Design of car carrier robot for stereoscopic garage based on TRIZ1141

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Abstract. Car carrier robot can effectively solve the city parking problem, and the core technology of stereo garage is the car carrier. The realizing form of car carrier comprising a loading plate type, fork comb type, clamping tire type. Clamping tire type can realize the automatic adjustment and handling the car by clamping arm’s clamping and lifting car tires, which is high efficiency for car accession. But the existing clamping tire type carrier implementation method is complicated and hard to use. Based on the TRIZ innovation theory, this paper puts forward a new scheme for tire clamp type carrier. The shoes is used to realize the clamping and lifting movement of the driving wheel, and then the vehicle can be carried into the appointed position. The new scheme is simple and easy to realize, and it also improves the transportation efficiency of the car.

1. Introduction

In recent years, as Chinese rapid development of urban economy and the automobile industry, parking are increasing contradictions between the environment and urban planning. Automated stereo garage has become effective important way to solve the problem of urban parking. The core technology of garage is car carrier robot. Car carrier robot can take out the parking car from garage to the lifting platform automatically, then deposit it to the corresponding parking position. Taking the car process is a reverse process.

The current car carrier robot is summarized as the following three types: the loading plate type, fork comb type, clamping tire type [1-3]. Car loading plate type robot is implemented for the car parked on the plate, through plate’s translation the car is promoted and carried into the parking space. This type has simple structure, but in the process of accessing cars the plate is needed as a media, which reduces the access efficiency and increases the complexity and cost of equipment.

Fork comb type through interleave between the comb fork and the comb fork fixed on car load platforms to lift and transport cars s to parking. In parking Spaces the fork is exchanged with the fixed comb on it to put the car into the parking space. The taking process action is a reverse process. Comparing with loading plate type, the fork comb type is no need to follow the car except operating the car that can improve the equipment utility efficiency. But the fork comb type has many disadvantages, the fork belongs to unilateral support beam, the demands for the strength and stiffness
of the fork is high, the fork comb positioning accuracy is harder to achieve, the garage space utilization rate is low due to the car need to be lifted with a certain height before operation [4, 5].

Clamping tire type is a relatively ideal stereo garage handling robot. It lifts and clamps the four tires by clamping arms stretch. A couple of arms clamp and lift a tire. After finishing the work, the lifting arms is retracted to the initial location to let the robot leave the car. Clamping and lifting motion can be driven by hydraulic drive and mechanical drive, etc. It can realize automatic adjustment and handling capabilities, but it also has some faults, the body is longer, the number of arms is more, the structure is more complicated [6, 7].

TRIZ as an invention problem solving theory, has nine big classical theory systems. Shandong Jianzhu University Institute of TRIZ concludes TRIZ theory to TRIZ1141 system (a law, a kind of ideal, four class models, an algorithm), provides the specific methods and tools to solve the problem of the invention. Based on TRIZ1141 design theory, the paper designs a new type of car carrier robot to improve efficiency of handling and simplify the structure [8].

1. Car frame 2. The front fork combs 3. The back fork combs 4. Lifting mechanism

**Figure. 1** Fork comb type

1. The first car body 2. The second car body 3. The arm’s initial location 4. The arm’s stretch location

**Figure. 2** Arm clamping tire type

2. **Car carrier robot based on TRIZ1141 innovation analysis**

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2.1. **Determine the ideal final resolve**

One innovative design must first determine the ideal final resolve (IFR), Solution steps is as follows:

1) The first step: The purpose of design is? Cars is carried from the entrance to the garage.

2) The second step: What is the ideal solution? Car carrier lifts tire and realizes handling.
3) The third step: What obstacles to achieve ideal solution? Car operating time is long and handling needs large space.

4) The forth step: How to make the obstacles disappear? Narrow the size of Car carrier robot and compact the structure.

By analyzing the ideal final resolve, the design of the existing car carrier robot can basically meet the basic requirements and potential demand, but there is room for improvement.

2.2. Innovative design based on TRIZ

Under the guidance of TRIZ, design is improved on the basis of the current fork comb type and arm clamp tire type car carrier robot.

A law (technical system evolution theory) can indicate the direction and way of design. Fork comb type car carrier robot lifts wheels and transports car by fork. The advantage is simple and reliable. The disadvantage is that the requirement for comb the fork strength, stiffness and positioning accuracy is very high, that increases the processing cost. In the other way car carrier robot’s fork comb need to exchange with fork comb on loading platform to pick up car, which increases the height of the garage. According to cutting evolution route, fork comb and car loading platform can be deleted to reduce the manufacturing cost. According to the structure of the merger evolution route, the same multiple system can reduce the number of functions, and even merge into a single system. Handling four tires can be changed only handling the two driving wheels of the car, then the other two passive drive wheels can cooperate with car carrier robot, which narrows the volume handling robot. Through technical evolution theory instruction, the design direction of the car carrier robot is no fork comb and carrying two driving wheels, but the concrete solution still need to study.

Through TRIZ, four technical contradictions and class model in invention principle, the clamping mechanism of clamp tire style car carrier robot needs to be improved. First of all, conflict is analysed with clamp tire style. During the process of arm clamping the tire, the two arms need to reverse direction to holding the tire. Four tires need eight arms, so the number of arms is large. Furthermore, the arm’s strength and stiffness is poor due to the cantilever structure. Determine the technology conflict for clamp tire type car carrier robot is:

- **①** Improve parameters: the number of arms.
- **②** Deterioration parameters: the stiffness and strength of arms.

After the opposing sides of the definite technical conflict are determined, they can be converted into standard problem of TRIZ, and then the task is to find the contradiction matrix to resolve the conflict in a group of invention principle, such as the separation principle. Separation principle isolates useful or harmful part from the whole system. Arms holding and lifting the wheel is useful parts. Arms lever structure’s poor stiffness and strength are harmful parts. The technical conflict can be solved that arm structure can be changed to the shoe type structure and the arm’s rotary motion can be changed into stretching of shoe type structure.

Through the guidance of TRIZ, the car carrier robot design is improved based on fork comb style and clamp tire style. The Innovative solutions is shoe clamping driven wheel style.

3. Design for car carrier robot

3.1. Mechanism design

The shoe clamping driven wheel style’s mechanism principle is shown in Figure 3. The new car carrier robot concludes stretching mechanism and clamping mechanism. Stretching mechanism concludes arm I, sliding block and arm II. The end of the arm is design into the shape of shoes with inside lower. Arm I and arm II connect the sliding block with sliding pair and can finish reverse movement with same speed inside the sliding block. Clamping mechanism concludes Sliding block and fixed arm. Sliding block extension part connect the fixed arm with sliding pair. Fixed arm can move along the sliding block extension part. The mechanism working process is shown in Figure 4.
1) Car carrier robot is driven into the bottom of the car from the back. Two fixed arms is aligned at the back of rear wheel.

2) The arm I and arm II is stretched and aligned at the front of rear wheel.

3) The fixed arm is slid along the sliding block. The shoes at the end of the arms clamp the rear wheel. The rear wheel along the shoe's arc groove climbs up the arms.

4) Car is driven by car carrier robot into the designated parking Spaces. Taking action is contrary to parking action.

3.2. Structure design

The sliding pair between arm and sliding block can be realized by gear-rack drive. The end of the arm is design into the shape of shoes. Small roller can be used in the shoes to reduce friction. Car carrier robot can move through the installed walking wheel under the chassis below. The 3D model three-dimensional model is shown in Figure 5.

![Figure 3](image)

**Figure 3** The principle diagram of the mechanism

![Figure 4](image)

**Figure 4** The schematic diagram of mechanism working process
4. Conclusion
The paper proposes a new type of car carrier robot about shoe clamping driven wheel. It uses front arm and fixed arm to clamp the rear wheels to realize lift. The end of the arm is designed into the shape of shoe. This design structure is easy to implement and can improve the efficiency of car parking.

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