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Structural design of traffic cone delivery car

Cuiyi Liu[1,a], Hongwei Peng[2,b,*], Shiwen Zou[3,c], Xiang Long[1,d]

[1]School of Mechanical and Electrical Engineering, Guilin University of Electronic Science and Technology, Guilin, Guangxi Province, China
[2]School of Business, Guilin University of Electronic Science and Technology, Guilin, Guangxi Province, China
[3]Ji'an Chuangxiang 3D Technology Co., LTD, Ji'an, Jiangxi Province, China
[a]3027150774@qq.com, [b]penghongwei@guet.edu.cn, [c]2812348169@qq.com, [d]1727435023@qq.com
[*]Corresponding author

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Abstract: With the development of science and technology, traffic accidents happen frequently. As an important facility, traffic cone plays an important role in drainage and warning. At present, the traffic cone is mainly put by manual, but in the accident black spot, the operation efficiency is low and there are security risks. Based on this background, a simple and portable traffic cone delivery car is designed. The device designed in this paper is mainly composed of a delivery mechanism and a moving part. Three-dimensional modeling of the delivery mechanism is carried out, and static simulation analysis of its related parts is carried out to ensure the safe and stable operation of the mechanism, and physical objects are built for experimental analysis to verify the feasibility and rationality of its structure.

1. Introduction

Traffic cone is a common road traffic safety facility, which is generally deployed in sections requiring road warning and vehicle diversion [1]. Road traffic safety facilities are essential for traffic safety, and it is difficult to ensure road traffic safety once there is a lack of them [2]. Because of its flexible use and cheap price, traffic cone bucket appears frequently in traffic environment, so it is of great practical significance to study this scenario.

The traditional traffic cone delivery method relies on manual operation, which is not only inefficient, but also easy to cause security risks in emergency situations [3]. Therefore, the development of a convenient delivery cone drum device can not only improve the response speed of traffic management, but also reduce the labor burden and enhance the safety of traffic operations. The continuous progress of modern science and technology provides a new idea for intelligent traffic management. For example, computer technology is used to transform traffic cones to improve their application efficiency [4]; Intelligent transformation of traffic cones is carried out through radar and visual target detection methods [5]; Design control models to reduce vehicle congestion to optimize traffic management problems [6]; With the help of automated equipment, the rapid deployment and withdrawal of traffic cones can be realized [7]. The purpose of this paper is to study the structural design of traffic cone delivery car, and then to judge the rationality of its structural design through static analysis and experimental analysis.

2. Main Research Content

2.1 Overall structure design

The design concept of traffic cone delivery car is mainly divided into two parts: delivery device and mobile frame, as shown in Figure 1. The delivery device and the mobile frame are connected by a support seat. In the moving process of the traffic cone delivery car, through the separation of the fork resistance mechanism and the blocking mechanism of the delivery device, the traffic cone can be dropped one by one, the device moves forward smoothly, the traffic cone is dropped during the movement, and the traffic isolation belt is made smoothly.

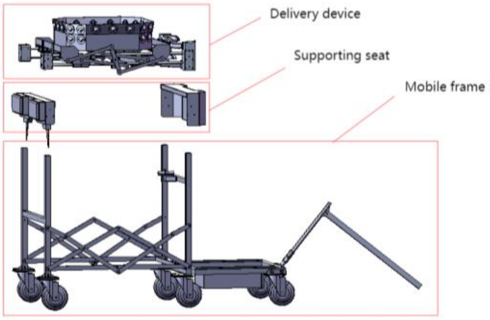

Figure 1: Structural diagram of traffic cone delivery car

2.2 Structural Design of the Delivery Mechanism

In order to ensure the stability of the whole structure of the trolley and simplify the mechanical structure of the device, the traffic cone is dropped one by one by separating the fork resistance. The structure of the delivery device of the traffic cone delivery device is shown in Figure 2, which is composed of a sliding support mechanism, a blocking mechanism, a fork resistance separation mechanism and a cone bucket guide mechanism. When the device is working on the road, the blocking mechanism of the cone drum delivery device is closed, the separation fork resistance mechanism is in a separated state, and the spare cone drum sleeve is placed on the placing table. A plurality of set cones are placed on the blocking mechanism and located in the cone guide mechanism. The separation fork resistance mechanism is then operated and inserted between the bottom two cone buckets, and the barrier mechanism is then opened so that the bottom cone bucket falls and is placed on the road.

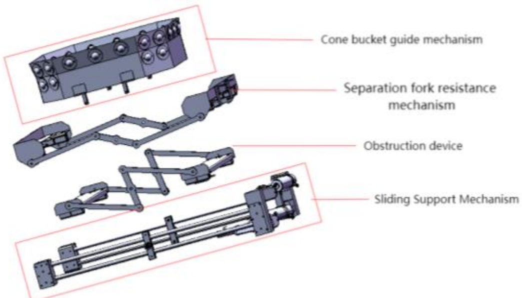

Figure 2: Structural diagram of the delivery device

2.3 Working Mode

The traffic cone dropping device is mainly composed of sliding support mechanism, blocking mechanism, differential separation mechanism, traffic cone guiding mechanism and foldable walking vehicle body. When the device is working on the road, the blocking mechanism of the cone barrel delivery device is closed, the separation fork resistance mechanism is in a separated state, and multiple traffic cones are placed on the blocking mechanism, as shown in Figure 3. The separation fork resistance mechanism works and is inserted between the bottom two cone buckets, and the blocking mechanism opens so that the bottom cone bucket falls and is placed on the road, as shown in Figure 4. When the walking car body continues to move, the blocking mechanism is closed, the separation fork resistance mechanism is separated, and the multiple cone buckets of the set fall on the blocking mechanism, as shown in Figure 5. When the moving car body reaches the next position, the separation fork resistance mechanism is inserted and separated again, so as to complete the next cone bucket.

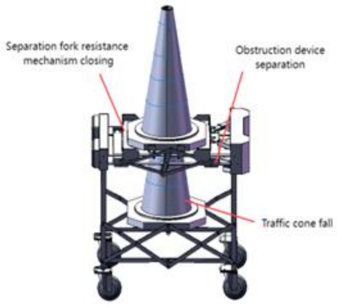

Figure 3: Initial working condition

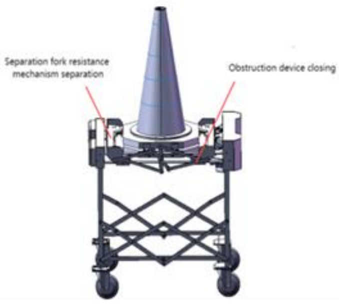

Figure 4: Drop mode

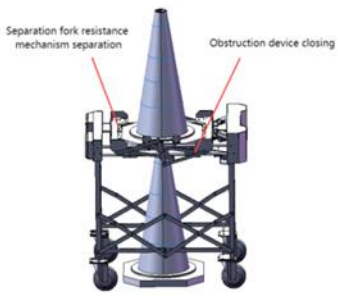

Figure 5: Complete release status

3. Static Analysis

3.1 Static stress analysis of separation fork resistance mechanism

The separation fork resistance mechanism uses 45# steel, 45# steel is a carbon structural steel material with high strength, and its mechanical property parameters are shown in Table 1.

Table 1: Parameters of 45# steel

Density	Elastic Modulus	Poisson ratio	Tensile strength	Yield strength
$7.85g/cm^3$	210GPa	0.269	>600MPa	>355MPa

The total weight of the traffic cone carried is set at 20kg (The gravitational acceleration is calculated to be 10m/s2). The left and right parts of the separation fork resistance mechanism have the same force, and the right part is selected for static force analysis, as shown in Figure 6. Simulation plug-in in SolidWorks was used for finite element analysis, and stress cloud and static diagram were drawn, as shown in Figure 7 and Figure 8.

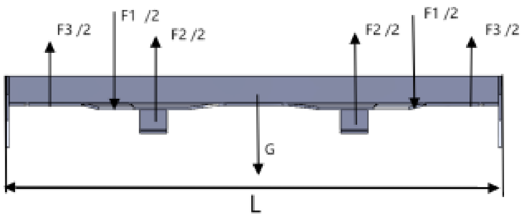

Figure 6: Static force analysis diagram of the right part

Where, G represents the gravity of the component, F1 is the pressure of the traffic cone on the component, F2 and F3 represent the support force of the sliding support mechanism on the component.

$$F_1 + G = F_2 + F_3 \quad (1)$$

$$M_1 = \int_0^{\frac{1}{2}L} F_1 * x \, dx \quad (2)$$

$$2 * M_1 = F_2 * L_2 + F_3 * L_3 \quad (3)$$

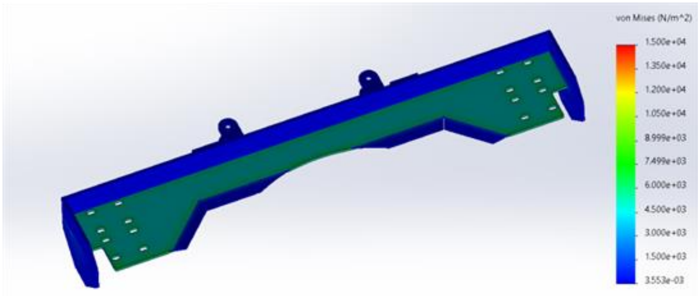

Figure 7: Stress diagram of the right plate of the separation fork resistance mechanism

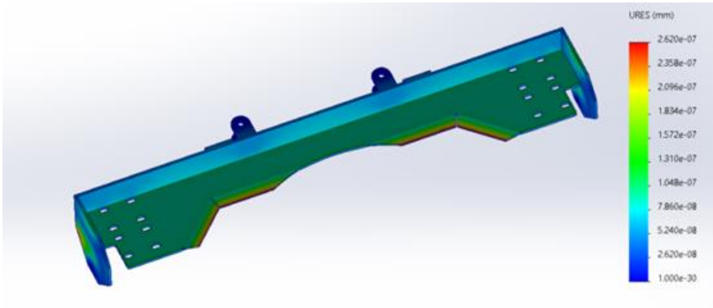

Figure 8: Displacement diagram of the right plate of the separation fork resistance mechanism

It can be seen from Figure 7 that the maximum stress occurs in the contact part between the traffic cone and the member, and the maximum stress is 1.5*104N/m2, which is far less than the yield strength of 45# steel. As can be seen from Figure 8, the maximum deformation area appears at the contact end, and the maximum displacement of the component is 2.62*10-7mm, which is far lower than the maximum deformation of 45# steel, so the component design is reasonable.

3.2 Static stress analysis of the barrier mechanism

The load borne by the blocking mechanism is greater than the separation fork resistance mechanism, so the blocking fork resistance mechanism uses 45# steel as the material. The total weight of the traffic cone carried is set at 30kg. The left and right parts of the separation fork resistance mechanism have the same force, and the right part is selected for static force analysis, and its force situation is consistent with that of the separation fork resistance mechanism, as shown in Figure 6. At the same time, Simulation plug-in in SolidWorks was used for finite element analysis, and stress cloud map and static diagram were drawn, as shown in Figure 9 and Figure 10.

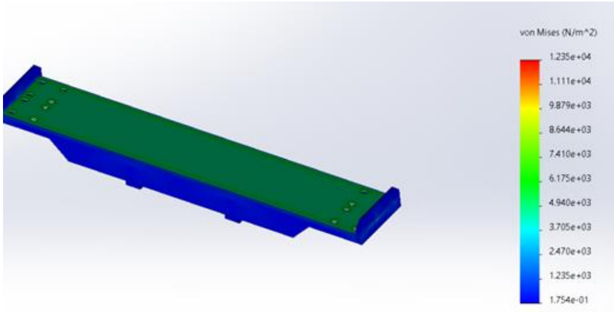

Figure 9: Stress diagram of the right plate of the resistance mechanism

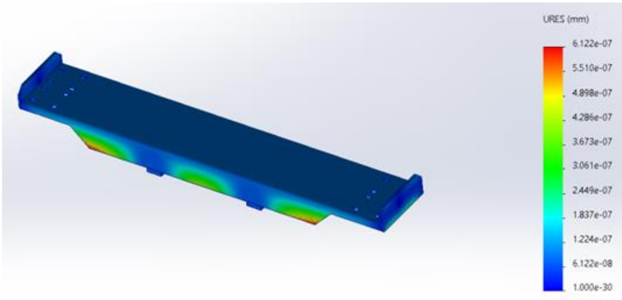

Figure 10: Displacement diagram of the right plate of the resistance mechanism

It can be seen from Figure 9 that the maximum stress also appears in the contact part between the traffic cone and the member, and the maximum stress is 1.25*104N/m2, which is far less than the yield strength of 45# steel. As can be seen from Figure 10, the maximum deformation area appears at the edge of the structure, and the maximum displacement of the component is 6.122*10-7mm, which is far lower than the maximum deformation of 45# steel, so the component design is reasonable.

3.3 Inspection of the delivery device

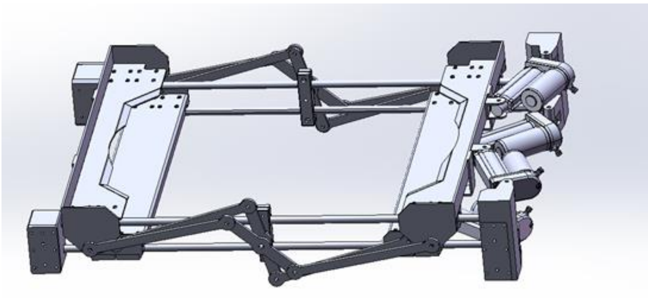

Figure 11: Delivery device structure diagram

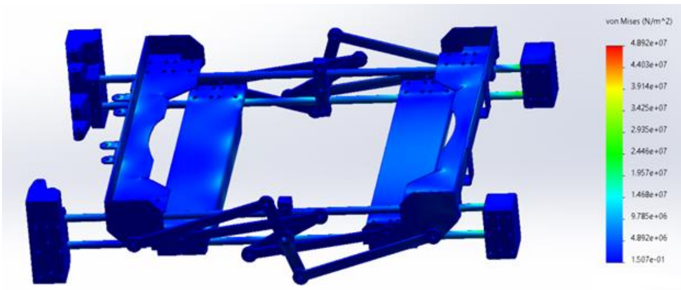

Figure 12: Finite element analysis of delivery device

As shown in Figure 11 and Figure 12, the finite element analysis of the delivery device shows that the design of the delivery device can well meet the design requirements. Through the finite element analysis of the verified delivery device, the deformation of the delivery device is significantly reduced, and from the color distribution, the force acting on the delivery device is far less than the min value of its yield force, and its maximum displacement is not enough to cause damage to the material. The middle sliding support structure has no obvious deformation, and its stress is much less than the yield stress. By comparison, it can be concluded that the verified delivery device not only meets the use conditions, but also considers the safety.

4. Experimental verification

Through 3D printing, laser cutting, machine milling and other processing methods, the parts of the car are processed to complete its mechanical structure assembly, equipped with electronic modules such as servo and push rod motor, and the control system and detection system are built to complete the assembly of the physical prototype of the car, as shown in Figure 13. The test and experiment of the physical prototype mainly include: (1) whether the car can smoothly drop the traffic cone as expected; (2) Test the speed at which the car drops the traffic cone.

Figure 13: Traffic cone delivery car prototype

Choose a level level for the experiment. The traffic cone dropping car is equipped with traffic cones to carry out the experiment, five traffic cones are equipped on the dropping device, and ten traffic cones are placed on the standby placement table. The car moves to drop five traffic cones along the predetermined route, and records the time and spacing of the traffic cones, as shown in Figure 14 and Table 2. a, b, c, d and e in Figure 14 correspond to the real-time conditions of the first to the fifth traffic cones.

(a) (b) (c) (d) (e)

Figure 14: Traffic cone drop car experiment record

Table 2: Traffic cone drop car drop traffic cone experiment record

Launch activity	Drop time interval	Layout spacing
First drop	0	0
Second drop	5.7s	4.9m
Third drop	5.3s	4.7m
Fourth drop	5.2s	4.3m
Fifth drop	5.2s	4.2m

Through the experimental results, it can be concluded that the time interval and layout distance can be controlled by controlling the walking speed. The total time of the experiment is 21.4s, and the total distance of the arrangement is 14.1m. The traffic cone dropping car can smoothly drop the traffic cone as expected. In addition, in the running process of the car, there is no interference between the devices, smooth action, in line with the design requirements.

5. Conclusions

In this paper, a convenient traffic cone dropping car is presented. The dropping device of the car is controlled by a pusher motor, and the traffic cones can be dropped one by one through a reasonable mechanical structure. The delivery car has the advantages of compact structure, folding and small occupying space. The static analysis and experimental verification of the delivery car are carried out. The simulation and experimental results prove the feasibility of the traffic cone dropping cart, which can replace the traditional manual traffic cone dropping.

Acknowledgment

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