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*Jan Semjon, Ján Grexa, Peter Mako***DESIGN OF DOCKING SYSTEM FOR MOBILE ROBOTICS  
PLATFORM TYPE AGV**

**Urgency of the research.** Automatic battery charging of AGV platforms allows you to maximize their potential. Safe and quickly positioning AGVs in a charging station equipped with appropriate contacts, reduces the charging time as well as the purchase price of the device.

**Target setting.** The aim of the solution is to design an automatic docking and charging station from a used hand-held charging station. In the design, it was necessary to ensure the appropriate position of the AGV platform against the docking station.

**Actual scientific researches and issues analysis.** The issue of fast and reliable charging of mobile service robots is highly up-to-date. The reason for this is the growing deployment of AGV platforms in various industrial or service sectors.

**Uninvestigated parts of general matters defining.** This article focuses on a specific solution for the provision of transport services. Transport services come from the need to transport medical supplies and medications in a multi-storey hospital building. The movement of the robot between the floors is solved by the use of lifts used by the personal of hospital.

**The research objective.** The aim of the research was to design a docking and charging station utilized an already purchased power-up charger. The design was aimed at creating an appropriate power transmission system between the charger and the AGV platform batteries. The price ceiling for the whole facility was worth € 2,000.

**The statement of basic materials.** The use of docking and charging stations for mobile service robots is dependent on a number of parameters. In particular, the parameters depend on the area of use, the size of the battery to be charged, and the amount of robots being recharged at the station. Last but not least, charging time and purchase price are also important.

**Conclusions.** The task of the solution was to design a docking station design for the AGV platform. At the beginning, three variants were created, from which the most appropriate solution was chosen using the scoring method. However, before designing the docking station design, it was necessary to modify the existing AGV platform construction so that it could be connected to the docking station charging mechanism. The design of the docking station itself consisted of the design of the charging and charging mechanism. These mechanisms provide charge and guidance of the AGV platform to the docking station. Mechanisms are not dependent on each other, since the charging mechanism is activated later than the drive mechanism. Subsequently, a design of the docking station, which can be anchored to the floor or to the wall, was created. At the docking station there is a charger from Hoppecke, which provides the AGV platform charging. The design dimensions of the docking station have been greatly influenced by the size of the above-mentioned charger. It has been found that new and better technologies will not be needed at the docking stations in the future, as AGV platforms can be guided without their help. The development of new and better quality systems will bring new guidance options to AGV platforms and docking stations.

**Key words:** AGV; docking system; battery; mobile platform.

Fig.: 6. Table: 1. References: 6.

**Problem definition.** Industry 4.0 marks the current trend of digitization and automation of production. Basic visions emerged in 2011. With the onset of the Industrial Revolution, the development of AGV (Automated Guided Vehicle) platforms for automated material transport is also closely linked. Automated Vehicles in Industry 4.0 play an important role because they partially take on simple and repetitive activities that do not require human intervention. AGVs have different uses not only in industry but also in other areas. Over time, new intelligent factories will be created to use cybernetic-physical systems and take on the repetitive and simple activities that people have done so far [1; 2]. The first versions of AGV used navigational aids in the environment to navigate (for example magnetic passports, colour lines, floor wires). Thanks to advances in autonomous navigation, solutions are now available that allow for mapping and localization without the need for external navigation aids. The latest AGV models can map the environment using LIDARs (Light Detection and Ranging) and then create a virtual map of the environment. AGV is able to detect its exact location in this way and therefore works very accurately and precisely with regard to safety. AGV platforms include Mobile Industrial Robots (MiR), Omron Adept Technologies, SMP Robotics, VAHLE, WiBotic, Clearpath Robotics, Fetch Robotics, Swisslog, and the Slovak company CEIT. The issue of mobile AGV platforms is inseparably linked to the need to deliver energy to the system. In case of battery-powered AGVs, charging is required. Charging can be solved in a variety of ways. The simplest case is to manually connect the platform to the charging station, which however requires human intervention to (disrupt process automation. If we are trying to maximize the automation of material transport, it is necessary to solve the problem of automatic battery recharging [3]. Several concepts are currently used to automatically charge mobile robots. The best-known ones are dock-

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ing stations, floor charging, and wireless charging. The article presents a proposal for automatic battery recharging for the AGV platform developed by a Slovak company. The manufacturer aims to bring to market a modern AGV platform based on the latest knowledge of autonomous navigation, localization and solving the problem of automatic energy recharging. The solution to this problem was to consider all currently available charging technologies on the market. On the basis of the acquired knowledge, three proposals for designing the integration of automatic charging technology into the system were developed. Based on cost analysis and complexity of the solutions developed, the final proposal was selected.

**Use and parameters of AGV platform.** The proposed AGV platform uses the latest knowledge of localization and autonomous navigation of mobile robots, can create a virtual map of its surroundings and then move it according to the chosen trajectory. With laser guidance and a virtual map, no lines, magnetic strips, or magnets placed in the floor need to be navigated. The first AGV platform is tested in the Kosice-Šaca hospital (Slovakia). It facilitates the work of the staff and is able to safely and fluently transport the necessary material to other floors through a lift that can be called. The proposed platform is shown in Fig. 1.



*Fig. 1. AGV platform*

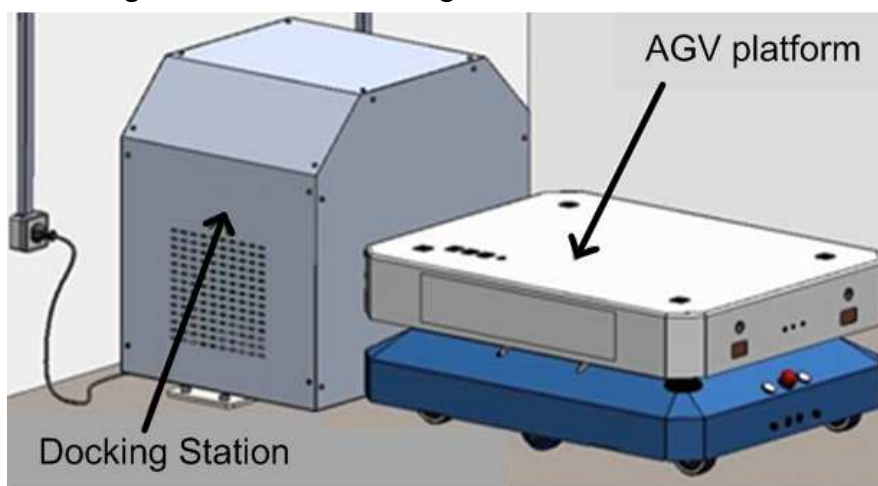
Basic technical parameters of AGV platform:

- Maximum carrying capacity: 100 kg.
- The maximum towable weight: 500 kg.
- Maximum speed: 1.0 m / s.
- Battery life 10 km (with 50 Ah batteries).
- Charging device integrated in the home station.
- Machine weight 80.5 kg.

AGV platform is ready to integrate various add-ons. The superstructure in the form of a robotic arm allows you to move or store the required goods in the designated area. The use of the arm is possible in several areas (e.g. the automotive industry). The electronically lockable box is the superstructure that is most commonly used in hospitals where it is used to transport medical supplies. Thanks to an electronic lock, this box cannot be opened while moving, making the material anti-theft. This add-on is not exclusively for the hospital environment, and its use is also possible in other sectors (e.g. hotels). AGV uses power via two 50 Ah Hoppecke battery type 12 TB 50 [4]. The batteries are connected in series to provide the 24 V required to power the system and the robot drives (AGV can run 10 kilometres per charge).

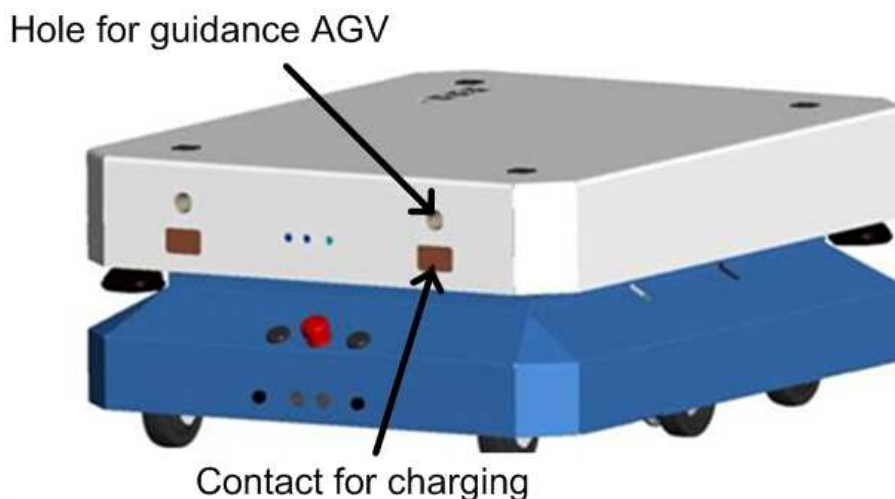
**Proposal of docking station.** The docking station consists of a frame on which the guiding mechanism and the cover plates are attached. The station has the possibility to attach it to the floor, but also to the wall, which will ensure against unwanted displacement. There is a charger inside the docking station to quickly charge the AGV platform. Powering the docking

station is via a cable that is suitable for a conventional 230 V plug. In addition to the fact that the AGV platform can be effectively brought to the docking station by means of the sensors separately, in the case of a slight deviation in the docking station, a guidance mechanism is installed that can correctly rotate AGV platform for charging mechanism [5]. One of the advantages of the docking station is that it is possible to place it in any place in the hall without complicated intervention. The price of such charging devices is around € 2,200 per piece. In Fig. 2, a docking station is shown along with an AGV platform that is suitably adapted for charging and flexible guidance into the docking station.



*Fig. 2. AGV and docking station*

In Fig. 3 is a proposed AGV platform that is equipped with connectors. These connections consist of a guide cone hole and a charging contact.



*Fig. 3. Connections of the AGV platform to the docking station*

Before designing the docking station itself, the design of the connection in the AGV platform is still needed. The connector structure is hidden under the top cover of the AGV platform. The top cover has out the required holes for charging and guiding. The simplicity of this design also reflects the resulting price. The production cost for the one connector of AGV platform is around € 70 per piece. There are four such connectors on the AGV platform, so the final cost for modification the AGV platform is € 280. Charging connection for AGV platform, fig. 4 consists of two main parts, which are the guiding and the charging contact (mechanism).

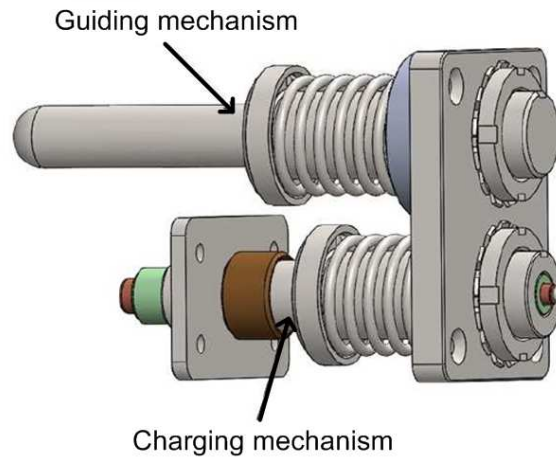


Fig. 4. Charging connection for AGV platform

The guide sleeve is fastened by screws to a frame to which a flange is attached due for extension of the screw thread. The charging contact is connected by means of screws that connect it to the insulating plate. The insulating plate is then used with other screws connected to the frame of the AGV platform. On the charging contact, a rubber insulation is provided to protect the frame of the AGV platform from electric current. There is a screw in the charging contact which connects the conductive contact with the charging contact. The entire connection solution is hidden under the top cover of the AGV platform. In this cover, holes are cut out so that the AGV platform can be routed through the guiding mechanism and charged with the charging mechanism. The first step in designing the docking station is to create a rigid frame that can withstand unexpected impacts, as there may be different situations in the production halls. Figure 5 shows a frame on which there is also a charging and guidance mechanism. This frame is formed from a hollow square profile.

Frame of AGV Docking Station

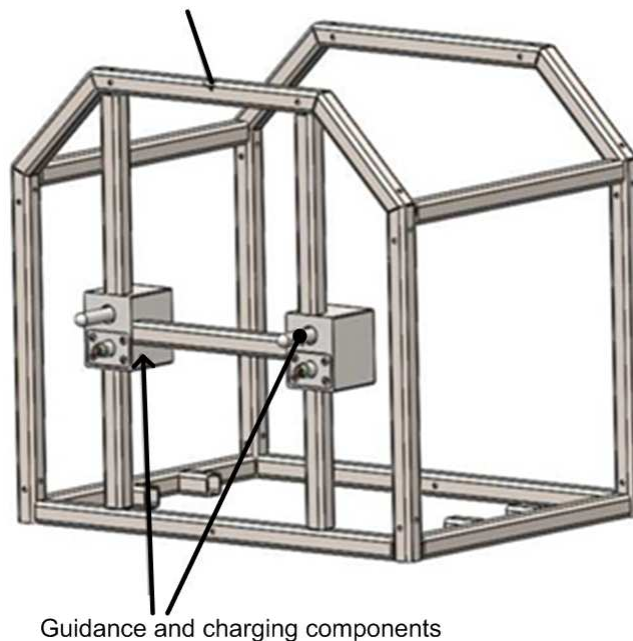
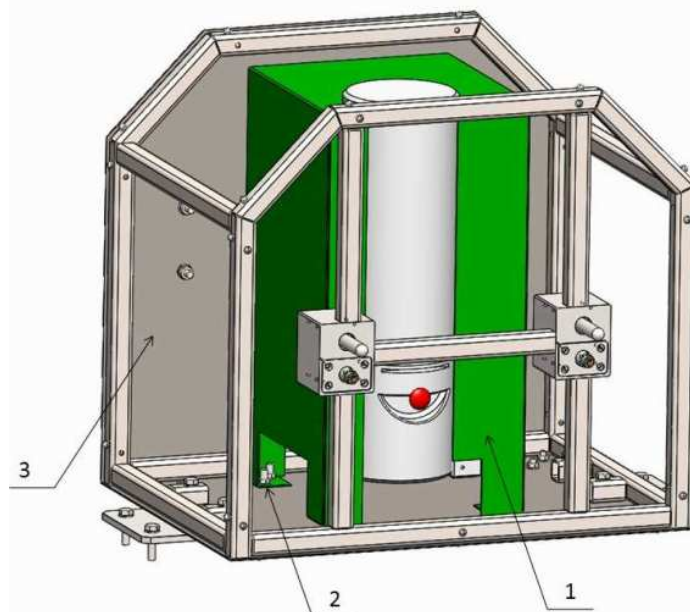


Fig. 5. Connections of the AGV platform to the docking station

In Fig. 6 shows a charger from Hoppecke, which is already incorporated in the docking station [6]. The dimensions of this design are largely influenced by the size of the charger to be mounted in the docking station. This problem with the construction was easily solved by enlarging the docking station.



*Fig. 6. Docking station without cover:*

- 1 – Hoppecke charging device; 2- Attaching the charger to the docking station;  
3- The rear part of the docking station for attachment to the wall

The docking station is not very compact, but robust and shock-resistant. If necessary, the docking station can also be moved to other locations. The charging mechanism is designed to withstand even tougher impacts and careless handling. The basic information on the docking station is shown in Table.

Table

*Parameters of the charging and docking station*

Base dimensions of docking station (Width x Depth x Height) [mm]	676 x 505 x 632
Basic dimensions of the guide mechanism (Width x Depth x Height) [mm]	80 x 165 x 100
Weight of the charging and docking station [kg]	52

The cost of manufacturing, welding and assembly work is estimated at € 500. The total purchase price for the materials is € 1475, which means that the total cost of one docking station is € 1975.

**Conclusions.** The task of the solution was to design a docking station design for the AGV platform. At the beginning, three variants were created, from which the most appropriate solution was chosen using the scoring method. However, before designing the docking station design, it was necessary to modify the existing AGV platform construction so that it could be connected to the docking station charging mechanism. The design of the docking station itself consisted of the design of the charging and charging mechanism. These mechanisms provide charge and guidance of the AGV platform to the docking station. Mechanisms are not dependent on each other, since the charging mechanism is activated later than the drive mechanism. Subsequently, a design of the docking station, which can be anchored to the floor or to the wall, was created. At the docking station there is a charger from Hoppecke, which provides the AGV platform charging. The design dimensions of the docking station have been greatly influenced by the size of the above-mentioned charger. It has been found that new and better technologies will not be needed at the docking stations in the future, as AGV platforms can be guided without their help. The development of new and better quality systems will bring new guidance options to AGV platforms and docking stations.

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## ПРОЕКТУВАННЯ ДОК-СТАНЦІЇ ДЛЯ МОБІЛЬНОЇ РОБОТОТИЗОВАНОЇ ПЛАТФОРМИ ТИПУ AGV

**Актуальність теми дослідження.** Автоматична зарядка акумуляторів на платформах типу AGV дає змогу максимально використовувати їхній потенціал. Безпечно та швидко розміщення AGV на док-станції, що оснащена відповідними контактами, скорочує час зарядження, а також вартість покупки пристрою.

**Постановка проблеми.** Метою роботи є розробка автоматичної док-станції і зарядного пристрою із вживаної портативної зарядної станції. При проектуванні необхідно було забезпечити належне положення платформи AGV щодо док-станції.

**Аналіз останніх досліджень і публікацій.** Проблема швидкої й надійної зарядки мобільних сервісних роботів дуже актуальна. Причиною цього є зростаюче розгортання платформ автономних керованих транспортних засобів (AGV) у різних промислових і сервісних застосуваннях.

**Виділення недосліджених частин загальної проблеми.** Дана стаття присвячена конкретному рішення для надання транспортних послуг. Транспортні послуги викликають через необхідність перевозити медикаменти і медикаменти в багатопверхові будівлі лікарні. Рух робота між поверхами реалізується за допомогою ліфтів, які використовуються персоналом лікарні.

**Постановка завдання.** Мета дослідження полягала в тому, щоб спроектувати док-станцію з використанням вживаного зарядного пристрою. Розробка була спрямована на створення відповідної системи передачі енергії між зарядним пристроєм і батареями платформи AGV. Обмеження по вартості всього об'єкту становило 2000 євро.

**Виклад основного матеріалу.** Використання стикувальних і зарядних станцій для мобільних сервісних роботів залежить від багатьох параметрів. Зокрема, параметри залежать від галузі використання, розміру батарей для зарядки і кількості роботів, що заряджаються на станції. Наразі, що не менш важливо, час зарядки й ціна покупки також важливі.

**Висновки відповідно до статті.** Завданням було розроблення конструкції док-станції для платформи AGV. На початку було створено три варіанти, з яких було вибрано найбільш відповідне рішення з використанням методу оцінки. Однак перед проектуванням конструкції док-станції було необхідно змінити наявну конструкцію платформи AGV, щоб вона могла бути підключена до механізму зарядки док-станції. Конструкція док-станції передбачає наявність зарядного механізму. Ці механізми забезпечують зарядку і управління платформою AGV до док-станції. Механізми не залежать один від одного, так як механізм зарядки активується пізніше, ніж механізм приводу. Згодом була розроблена конструкція док-станції, яку можна закріпити на підлозі або на стіні. На док-станції є зарядний пристрій від Норреке, який забезпечує зарядку платформи AGV. На габаритні розміри док-станції істотно впливали розміри вищезгаданого зарядного пристрою. Було встановлено, що в майбутньому на док-станції не будуть потрібні нові й більш досконалі технології, оскільки платформи AGV можна орієнтувати без їх допомоги. Розробка нових і більш якісних систем принесе нові можливості управління для платформ AGV і док-станцій.

**Ключові слова:** AGV; стикувальна система; акумулятор; мобільна платформа.

Рис.: 6. Табл.: 1. Бібл.: 6.

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