Design of a Balancing Module for Easy Bicycle Parking Operation

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Abstract

Bicycle rack is a key device of the bicycle network and it provides essentially secure parking for people used as a means of transport. This paper introduces a new mechanism for easy bicycle parking operation by a balance weight module which allow users to park their bicycles with a small effort. The first part discusses how to clamp the bicycle when it's parked on the rack. The later part of the paper introduces how to make parking operation easier.

Keywords

Bicycle parking, Parking rack, Mechanical design.

1. Introduction

Bicycle sharing service stimulates the growing use of bicycle in China, which makes bicycle parking become more and more important[1,2]. For one thing, provision of bicycle parking is necessary to support bicycle as a practical transport choice for people that are expected to travel to and from any new development. For another, a lack of enough parking facilities generates one of the problems that riders park their cycles at random and this results in congestion in public areas.

How to park bicycles safely and orderly in the limited public space is a problem that needs to be solved in urban planning. Generally, current parking facilities are based on three design principles, which are fit for purpose, well located and secure. For instance, most common and simple design is the Sheffield type stand, shown in Fig.1[3]. This type of design as tubular stand provides a robust and cost-effective solution since two bikes can be parked on one stand.

Other designs like shelters or cages offer bicycles to be parked for a significant time with security by means of lockers or having lockable door, shown in Fig.2[4].

For high volume of bicycles to be stored, tubular stands and shelters normally need more space to park. Two-tier rack gives good example of high capacity cycle parking for tackling the issues of space constraints, increasing the capacity by storing cycles above (as Fig. 3). However, some users find it difficult to operate, especially for the older and children when they intend to park the cycles on the high-level rack.

So this paper is aimed to design and introduce a new mechanism for easy parking and operation in the two-tier rack parking. Although there are already related products with labor-saving operation functions on the market, most of them use assistance mechanism, like gas assisted, required additional power support [5]. And additional power source may need another installation and maintenance.

Fig. 1 Sheffield type stand

Fig.2 Shelters for bicycle parking

Fig. 3 Two-tier rack

2. Rack Design and Its Clamping mechanism

2.1 Rack Design

The paper uses a general household bicycle as the research object to design a double-layer parking rack. The basic size of the selected model bicycle is 1800mm×650mm×1100mm, and the bicycle weight is 13kg. The length of the parking rack is designed according to the length of the bicycles parked on it, which is designed to be 1800mm. The height of the vertical column between the upper and lower rack is designed to be 1300mm.

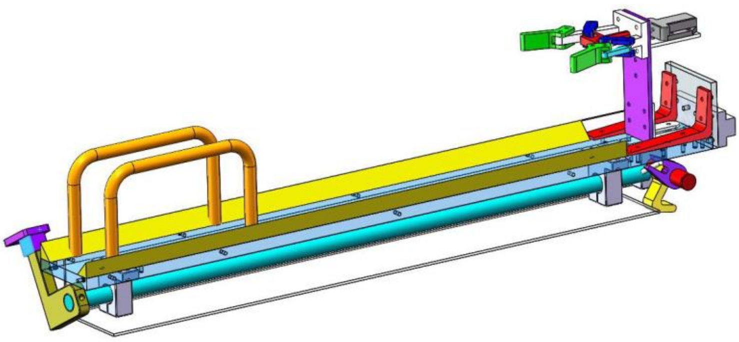
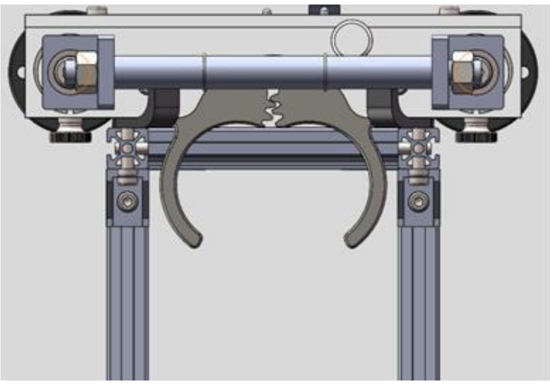


Fig. 4 3D CAD model of Rack

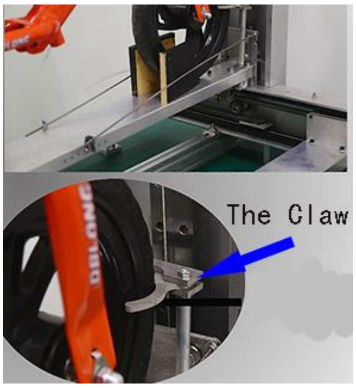
There is also a rear bumper at the end of the parking rack, which can block the rear wheel of the upper parking bicycle, preventing it from moving left and right and backward. The size of the left and right baffles at the front end of the parking rack is designed according to 2/3 of the diameter of the bicycle tire. According to actual measurement, the diameter of the bicycle tire is 660mm. The width of the upper and lower parking racks is designed according to the width of the bicycle tire. In addition, The width of the bicycle tire is about 50 mm, so the width of the parking rack is designed to be 60 mm. Based on the information listed above, the rack is modeled as Fig. 4.

2.2 Clamping Mechanism Design

Careful consideration like security should be given to design two-tier rack.The claw is one of the most important parts for clamping mechanism. Its movement is mainly through a groove in the claw, and a stepped pin cooperates with the groove to loosen and lock the claw. A rebounding pin is far away from the claw in the initial position. When the bicycle is pushed into the claw, the claw pushes the rebounding pin to the locking pin of the slider platform to lock the bicycle tire, as shown in Fig. 5.



(a) CAD model of Clamping Mechanism



(b) Experiment of Clamping mechanism

Fig. 5 Clamping Mechanism Design

3. Balancing Module Deisgn

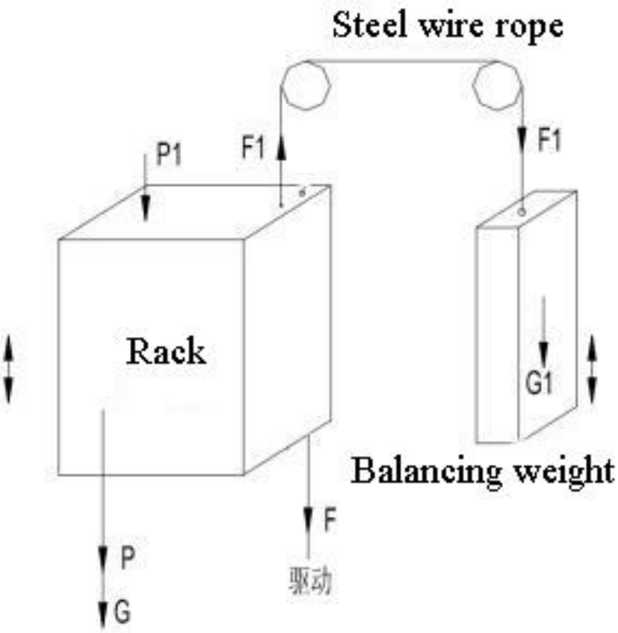


Fig. 6 Schematic Diagram of Balancing Module

Where G—the weight of the parking frame (N); G_1—counterweight weight (N); P—theoretical external load (N); P_1—actual applied load (N); F_1—The actual load carried by the counterweight wire rope (N); F—The necessary driving force (N)

The lifting drive of the upper parking rack adopts counterweight and manual drive mode without additional power source. The counterweight and manual traction are arranged at both ends of the lifting platform. The counterweight system is directly connected to the main body of the parking frame through a wire rope, and the parking rack can move up and down with only a small amount of assistance force during the lifting process. During the movement of the parking rack, the force direction of the driving force F alternates between up and down, and the change will depend on the magnitude of the applied dynamic load.

During the realization of the parking rack scheme, the parking rack system can be simplified to a single-sided counterweight for consideration, as shown in Fig. 6.

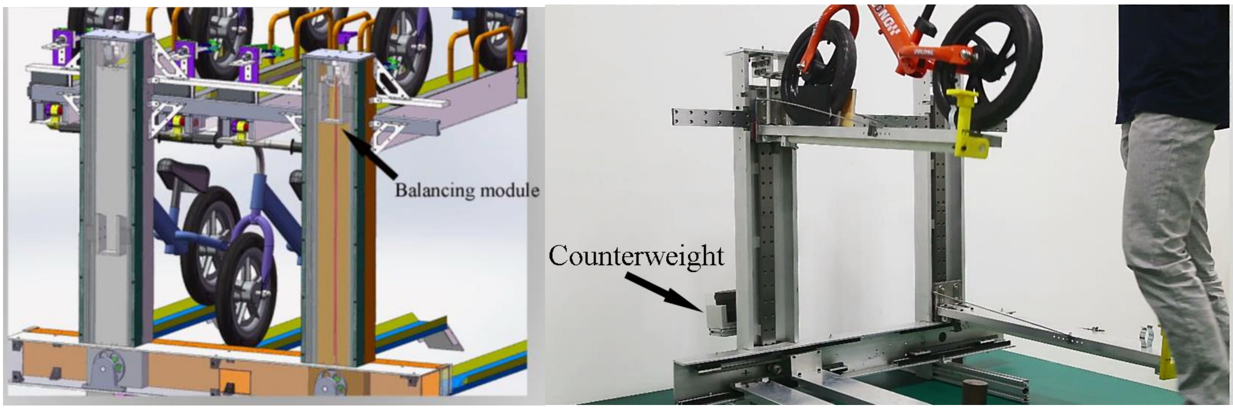
In Fig. 6, P is the theoretical maximum external load that can be applied to the parking rack. When calculating the weight of the counterweight G1, P and G are the main considerations. In the actual movement of the parking rack, the self-weight G of the rack remains basically unchanged, and the actual external load P1 will vary. But it is not greater than the maximum bicycle weight PLUS the self-weight of the parking frame. However it may be empty (P1 is 0). So we define G1 as the following equition.

$$G_1 = G + P/2 \qquad (1)$$

When P1=P/2 and the parking rack is at a stationary state, the parking rack will move along the load direction and the required driving force is the smallest. When P1=0, G1>G+P1, the counterweight wire rope is the active rope, the direction of driving force F as upward. In theory, the automatic upward movement can be realized by simply releasing the parking rack.

Conversely, when the lifting platform needs to be lowered, the driving force that needs to be applied will be greater than P/2. After calculation, the weight of the parking rack is 4.58kg. Currently, the weight of bicycles on the market is about 15Kg. Therefore, the weight of our counterweight G1 is 18Kg. The weight of the heavy block is slightly less than the total weight of the bicycle and the parking rack. It needs assistance force from people when it rises, and it relies on the weight of the bicycle when it falls.

The CAD model of balancing module and the physical tests are shown in Fig. 7.



(a) CAD Model of Balancing Module (b) Physical Test of Balancing Module

Fig. 7 Balancing Module Design

4. Conclusion

This paper discusses a novel two-tier rack with balancing module that allows cyclists park their cycles on the upper level rack using just small effort. And this novel rack is pure mechanical structure without any power source which means no need any additional maintenance for assistant mechanism. And this balancing module is also simple with just a counterweight and synchronous belt to lift the rack up and down.

Acknowledgements

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