Research on innovative design of vehicle loading plate for non avoidance stereo garage based on ARIZ

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Abstract—As a form of garage with simple structure and convenient installation, non avoidance stereo garage is widely used in densely populated places such as shopping malls and hospitals. It can effectively improve the land utilization rate in a narrow space, which is of great significance to solve the parking problem. In this paper, the ARIZ algorithm of TRIZ is used to deeply study the car loading plate of non avoidance stereo garage in the market, and analyze the shortcomings of its existing structure. According to the process of ARIZ algorithm solving the problem, the nonstandard problem is transformed into a simple problem model, and the ideal solution is conceived. Using the conflict matrix and 40 invention principles, a new type of vehicle loading plate for non avoidance stereo garage is designed Vehicle loading plate structure.

1. Introduction
Now the economic development situation is getting better and better, the people's living standard has also been greatly improved, the private car in the family has become an indispensable part of every household. With the increase of the number of cars, the traffic jam and the sharp shortage of parking spaces are always bothering the car owners. Parking difficulty is an important problem in static traffic. Static traffic occupies an indispensable position in the whole traffic system, and parking space is a necessary part of static traffic [1]. It is a recognized fact that stereo garage has the function of improving and solving parking difficulties. In the future development trend, it will gradually replace the parking lot in the static traffic system. No avoidance three-dimensional garage means that the upper and lower parking spaces do not interfere with each other when working, while the upper parking space is in operation, the lower parking space does not need to avoid [2]. Among them, the realization of non avoidance function needs the assistance of lifting mechanism, translation mechanism and rotating mechanism. When this kind of garage is working, the driver will drive the car to the vehicle loading plate, through the rotation of the loading plate and the lifting mechanism, and finally park the car in the designated position through the translation mechanism. As an important part of the non avoidance three-dimensional garage, the weight of the loading plate will affect the safety of the whole garage and the working efficiency of the lifting mechanism [3].

2. Introduction to Ariz
TRIZ is a knowledge-based and human oriented systematic methodology for solving invention problems. It is a basic method to solve invention problems extracted from 2.5 million outstanding patents by the team headed by Soviet engineer and scientist G.S. Altshuller [4]. An important step for
TRIZ to solve the problem is to transform a fuzzy original problem into a standard problem. The clearer the description of the problem is, and the more standardized the problem is, the better it will be.

TRIZ contains many systematic, scientific and operable creative thinking methods and analytical methods and solving tools for invention problems. But in the actual project, especially in the case of complex problems, the selection and use order of these tools are often difficult. ARIZ is a set of continuous process program to solve problems. It integrates most tools in TRIZ theory, including ideal solution, technical contradiction theory, physical contradiction theory, material field analysis and standard solution, effect knowledge base, and establishes a complete process from problem analysis to problem solving [5,6,7].

3. Using ARIZ algorithm to solve the contradiction problem of vehicle loading plate in non-avoidance stereo garage

When the upper parking space of the double-layer stereo garage without avoidance can access the car, it is necessary to first move the whole vehicle platform out through the translation mechanism, and then lift the whole frame down through the lifting mechanism. Finally, the rotating mechanism drives the car carrier to rotate, making it convenient for the driver to drive the car to the vehicle loading plate. In order to facilitate the car to drive to the vehicle loading plate, the loading plate should be as low as possible. However, if the loading plate is too low, it will affect the work of the rotating mechanism, resulting in friction between the carrier plate and the vehicle platform. The fixed load plate needs to ensure sufficient stiffness to avoid friction with the vehicle platform due to deformation. However, the weight of the loading plate should be as small as possible, because it will affect the efficiency of the lifting mechanism, resulting in the upper parking space can not meet the parking weight of less than 1.5 tons of vehicles. This paper intends to design a new type of car loading plate for non-avoidance three-dimensional garage. The current problem to be solved is how to ensure that the specified weight of the car can be parked on the basis of reducing the weight of the loading plate as much as possible.

The ARIZ algorithm is used to solve the contradiction problem of the vehicle loading plate of the three-dimensional garage without avoiding collision. The specific steps are shown in Fig. 1:

Figure. 1 Ariz application flow chart

Preparation: collect information about the system where the problem is located.
1) Objectives that must be met to solve problems.
   a) The load plate should be as small as possible in weight.
   b) It can meet the function of carrying the specified type of vehicle (less than 1.5 tons).
2) Which parameters cannot be changed in solving the problem.
   a) The deformation of the loading plate is less than 10 mm.
   b) The load capacity is more than 1.5T.
   c) The weight of the carriage plate is less than 300kg.
3) Consider the initial problem and replace the problem solving method.
   Alternative method: change the original material of vehicle carrier plate, which will increase the
   cost, so other high strength materials are not used.
4) Choose the most promising way to achieve the goal between the initial problem and the
   replacement problem. Since there are many forms of vehicle carrier plate in the market, a new vehicle
   carrier plate is designed based on the existing technology.
5) Search for patents to define issues more clearly.
   Refer to the domestic and foreign patents related to the car loading plate of stereo garage, establish
   the corresponding patent database and analyze the patent.
6) Application of parameter (size, time, cost) operator.
   a) The size of the loading plate is greatly increased: it can meet the load requirements, but it will
      increase the weight of the plate.
   b) The size of the loading plate is greatly reduced: it can meet the requirements of weight
      reduction, but can not meet the requirements of load-bearing.

   Step 1: problem analysis and expression.
   1) Analyze the problem.
   At present, the splicing wave plate is often used to solve the problem of weight reduction of vehicle
   carrier plate in the market, as shown in Fig. 2. This kind of vehicle carrier plate is assembled by wave
   plates of several standard units, which has the advantages of simple processing and wide application
   range. This kind of carriage plate is not suitable for the carriage plate with rotation function, because
   its space does not allow the installation of rotating mechanism.

   Figure. 2 Plate wave

   2) State the minimum problem.
   ARIZ first uses the simple resources in the system to realize the ideal solution, so it defines the
   "minimum problem" to express the initial problem, which requires that the defined problem does not
   introduce new resources and does not increase the complexity of the system.
   "Minimum problem": through the minimum improvement of the system, the weight of the loading
   plate is as small as possible, and the load requirements are met.
3) Construction of technical contradiction.
   Technical contradiction 1 (TC-1): if the "car carrier plate adopts larger profile", then "it can easily
   carry the car", but "the weight of the car carrier itself will become larger".
   Technical contradiction 2 (TC-2): if the "carriage plate adopts smaller profile", then "it can reduce
   the weight of the carriage plate", but "it will not be able to carry the car".
   Among these two groups of contradictions, TC-2 can better describe the problem, so TC-2 is
   selected to solve the technical contradiction.
Step 2: Analysis problem model.
1) Action area: carrier plate frame and cover plate.
2) Action time: when the loading plate is working (i.e. storage / retrieval process).
3) External resources: turntable mechanism.

Step 3: Determination of ideal solution and physical contradiction.
1) The final ideal solution: to change the original car carrier plate, we should not only ensure the design advantages of the original structure, but also can not increase the complexity of design and manufacturing, and reduce the cost.
2) The macroscopic physical contradiction description is established: the load-carrying plate should not only realize the load function, but also ensure the required strength.
3) The description of microcosmic physical contradiction is established: optimizing the weight of the loading plate without increasing the manufacturing difficulty.
4) 39 general engineering parameters and 40 invention principles are used to solve the conflict.
   The No.40 composite principle, No.26 replication principle, No.27 cheap substitute principle and No.1 segmentation principle can be obtained by using the conflict matrix table. After the previous analysis, the No.40 composite material principle is excluded, and only the No.26 replication principle, No.27 cheap substitute principle and No.1 segmentation principle are used to optimize the design.
   Under the Enlightenment of No.26 replication principle and No.27 cheap substitute principle, the traditional internal structure of car carrier plate designed with channel steel as frame is changed to a new net format vehicle carrier plate internal structure welded by thin steel plate, as shown in Fig. 3. In addition, the original two side section steel main reinforcement is replaced by several small thin plates with low weight, which greatly reduces its own weight.

Figure. 3 Structure diagram of light weight design of car carrier plate I

Under the Enlightenment of No.1 segmentation principle, the original upper panel is divided into three parts, namely, the part that needs to bear the tire on both sides and the middle connecting part. 3mm thick checkered steel plate is used on both sides of concentrated stress, and 1mm thick checkered steel plate is used in the middle part with small force and large area, as shown in Fig. 4. This design can not only ensure the original strength, but also greatly reduce the weight.
In order to ensure the integrity of the vehicle carrier plate, during processing, only slots are cut out at the splicing position of the internal transverse rib plate. After the transverse and longitudinal rib plates are assembled into a whole, they are welded and fixed, and then the upper and lower cover plates of the vehicle carrier plate are successively welded on the upper and lower sides of the main frame. The welding schematic diagram of the loading car plate and the main frame is shown in Fig. 5.

**Step 4: Evaluation of principle solution.**

1) The Principle solution check: the design of the above scheme reduces the weight of the vehicle loading plate to the greatest extent, and ensures the rigidity of the vehicle loading plate. The solution has been able to solve the technical problems.

2) Preliminary evaluation of the solution: the new scheme ensures that the load plate does not exceed the limited weight and ensures the corresponding stiffness requirements; the new scheme solves the two contradictory objectives of large stiffness and small weight of the vehicle carrier plate; the scheme is simple in processing, and the raw materials are relatively common, which is easy to purchase, with better structure and easy realization.

**Step 5: Evaluation of improvement plan.**

The ARIZ algorithm is used to get the design scheme of the vehicle loading plate. Under the premise of reducing the overall weight of the vehicle carrier plate, the vehicle with greater bearing mass is realized. The improved scheme not only improves the overall stiffness of the vehicle carrier plate, solves the problem of large deformation, but also reduces the production cost. The peripheral design can be carried out around the solution.

4. Conclusions

In this paper, through the in-depth study of the car loading plate of the non avoidance stereo garage, the existing problems are found, and then the Ariz algorithm is used to solve the contradiction problem of the vehicle loading plate of the non avoidance three-dimensional garage. According to the
Enlightenment of 40 invention principles in TRIZ, the corresponding improvement scheme is proposed, and its rationality is analyzed, and the final solution is obtained.

REFERENCES
[1] Q. Weng, L. Lu, “Overview of the status and development of stereo garages at home and abroad,” Logistics engineering and management, vol. 7, pp. 159-161, 2016.
[2] W. Gong, “China’s mechanical parking equipment industry standard system,” Machinery Industry Standardization & Quality, vol. 2, pp. 15-18, 2014.
[3] J. Jang, W. Dong, Z. Zhao, “The optimal design of the rear cantilever stereo garage vehicle board,” Lifting and transporting machinery, vol. 2, pp. 19-23, 2016.
[4] S. Daniel, C. Chuan, “The 7 pillars of TRIZ philosophies,” Computers & Industrial Engineering, 2020.
[5] W. Chen, J. Chen, “Eco-innovation by Integrating Biomimetic Design and ARIZ,” Procedia CIRP, pp. 401-406, 2014.
[6] V. Fey, E. Rivin, “Algorithm for inventive problem solving (ARIZ),” Innovation on Demand, pp. 82-111, 2018.
[7] J. Hyun, C. Park, “The Butterfly Algorithm Eliminating the Brute-Force Mechanism in ARIZ for Contradiction Problem Solving,” 2015 8th International Conference on Security Technology (SecTech), 2015.