Research on the operation flow of commercial automobile Ro-Ro terminal

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Abstract. This paper studies and designs the specific import operation flow and export operation flow of modern automobile Ro-Ro terminal, and summarizes the loading and unloading operation plan of commercial automobile Ro-Ro terminal. In addition, this paper puts forward the technical points for the safe implementation of the loading and unloading operation of the automobile Ro-Ro wharf from the three links of the loading operation before, during and after the loading operation, which provides reference for the actual operation of the Ro-Ro wharf.

1. Introduction

Roll-on-roll transportation, with its advantages of large batch, fast speed, flexibility, simple operation, low cost, and non-polluting, has occupied an increasing share in the global automotive logistics transportation. J.C. uaresma Dias analyzed relevant documents and cases, and concluded that the automobile roll-on-roll terminal can effectively reduce the friction and resistance of the automobile supply chain operation and reduce the time space of its operation [1]. Gao Haiyao combined the MAS technology with heuristic algorithms to study the way of making the yard plan of the yard operation system of the automobile Ro-Ro terminal [2]. On this basis, this article studies the Ro-Ro operation technology of commercial vehicles, which can just fill the gaps in related theoretical research and provide references for actual port operations.

2. Operation Process of Roll-on Roll-off Terminal

2.1. Operation process of the import of automobile ro-ro loading dock

Commercial vehicles are parked at the storage yard of the roll-on/roll-off wharf. After a short period of storage on the storage yard, they leave the storage yard and are delivered to consumers through the storage and transport vehicles, as shown in Figure 1.

![Figure 1. Operation flow of the import of automobile terminal](image-url)
(1) Import unloading plan: The dispatch room shall arrange the berthing of the ship according to the recent plan of the ship.
(2) Import and unloading: Real-time dispatching and organizing ship unloading according to the import and unloading plan.
(3) Yard work: Including moving and lifting. The main purpose of the moving operation is to improve the concentration degree of vehicles belonging to Ro-Ro ship in the yard, to grasp the operation dynamics of vehicles, and to better arrange the next loading and unloading operation.
(4) Exit operation: After the cargo owner goes to the vehicle customer service area for picking up according to the corresponding documents, the carrier will go to the rear of the depot to pick up the vehicle, the dock staff will load the vehicle to the carrier, and the carrier will exit through the crossing. Due to the limited space resources of the car loading dock yard, the operation of clearing port is carried out for the vehicles piled up over a certain period of time.

2.2. Operation process of automobile ro-ro terminal exit
Car manufacturers park their cars in the car loading dock, load them onto the Ro-Ro ship and leave the car loading dock, as shown in Figure 2.

![Figure 2. The export operation flow of the automobile terminal](image)

(1) Collecting port: The collecting port time is determined according to the shipping date of the ship. After handling all the export business documents, the owner makes the vehicles arrive at the operating area behind the port through the crossing of the loading port, and park them in the storage yard to wait for loading.
(2) Stowage on Ro-Ro ship: Stowaging the export vehicle according to the shipping date and the export preloading plan of the shipping company or the shipping agent, and getting the consent and signature of the ship's chief officer to prepare for loading.
(3) Export loading: The actual loading operation shall be directed by the dispatching room, and the vehicles shall be driven on Ro-Ro ships in shifts.

3. Loading and unloading production operation plan
In the process of commercial vehicles, the production and operation schemes can be divided into two categories according to the different waiting and parking places [3].

(1) Plan 1
In most cases, commercial vehicles are directly unloaded from Ro-Ro ships to wharf yards or driven into Ro-Ro cabins by wharves with limited frontage area or river wharves operated by barges. However, the route for commercial vehicles from the depot to the completion of positioning in the cabin is long and time-consuming, which leads to a long time for ships to dock and low turnover efficiency of ships, as shown in Figure 3.

![Figure 3. Production plan I for loading and unloading at the Ro-Ro terminal](image)
(2) Plan II

A temporary stacking area is set up at the wharf front, and the commercial vehicles are unloaded from the Ro-Ro ship to the wharf front and then moved to the stacking area to complete the unloading operation. On the contrary, when loading, commercial vehicles are first moved from the storage site to the wharf front, and then loaded from the wharf front to the Ro-Ro ship, as shown in Figure 4[4].

![Figure 4](image)

**Figure 4.** Production plan II for loading and unloading of Ro-Ro terminals

The advantage of this scheme over the previous scheme is that the work process of commercial vehicles from the yard to the front of the dock can be completed in advance, shortening the positioning operation route into the Ro-Ro cabin, reducing the time of ships in the port, and improving the efficiency of ship turnover, but it still cannot satisfy the demand for loading and unloading of high-volume commodity cars [5].

4. Loading and unloading process

The process of Ro-Ro loading and unloading of commercial vehicles can be divided into "one-step" and "step-by-step".

"One-step" means that a single operator completes all loading and unloading operations. As shown in Figure 5, the driver drives the car into the cargo bay from the cargo yard and locates at the specified position, or operates in reverse, that is, drives out of the cargo yard from the specified position and stops at the specified position. The driver commuted by car.

![Figure 5](image)

**Figure 5.** A schematic diagram of "one-step" loading and unloading process for commercial vehicles

"Step-by-step" can be divided into two steps, namely "barge" and "cabin positioning". As shown in Figure 6, "barge" drivers drive the commercial vehicles into the cabin from the dock cargo yard parking area or drive out from the cabin to the dock cargo yard parking area, and the barge drivers take the transportation vehicles back. "In-cabin positioning" is operated by special positioning pilots. "Step by step" divides the division of loading and unloading operators into barge drivers and positioning drivers, which reduces the difficulty of operation and improves the level of safe production.
4.1. Before shipment

The port side organizes a pre-ship meeting to coordinate and arrange shipment matters; the single-ship instructor assigns the operation content to the operation team according to the operation plan, and organizes the operation team to hold a pre-springboard meeting before the start of construction.

The specific method is to check the lowered height of the springboard of the Ro-Ro ship, and confirm that the landing front of the springboard of the ship has been covered with rubber mats to prevent the head and bottom of the commercial vehicle from being damaged by the springboard bounce; use traffic cones to close the operation area as necessary; Prepare batteries, battery cables, fuel, ferry boards, signal flags (lights) and other operating supplies (spare parts); arrange walking routes in the cabin, and all operators and traffic vehicles conduct trial runs to clarify the operating routes of the operators, Reduce the disorder and randomness of operation, and improve safety; place traffic cones in dangerous areas such as ramps, corners, and columns in the cabin and confirm the height of the cabin to help operators, especially short barge and positioning drivers, to operate clearly Difficult areas to improve work safety.

4.2. In the loading operation

4.2.1. Short refueling link. The short barge link can be divided into the starting link of the vehicle storage yard, the driving link from the storage yard to the cabin, and the parking link inside the cabin.

First, the starting link includes the driver's confirmation of the loading vehicle type, port of destination and other basic information. Before starting the commercial vehicle in the yard, it should be checked around the vehicle first, and the vehicle can only be started after confirming that there is no vehicle damage. If there is any vehicle damage, the vehicle can only be started after reporting to the yard staff for confirmation and registration.

The second is the driving link from the storage yard to the temporary parking area in the cabin: follow the driving route confirmed before the start of loading and unloading operations, and generally require the driving speed of the road in the port to be below 35km/h; the driving speed in the cabin and the storage yard is usually controlled Below 20km/h, when turning or passing a springboard, the vehicle speed is controlled below 5km/h. When the vehicle speed is 20kmh, the distance between the front and rear vehicles should be kept at about 15m (different Ro-Ro terminals have slightly different requirements for speed limit and safety distance). It should be noted that generally only one vehicle is allowed to pass on the same ramp, and other vehicles should wait for the signal to pass at the passageway. In the event of parking or traffic jams, a safe distance of 1.5 times the length of the body must be maintained, and it is not possible to stop in the ramp. It is generally not allowed to stop during driving. If the shuttle driver has to stop for some reasons, he should turn on the double jump lights and drive off the road; if he cannot continue driving due to lack of fuel or malfunction, he should turn on the double jump lights and direct others When the vehicle detours, if safety is ensured, notify the operation team leader or single boat instructor to take emergency measures. When driving in the cabin, vehicles are prohibited from passing over the lashing straps or other objects on the deck. The details are shown in Table I.
**Table 1.** The corresponding table of speed and safety distance in commercial vehicle roll-on roll-off operation

|                  | 5km/h | 20 km/h | 30 km/h | 40 km/h |
|------------------|-------|---------|---------|---------|
| **Short walking distance** | 2m    | 6m      | 8m      | 11m     |
| **Braking distance**      | 1m    | 3m      | 6m      | 11m     |
| **The space between two**  | 1.5 times the conductor | 15m  | 20m   | 25m     |

Third, the parking link in the cabin: After the shuttle driver arrives at the temporary parking area, he will stop slowly according to the prescribed order according to the instructions of the positioning driver (if reversing is required, a guide must be instructed). When getting off the car, pay attention to avoid colliding with surrounding obstacles when opening the door, and pay attention not to touch the door trim with your feet. After leaving the vehicle, return to the traffic vehicle from the safe path, or wait for the traffic vehicle in a safe area beside the cabin that does not affect the positioning operation.

4.2.2. **Positioning.** The first is starting the car in the cabin. The driver should confirm the destination port and stowage position in advance, confirm the direction of the front door and the wheel, open the door, get on the car, start the car in the prescribed order, release the brake according to the direction of the positioning signal officer, start the car slowly, and forbid sudden acceleration and steering.

The second is the positioning in the cabin. Different types of vehicles use different positioning methods. One is a three-step positioning method for cars, small buses, pickup trucks and other small vehicles, the other is the direct positioning method for buses, trucks, special machinery and other vehicles that cannot be turned around in the cabin without power steering.

Among them, the three-step positioning method requires the positioning signalman to stand behind/in front of the passenger compartment of the vehicle to be positioned and instruct the vehicle to back/forward. After the rear/front of the vehicle reaches the positioning position, the driver is then instructed to adjust the steering wheel and back/forward. After the body is fully restored, instruct the driver to straighten the steering wheel. Shuttle positioning). The positioning signalman then stands behind the cab at the reserved position of the vehicle and instructs the vehicle to back/forward to fully reach the positioning position and complete the positioning operation. Special attention should be paid to the three-step positioning method: vehicle movement and steering wheel rotation operations cannot be performed at the same time. The direct positioning method is to realize the positioning of the vehicle according to the direction of the positioning signalman during the reversing positioning process of the driver. The vehicle should be directly in front of the positioning position before entering the positioning position. When the rear view is poor, a positioning signal officer should be added to the front of the vehicle to guide the vehicle with the rear signal officer. Regardless of the positioning method, the positioning operation vehicle speed is generally required to not exceed 5km/h.

The third is the parking link after positioning. The positioning driver should stop according to the prescribed operation sequence. The positioning driver should prevent his feet from touching the interior decoration of the door when getting off. After leaving the cockpit, the original protective equipment (such as the car clothes) should be restored. The positioning signalman confirms that the car keys (generally placed in the ashtray) and gear are properly positioned. After the brake is locked, close the door.

Regarding positioning and parking, it should be noted that when the vehicle is positioned and parked on a ramp, triangle skids should be placed under the tires at the lower end of the ramp after the vehicle is parked and braked; the ramp should give priority to parking automatic vehicles. To locate the driver in the cabin, ensure a reasonable distance between the car and the workshop. The specific parking distance requirements are shown in Table II.
Table 2. Parking distance requirements for positioning parking of commercial vehicles in the cabin

| project                     | location                                             | Distance requirements         |
|-----------------------------|------------------------------------------------------|------------------------------|
| Left and right of each vehicle | Between the doors                                   | 10 cm or more                |
|                             | Between the door and the hull structure             | 10 cm or more                |
|                             | Between the side of the steering wheel and the hull structure | 30 cm or more               |
| The front and rear of each vehicle | Between the bumper                                 | 30 cm or more                |
|                             | Between the bumper and the hull                      | 30 cm or more                |
|                             | Wide door opening                                   | 30 cm or more                |
|                             | Inside the cabin, near the stairway, etc            | 50 cm by 50 cm or more        |
|                             | Around the fire apparatus                           | Space within the reach of personnel |
|                             | Around the ship's working vehicles                  | Do not interfere with the operating space |
|                             | Around large vehicles                                | The space required for binding |

4.2.3. Binding and fastening. Due to its high freeboard and large wind-borne surface, the roll-on/roll-off ship is prone to sway during sea navigation. In order to prevent the vehicles stowed in the cabin from moving due to hull sway and thus causing vehicle damage due to vehicle collision, it is necessary to effectively bind and fix the loaded vehicles. Binding and fastening should be able to choose reasonable area, appropriate fastening device, equipment under the premise of scientific and effective method to fasten the vehicle, to prevent its movement due to external forces, at the same time, should strive to operate simple, safe and effective.

To ensure the effectiveness of binding, the binding system should meet the following requirements: First, the binding system should comply with international conventions, regulations, classification society norms, and relevant regulations of the competent authorities, such as IMO Safe Operation Rules for Stowage and Binding (CSS Rules); Secondly, in the design stage, the movement risk of the ship fitting vehicle is evaluated. A mathematical model is established to simulate the main working conditions of the ship, analyze the strength and stability of the binding system, and improve the design accuracy according to the data of the size, physical characteristics, position and stowage of the roll-on/roll-on vehicle, voyage climate and sea conditions. Finally, practical experience in binding should be fully considered. For example, typical binding failure cases such as structural failure and binding failure caused by unreasonable binding site layout.

4.3. After shipment
After loading, the main work is to restore and clean the work site and collect and store the work supplies at the wharf. For example, the excess binding materials on the passage after vehicle binding and fixation should be cleaned in time and placed and fixed on the side of the bulkhead or the side of the passage, which will not affect the loading and unloading position of vehicles. Battery, battery line, fuel oil, ferry board, signal flags (lights) and other operating supplies shall be taken back to the dock.

5. Conclusion
In this paper, the important node in the whole vehicle logistics is the research object of the Ro-Ro terminal, sorting out the operation process of the Ro-Ro terminal, summarizing the loading and unloading production plan, and focusing on the core links involved in the loading and unloading process. The terminal provides a scientific and efficient way of loading and unloading.
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