Automatic sorting car design

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Short Abstract: As intelligent logistics is the development direction of contemporary logistics, the problems of high degree of non-intelligibility and immature traditional logistics terminals is what we need to solve. This paper puts forward the idea of an automatic sorting express delivery car, builds an automatic sorting container, analyzes the steering system, designs the frame and chassis structure, analyzes the statics of the frame and the cargo box transverse longitudinal beam, and finally completes the complete design of the automatic sorting car. One prototype model car was made.

key words: logistics, express delivery, engineering design

1- Introduction

Since China's express delivery volume surpassed that of the United States for the first time in 2014, China's express delivery industry has continued to develop vigorously. In 2018, the total business income of the postal industry reached 790.47 billion yuan, tripling that of the United States, and its scale continues to be the first in the world. The development of China's express delivery is enormous. However, under the booming development of the express logistics, there are many shortcomings in the traditional Chinese industry that do not meet the requirements of the times:

1. The level of intelligence is not high

low efficiency, as most sorting, transportation, and storage are manual operation

2. Structural imbalance

The distribution of resource in the traditional Chinese express delivery is uneven. At peak times, the overload of transport trucks and excess storage in warehouses is very serious.

3. "Last mile" is not mature

This is a big challenge is a big problem to traditional delivery companies, with high labor costs and low efficiency.

To this end, the project team designed and manufactured the 1:4 prototype model of the self-driving concept express delivery vehicle.It included with automatic sorting of intelligent containers to counter the drawbacks of the above traditional logistics industry, enabling it to be applied to new logistics systems and enhance express logistics' operational efficiency.

2- Automatic sorting container construction

2.1- Determine the hard point

Since this car is a self driving car, it can be divided into two basic structures: the cargo box and the chassis. The highlight of our design and the focus is the design of the cargo box.

Before the engineering modeling, it is necessary to determine the hard point size of the whole vehicle to facilitate the arrangement of the mechanism. The main body of the automatic sorting container includes a shelf, a courier sorting,

a container moving mechanism and a moving space thereof. According to the standard commercial vehicle and minivan size similar to this model, the hard spot size of the ground courier is determined without involving the layout space of the car chassis. As shown in Figure 1 and Figure 2.

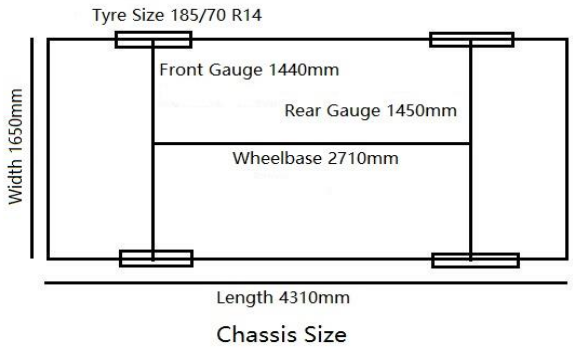

Figure 1: Chassis Size

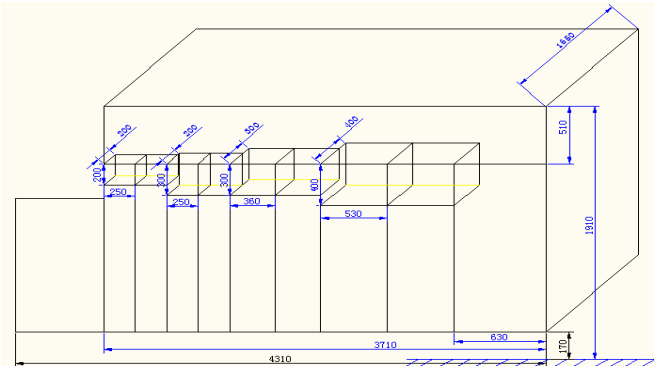

Figure 2: overall hard point

2.2- Container structure design

The container is used as the carrier for express delivery and needs to complete sorting task in real time. In order to save limited space inside the car, we design the form of "roadway" in the shelf, that is, there is only one sorting mechanism in the multiple shelves. Through the lanes, the shelf is fixed on a slider that can move along the sliding rail at the bottom of the compartment, and is moved by the shelf moving mechanism to realize the lane position switching (as shown in Fig. 3).

2.2.1- Shelf moving mechanism

The switching used to control the air to get the distance from the roadway is achieved by the shelf moving mechanism. The shelf is fixed to the slide rail by a slider at the bottom, and the shelf moving mechanism is mounted on the beam to move with the beam. The mechanism movement process is as follows:

a) When the courier to be removed is in the middle shelf, synchronous motor 1 drives the synchronous belt to move the gripping mechanism to the proper position in the positive direction of the Y-axis.

b) The rotary motor of the gripping mechanism drives the gripping mechanism to rotate 90° clockwise around the X axis to a horizontal position.。

c) The synchronous motor 2 drives the beam to move in the negative direction of the X-axis to the appropriate position above the corresponding shelf.

d) The steering gear drives the cargo box moving mechanism to rotate about the Y axis until it comes into contact with the shelf.

e) The synchronous motor 2 drives the beam and the container moving mechanism to move along the positive direction of the X axis to drive the shelf to move together with the beam, so that the roadway is switched to the front of the target shelf.

f) Finally, the grabbing mechanism completes the work and resets.

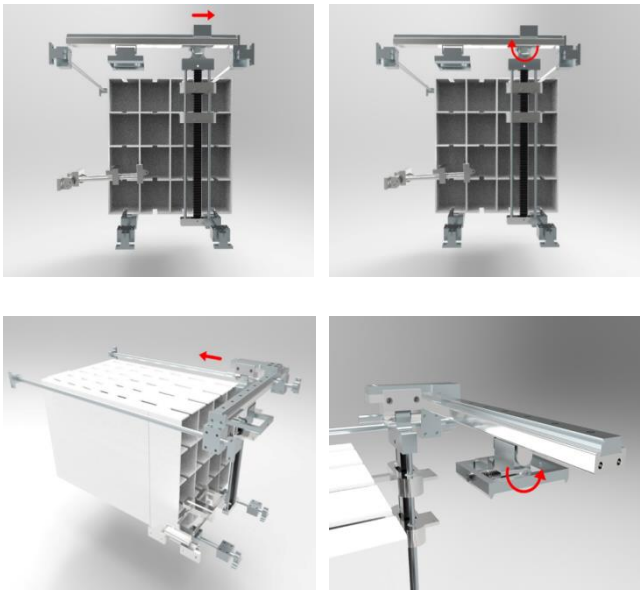

Figure 3: working process of the shelf moving mechanism

2.2.2- Grabbing mechanism

The movement process of the express picking mechanism is as follows:

a) After the shelf movement is completed, the gripping mechanism is rotated 90° counterclockwise from the horizontal position to the vertical position.

b) The synchronous motor 1 drives the gripping mechanism to move along the Y-axis to a horizontal position corresponding to the cargo compartment.

c) The upper and lower jaws of the motor-driven gripping mechanism are moved along the Z-axis to the vertical position of the corresponding cargo. The lower jaw first lifts the courier box, then moves the upper claw down to grab the courier box.

d) After grasping the courier box, the gripping mechanism rotates 90° clockwise around the X axis to the horizontal position.

e) After the gripping mechanism moves to the original position along the positive X axis, it rotates 90° counterclockwise around the X axis to reach the vertical position. The courier can be placed in the target cargo by the same procedure as described above.

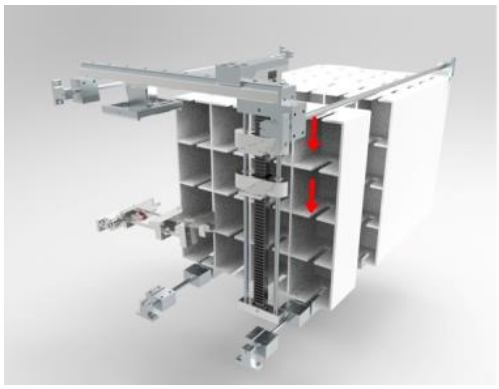

Figure 4: grabbing mechanism

2.2.3 Shipping mechanism

Since the courier car on the ground bears the task of sending the pieces, the mailing mechanism and window are designed on the side of the car to meet the needs of the users.

a) After grasping the cargo, the gripping mechanism rotates 90° counterclockwise from the vertical position around the X axis to the horizontal position.

b) After the grabbing mechanism reaches the horizontal position, the synchronous belt drives the express box along the X axis. After reaching the outermost shelf, the grabbing mechanism rotates 90° counterclockwise around the X axis to the vertical position.

c) The grabbing mechanism places the seized goods on the platform of the pick-up mechanism, and at the same time opens the pick-up window, and the customer can take the goods. Finally, the pick-up mechanism resets.

The above is the intelligent sorting container design, which can complete the function of sending parts and internal express sorting, and automate and make the sorting process intelligent without human operation. At the same time, the “shared roadway” is adopted to make the internal structure of the train compartment compact. It greatly reduces the moving space of the sorting mechanism, making it possible to complete the express sorting during the vehicle's travel process, and further improving the efficiency of express logistics.

Figure 5: shipping mechanism

3- Construction of the chassis

3.1- Frame design

In terms of frame design, we designed the structure according to the requirements of the working environment. Considering the space arrangement of the chassis, the battery and circuit control device are put in the middle space, the suspension and motor on the lower space, and elements that support and connect the container in the upper space. We use independent suspensions on the front and rear wheels. The front wheel uses a McPherson independent suspension and the rear wheel uses a multi-link independent suspension.

In terms of drive and transmission system, the rear-motor-driven mode is adopted, that is, the motor drives the drive shaft, and the drive shaft transmits torque to the rear axle through the differential to drive the wheel to rotate. The rear wheel and frame are connected by a transaxle.

3.2- Steering system design and analysis

In order to verify whether the steering mechanism can achieve the steering function and avoid interference during exercise, kinematics analysis is required:

1) Assuming that the frame is evenly stressed, the chassis portion is analyzed as a dynamics system.

2) Using the UG/motion module, set the solver as rcurdyn to get all types of connections.

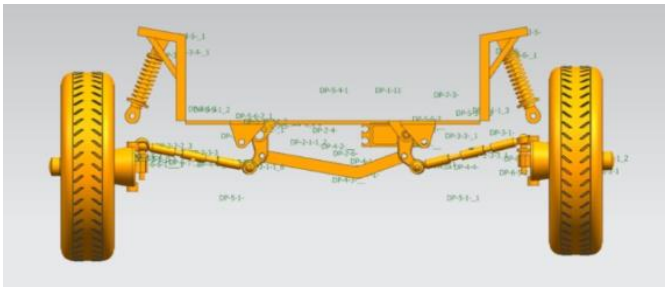

Figure 6: Steering mechanism structure

As shown in Fig. 4 we use the right L-shaped rod frame as the joint motion, the rod 1 and the rod 2 are named for two symmetric identical rod frames, and the longer one in the middle is called the rod 3. When the chassis needs to turn left, rod 1 should be set to rotate counterclockwise around the point where the J100 is located. At the same time, rod 1 drives rod 2 to move toward rod 3 so that rod 2 can rotate counterclockwise around the point where the J83 is located. With the special properties of spherical joints, we can successfully achieve the steering mechanism. We use 4 ball joints in the steering mechanism so that the plane motion can be changed from the Y-Z plane to the X-Y plane. The kinematic analysis results show that the steering mechanism can realize the steering function without interference.

4-Prototype

We developed a 1:4 prototype to further demonstrate the feasibility of our project.

The first is the prototype of our self-driving concept express delivery vehicle, which can successfully complete the sorting and distribution of express delivery, confirms that our design is reliable.

Figure 7: Prototype of the self-driving concept express delivery vehicle

Secondly, we make our whole logistics system into a sand table, which can show the operation of our system more intuitively.

Figure 8: The sand table

5- Conclusion & Future Work

With the advent of the era of e-commerce, the logistics has developed rapidly, and the design of this automatic sorting express vehicle can not only improve the operational efficiency of logistics, but also reduce the energy consumption rate and environment contamination. This vehicle will not only promote the sustainable development of urban logistics, but also facilitates the further standardization

of logistics operations. This paper elaborates from the aspects of design and stress analysis, and combines the manufacture of physical models to prove that the logistics sorting car program is technically feasible.

Our plan coincides with the concept of "promoting the intellectualized reform and development of logistics industry" mentioned in the "Report on the Work of the Chinese Government" in recent years. When we took part in an innovative competition in China, many enterprises and even local governments expressed interest in our projects. Therefore, we believe that our system can be used as a prototype of innovative development of China's logistics industry in the future.

Of course, our research is still in primary stage, automatic sorting vehicles are limited to model research and have not produced physical objects; and because the underground logistics solutions do not have many practical cases for reference, our research is still in the conceptual stage. After that, it needs more comprehensive analysis from mechanics, materials science, underground space planning, operation management and other aspects to provide a more powerful theoretical basis for the further realization of the system.

Figure 9: Automatic sorting concept car design

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