

Automated cranes can load and lift goods without any human interaction. Against the manual operation, these machines have some specifications related to the automatic operation:

- handling devices (gripping problems),
- lifting devices (positioning problems), etc.

Traditional gripper for cranes is the hook, which can be used only for manual control of units. For the substitution of hooks, several automated gripper solutions can be applied (Fig. 9), their most important characteristics are

- they have to suite to the handled unit,
- they have to operate separately,
- they have limited applicability (only certain unit types), etc.

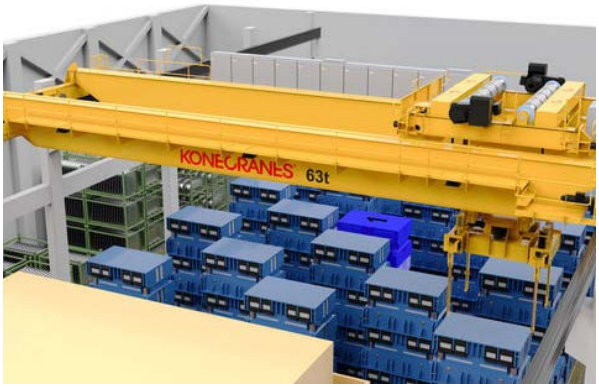

Figure 9. Example for automatic crane gripper [13]

Grippers of cranes for bulk solids are the grabs, which can be used for manual and also automated control. Using grabs in automated operation, the next aspects must be considered:

- volume is controlled by the opening angle,
- load mass can be determined by the bulk density,
- lifting cable can cause swinging, etc.

4.8. Automated lifting devices for cranes

Cranes usually use cable hoist to lift goods. Because the cable is flexible, goods swing during the motion of the crane. Swinging of the goods influences the positioning during handling processes (increase the loading times). This phenomenon cause problems for the automated operation. Important task to reduce the swinging of the goods for the effective operation.

Avoiding or reducing of the swinging of the goods, different lifting solutions can be applied:

- oscillation reducing solutions,

- guiding elements,
- scissor mechanism (Fig. 10), etc.

Figure 10. Example for scissor hoist [14]

5. SUMMARY

Nowadays, there are many automated devices in materials handling. Near the half of the handling equipment has continuous operation, which does not require too much automation activities. Most of the automation tasks and problems related to discontinuous handling machines, their application requires much more planning and operation tasks.

This paper gave an overview about the automated material handling machines, especially focusing to those features, which can influence the handling processes and many parameters of the material handling machines.

The objective of this research was to uncover the specifications of material handling machines which can limit their applicability in automated handling systems. As a result, the most important features of the automation process of material handling solutions were summarised and described.

REFERENCES

[1] Alwi, S. R. W., Manan, Z. A., Klemeš, J. J. & Huisingh, D. (2014). Sustainability engineering for the future. *Journal of Cleaner Production* **71**, 1-10, https://doi.org/10.1016/j.jclepro.2014.03.013

[2] Telek, P. (2023). Transport channels in advanced material handling systems. *Advanced Logistic Systems - Theory and Practice* **17**(3), 43-50. https://doi.org/10.32971/als.2023.022

[3] Ten Hompel, M., Schmidt, T. & Nagel, L. (Eds.). (2007). *Materialflusssysteme. Förder- und Lagertechnik.* Berlin: Springer, https://doi.org/10.1007/978-3-540-73236-5

[4] Cselényi, J. & Illés, B. (eds.) (2006). *Design and control of material flow systems I. (in Hungarian).* Miskolc University Press, Miskolc

[5] Müller, T. (1983). *Automated guided vehicles.* Springer-Verlag, Berlin

[6] Loggé, Y. (1975). *Automated material handling (in Hungarian).* Technical Press, Budapest

[7] *360 Degree Safety Bubble with IWR6843ISK.* Retrieved from https://e2e.ti.com/support/sensors-group/sensors/f/sensors-forum/955041/faq-mmwave-360-safety-bubble-lab-for-ros-is-now-

available-on-the-ti-resource-explorer
[8] Cognex: *Pallet scanning.* Retrieved from https://www.cognex.com/industries/food-and-beverage/warehousing-and-distribution/pallet-scanning
[9] Gofleet: *Key components of an Indoor Tracking System.* Retrieved from https://www.gofleet.com/key-components-of-an-indoor-tracking-system/
[10] BlueBotics: *AGV navigation methods 1: Line following and tags.* Retrieved from https://bluebotics.com/agv-navigation-line-following-tags/
[11] BlueBotics: *AGV navigation methods 2: Virtual path following.*. Retrieved from https://bluebotics.com/agv-navigation-methods-virtual-path-following/
[12] 6 River systems: *What is automated warehouse picking?* Retrieved from https://6river.com/what-is-automated-warehouse-picking/
[13] Konecranes: *Die gripper cranes for automotive industry.* Retrieved from https://www.konecranes.com/en-in/industries/automotive/proven-automotive-lifting-equipment/die-gripper-cranes-for-automotive-industry
[14] Woodtec Fankhauser GmbH: *Handling Crane Pro.* Retrieved from https://www.woodtec.ch/en/materialhandling/handlingcranepro/