Design and Application of a Container Agv Reloading Vehicle with Rotary Lifting Guide Rail

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Abstract: At present, the advanced automatic terminal horizontal transportation system mainly uses the automatic guided vehicle system based on magnetic nail navigation (English full name: Automated Guided Vehicle hereinafter referred to as agv) to complete the automatic transfer between the container terminal front and the yard. At present, the horizontal transportation equipment of automatic wharf mainly includes ordinary agv, ordinary agv with agv companion car and lifting agv with lifting platform. Ordinary agv can only realize the horizontal transportation of containers, while matching with agv partners can improve the overall efficiency, but the cost is too high, while agv with its own lifting platform can only realize the horizontal transportation and lifting of containers, which cannot meet the three-dimensional transportation needs of automated terminals. To solve the above problems, by designing a container agv reloading vehicle with a rotary lifting guide rail structure, it can meet the automatic three-dimensional transportation requirements of multimodal transport stations, container terminals, large logistics hubs, etc. The application of this device can reduce about 40% of ordinary agv guiding vehicles in automatic terminals. Realize the efficient connection of the three modes of transportation of public and hot metal, and achieve the purpose of reducing the cost of multimodal transport and improving the efficiency of multimodal transport.

Keywords: agv; multimodal transport; automated container terminal; high-efficiency connection equipment; rotary liftable platform

1. Introduction

In recent years, with the continuous expansion of China's foreign trade, the container transportation industry has developed rapidly. According to statistics, in 2020, the first three batches of 70 multimodal transport demonstration projects completed a total of container multimodal transport volume of about 4.8 million TEU (20 feet standard container, English full name: Twenty-feet Equivalent Unit hereinafter referred to as: teu). The port completed 6.87 million teu, which increased 29.6% year on year. With the continuous expansion of the scale of foreign trade, the international competition is increasingly fierce and the competition level is constantly improving, and the competition between China's coastal ports is gradually transformed into the competition between international supply chains. The port is no longer a single point in the transport chain, but a key link in the international supply chain. In order to seek a broader economic hinterland and source of goods, the inland "waterless port" (also known as "dry port", Dry Port) has gradually developed. With the continuous development and improvement of the function of the inland container transfer station, the waterless port has gradually developed from an inland container terminal to a multimodal transport transit station, further improved relevant functions, expanded its business scope, and developed into an inland cargo port integrating trade, logistics, customs declaration and other functions [1].

China's 14th Five-Year Plan It is proposed that the domestic cycle as the main body and promote each other to accelerate the construction of a new pattern of development. China's multimodal transport has since entered the fast track of development. At the same time, the implementation of the national regional strategy and deep-depth cooperation will soon stimulate the new transportation market demand, break the original transportation pattern, and bring new opportunities for the layout and development of China's multimodal transport. At the same time, our infrastructure construction is entering the key period of connecting network, as the comprehensive transportation system gradually mature and towards a higher level, modern logistics put forward higher requirements especially involving timeliness, controllability, reliability, etc., these will further promote multimodal fully reasonable cooperation, reasonable distribution of transportation resources and improve the connection efficiency of different modes of transportation. To promote the development of multimodal transport to the direction of digital, intelligent, automation and network development [2].

2. Design of Container Agv Replacement Vehicle

2.1. Appearance and Key Structural Design

"Container agv replacement car" is mainly composed of the body and guide rail. The body and guide rail of the device are processed with high strength carbon steel

machine, high hardness, wear resistance, high strength and toughness, corrosion resistance, to meet the transportation requirements of 20 / 40 ft ISO standard container. A lifting bearing connection between the rail and the body enables the rotation and lifting of the rail. Both guide rails are designed with hydraulic lifting columns for weight bearing and fixation. Four-wheel drive is used. A visual system, including visible light camera, light source, is installed at the front and rear of the device and position adjustment mechanism. There are limit brackets on the upper four corners of the car body and both sides of the central body, and a landing judgment mechanism is set on each limit bracket to determine whether the guide vehicle carries the container. Figure 1. The narrow side of the tractor, as shown in Figure 2. Built-in navigation equipment, power management system, sensor system, control and communication system, etc.

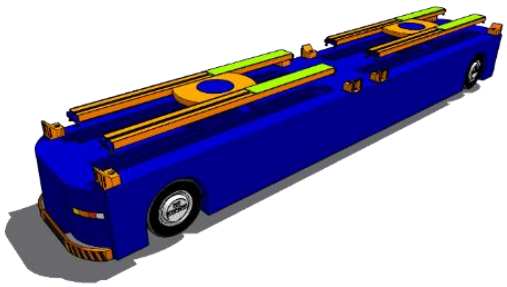

Figure 1. "Container agv replacement vehicle" Concept diagram (Specification I)

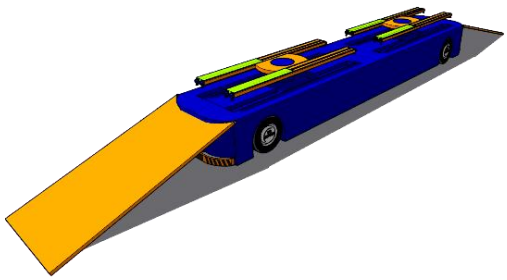

Figure 2. "Container agv replacement vehicle" Concept diagram (Specification II)

The specific parameters of the assembly agv replacement vehicle equipment are shown in Table 1

Table 1 . Specific parameters of replacement vehicle equipment

Change the car specifications	**Rated load / kg**	**Full-load running speed of km/h**	**No-load running speed is km/h**	**Minimum turning radius**
one	48000	10	20	12m
two	48000	10	20	12,
Wheelbase	**Outline dimensions**	**Outline dimension of guide rail**	**Rail maximum arm span**	**Wheel**
10m	13×2.46×1.28m	7.5×0.35×0.12m	10m	2.05m
10m	13×2.46×1.28m	7.5×0.35×0.12m	10m	2.05m

2.2. System Hardware Design

The device mainly consists of navigation equipment, power management system, sensor system, control and communication system [3].

Navigation equipment includes: navigation equipment motor, drive, lifting equipment and other sports systems.

Sensor system includes: visible light camera (equipped with light source), lidar, etc.

Power management system: responsible for collecting relevant status information of batteries, controlling battery charging and discharge, conducting battery protection, and providing power supply for various functional modules and driving motors of the system, etc.

Control and communication system: the core is the embedded industrial control machine, responsible for controlling each module and collecting data related to the equipment. According to the function can be divided into three levels: perception layer, decision layer, execution layer.

1) Perceptual layer

The sensing layer of the device includes a visible light camera and a lidar sensor positioned at the four corners of the body. Environmental information is collected through the visible camera, identify road markings to realize path planning and correct the car body. The lidar at four corners of the body is used to monitor the road conditions around the body, and the brake system can be started in time when obstacles are found.

2) Decision layer

The device uses the instruction set computer namely RISC architecture embedded computer (hereinafter referred to as RISC in Reduced Instruction Set Computing) as the controller of "container AGV replacement vehicle". As the controller of "container agv replacement vehicle", the control device of various activities is the core of the whole device.

3) Execution layer

The execution layer is responsible for receiving various action instructions from the decision layer and performing corresponding operations, mainly composed of drive motor, controller, wheel, lifting cylinder, etc.

3. Operation Process of Container Agv Replacement Vehicle

3.1. Specification 1 Specific Application and Related Operation Procedures

1) The device can be applied to the railway-rolling-on transport scenario as shown in Figure 3.

The overall process is the mode of "container agv replacement vehicle" transport container into the roll-on ship instead of the traditional trailer loading container. Detailed process – "Container agv replacement car" reaches the specified position through the prelaid yellow ribbon as the guide path [4], and the rail rises and extends the rail end to the bottom of the container. The hydraulic lift column device at the bottom of the rail raises the rail to contact the bottom of the container, and moves the container to the body of the car. There is a drop judgment mechanism on the limit bracket connected to the control

system of the device. After the container is fixed, the rotating lifting rail platform can be reset independently and carry the container for short transportation. If you can carry containers into the roll-on ship, iron and water multimodal transport.

Figure 3. Schematic diagram of railway-roll-on combined transport mode

2) It can replaces the application of ordinary agv in automated terminals, multimodal transport stations and other scenarios, as shown in Figure 4.

Because the "container agv" with rotating lifting rail platform, through the movement of the container, can independently change the container in different vehicles, avoid the automatic terminal, multimodal station scenarios, container guide car waiting for gate crane lifting waiting time, can greatly improve the automatic terminal, multimodal station and other automatic operation efficiency, reduce the number of ordinary container guide car by about 40%.

Figure 4. Schematic diagram of automatic

3) It can be applied to the border change scenario as shown in Figure 5.

Due to the inconsistent rail standards of different countries, the goods need to be replaced at the border port replacement stations, and the goods will be lifted from the standard rail trains to the wide-rail trains. The entire rail process took hours. Trains from China to Europe now have to be replaced twice at border crossings. There are four solutions for the border change: the bottom; the bogie; the third rail on the track; the use of the rail base (still in the experimental stage). There are great restrictions, and they are difficult to popularize on a large scale.

After the "container agv replacement car" reaches the designated position, the guide rail rises, rotates and extends, extending one end of the guide rail to the bottom of the container. The hydraulic lifting column device at the bottom of the guide rail to contact the slider with the bottom of the container, and the other end extends to the railway flat car that needs to be replaced. By moving the slider to move the container along the guide rail to another rail plate truck, the guide rail drops to recover the replacement of the container between different gauge trains. A number of container AGV replacement vehicles can be operated at the same time. After completing the replacement of one container, they can be independently moved to the next position to continue the operation. The whole process is automatically controlled by the central control system, with no manual operation. It has the advantages of low cost, multiple containers at the same time, no large-scale transformation of the park, and greatly improves the efficiency of replacement.

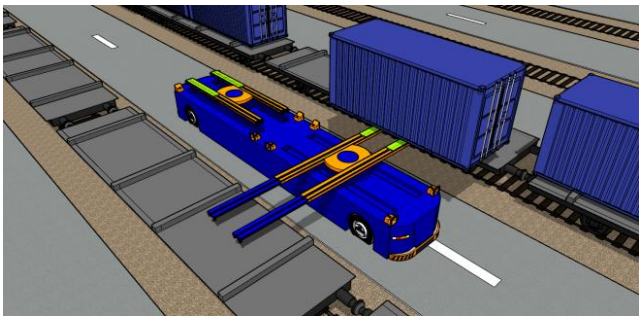

Figure 5. Schematic diagram of different gauge

3.2. Specification II Specific Application and Related Operation Procedures

A multimodal transport scenario applied to suspension and railway transport, as shown in Figure 6.

The "Container agv replacement" is used by prelaying a yellow guide belt as the guide path. After reaching the designated position, the guide rail rises and rotates and elongates, and the hydraulic lifting device at the bottom of the guide rail contacts the slider with the bottom of the container, and moves the container to the corresponding position through the slider movement. After the tractor moved to the "container agv replacement car" body, connect the trailer, hanging transport.

Figure 6. Schematic diagram of railway

4. Advantages of Container Agv Replacement Car

4.1. AGV Mode Advantage

1) Advanced nature: computer control operation. Compared with the form of manual forklift delivery materials, this mode has extremely high automation and

high positioning accuracy, which can accurately reach the designated location and complete the automatic replacement of the container, effectively reducing the labor intensity.

2) Reliability: Every step of the device operation is recorded with digital information, to some extent eliminating the influence of human factors and improving the accuracy of the operation. All the data of the operation is recorded in the database, which is conducive to data analysis and fully ensuring the accuracy of the vehicle replacement operation.

3) Flexibility: It can be organically combined with various production lines, delivery lines, platforms, etc., or compatible with other management systems. Reduce logistics turnover cycle with good compatibility and flexibility.

4) Uniqueness: It can replace artificial beings to play a unique role in some complex scenes. Relying on the computing power advantage of AGV dispatching information center can optimize the transportation path of AGV guide vehicle and reduce unnecessary resource waste. Relying on radio frequency identification (English full name: Radio Frequency Identification hereinafter referred to as: RFID), QR code and other related technologies can also realize the automatic upload of goods information, and realize the automatic operation and management.

5) Safety: control the replacement vehicle operation through the system, and greatly reduce the manual operation. Through the mutual cooperation of relevant control systems such as sensor system, line planning system, mechanical and electrical PLC logic control, vehicle scheduling and automatic obstacle avoidance system, the accuracy, flexibility, safety of container handling are greatly improved [5].

4.2. Unique Advantages of Container Agv Replacement Car

1) Realizes the efficient connection of roll-on transport- -railway transport mode

When the train loading container moves to a designated location, the r fid reader automatically recognizes the target object and obtains relevant data through the RF recognition signal, which can recognize high-speed moving objects and recognize multiple r fid tags at the same time. The system conducts vehicle scheduling according to the cargo information, the container agv replacement vehicle receiving the information is moved along the planning line to the designated container, and the information check is completed through rfid. After the information is accurate, the device carries the container along the guide rail and drives into the roll-on boat waiting for transport. After the ship reaches the designated position, the car automatically drives out of the ship, reaches the designated position to complete the relevant operation, and the operation is completed. The whole process is computer control, full automatic operation, intelligent and efficiency do not need the auxiliary support of other facilities and equipment, which greatly improves the operation efficiency.

2) Brings new solutions to the "border change" problem caused by different gauges

Due to the inconsistent gauge standards of different countries when entry and exit, China-Europe freight trains need to undergo at least two rail changes when heading to Europe, which greatly reduces the logistics operation efficiency. At present, the low operation efficiency of replacement equipment and the high cost of replacement equipment bring great obstacles to the development of multimodal transportation.

After the train loading goods reach the designated position (arranged in parallel with the train to be replaced), multiple container agv replacement vehicles arrive at the designated position, through the slider movement to move the container along the slide track to the train to be replaced, and complete the replacement process. This solution is more flexible, efficient and low cost compared to the current border replacement solution.

3) Is a brand new scheme to realize the joint suspension-railway transport

When the train loading container moves to a designated location, the rfid reader is used to automatically identify the target object and obtain the relevant data. The system conducts vehicle scheduling according to the cargo information, the container agv replacement vehicle receiving the information is moved along the planning line to the designated container, and the information check is completed through rfid. After the information is accurate, the device moves the container along the guide rail to the body, the tractor along the pedal to the device and connects the trailer to complete the replacement of the container in the train and hanging workshop. This mode reduces a large number of intermediate links compared with the traditional methods, realizing the efficient container connection between trains and tractors.

5. Conclusion

Under the context of trade globalization, China's continuous growth of international trade has put forward new requirements for the logistics industry. Container transport is a more advanced mode of transportation in the current cargo transport. Multiple combined transport can be carried out by various modes of transport. Therefore, it has been widely promoted and applied in the world, and towards the direction of large-scale, information, intelligent development. The application of this device can greatly improve the automation and intelligent level of multimodal and connection efficiency. The large-scale application of this equipment has very obvious advantages in energy consumption and economic benefits. It can reduce fuel consumption and transportation costs by 5% -10%, and greatly reduce carbon emissions. In response to the development requirements of China's green logistics, it can realize the intelligent and green leap of China's multimodal transportation.

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