Key parameter design of articulated dump forklift

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ABSTRACT

The main content of this study is the overall design and key structure design of a certain type of 2t forklift, including the determination of the main performance parameters and performance requirements of the forklift, the selection of the main system assembly scheme and the design calculation of its key structure, and the overall layout design of the above assembly; in order to ensure that the designed electric forklift has good working performance, it is necessary to verify and evaluate the main performance and structural strength of the vehicle. In this paper, we verify whether the design of the key structure of the electric forklift meets the industry standards by comparing the differences between the theoretical calculation results and the simulation results.

Keywords: Forklift, overall layout design, strength verification

1. PREFACE

A forklift is a material transport machine, specifically a wheeled transport vehicle that transports, stacks, loads and unloads finished items over short distances. It is widely used in various national economic sectors, such as the transport of various parts in workshops; the transport and stacking of luggage, goods and other items in railways, docks, warehouses and other places; and the transport and loading and unloading of tobacco, medicine and other items in places with high environmental requirements. At present, with the continuous development of the national economy, the warehousing and logistics industry has developed very well, and the production and sales of forklifts have also achieved sustained growth[1-3]. All countries are working hard to develop various types of forklifts. At present, the world's largest forklift with a rated lifting capacity has reached 80t, and the smallest is only 0.25t.

2. OVERALL LAYOUT DESIGN

The overall layout of the vehicle is to install and arrange the various systems in the vehicle on the frame in the most reasonable way. The purpose of overall layout of the vehicle is to make the forklift have a compact and coordinated structure and achieve optimal performance under the premise of meeting the use function of the whole vehicle. In the process of layout, various factors should be considered comprehensively. On the basis of determining the total width of the vehicle, the total length of the vehicle should be reduced as much as possible, so as to make full use of the space of the vehicle, make the layout more compact, and ensure the optimal use performance of the vehicle. The forklift is mainly composed of a power unit, a chassis, a working device and electrical equipment. The overall layout of the forklift studied in this article is shown in Figure 1 below.

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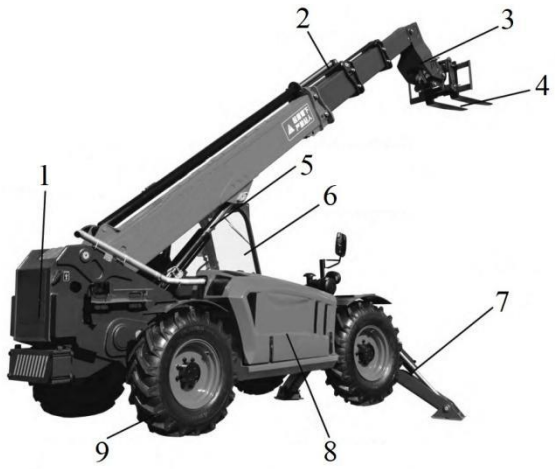


1-Engine compartment; 2-Hydraulic tank; 3-Driver's cab; 4-Hydraulic power compartment; 5-Articulated mechanism; 6-Top support cylinder; 7-Bottom support cylinder; 8-Dumping structure; 9-Modular cargo box.

Figure 1. Vehicle structure layout.

3. FORKLIFT MAST DISTURBANCE CALCULATION

The axle load of the front and rear axles of a forklift refers to the weight of the vehicle itself and other forces borne by the front and rear axles of the forklift. The axle load changes with the operation of the forklift, road conditions and load conditions. In this article, we discuss the axle load distribution of a certain type of 2t forklift when standing still on flat ground. At this time, the axle load of the forklift can be divided into the following two conditions: empty and fully loaded. The force analysis of the axle load under different conditions is shown in Figure 2 below, where Figure a represents the axle load of an empty forklift and Figure b represents the axle load of a fully loaded forklift[4,5].

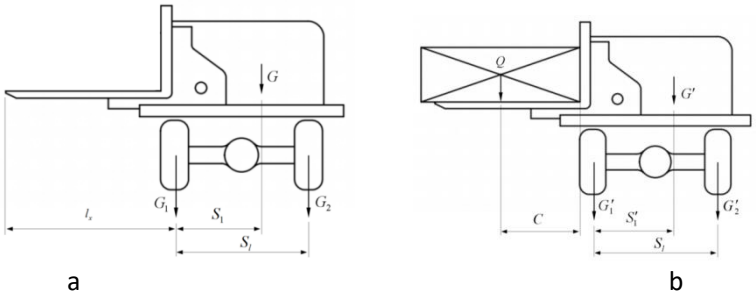


Figure 2. Force analysis of forklift with no load and full load.

① Under full load:

The expression of the front axle load G_1' is:

$$G_1' = \frac{(S_l - S_1')G' + Q(S_l + l_x + C)}{S_l} \tag{1}$$

Among them: S_1' -Horizontal distance from the center of gravity of the forklift to the front axle, 800mm; l_x -Front overhang, 470mm.

The expression of the rear axle load G_2' is:

$$G_2' = G - G_1' \tag{2}$$

②Under No-load:

The expression of the front axle load G_1 is:

$$G_1 = \frac{S_l - S_1}{S_l} G \tag{3}$$

The expression of the rear axle load G_2 is:

$$G_2 = G - G_1 \tag{4}$$

The calculated wheel hub load distribution is shown in Table 1:

Table 1. Calculation results of empty and fully loaded forklifts.

	Inner hub load/kg	Outer hub load/kg
No-load	5761	852
full load	2321	2530

4. ANALYSIS AND CALCULATION OF FORKLIFT'S PASSING PERFORMANCE

My country's forklift industry standard defines the minimum turning radius of a forklift as the minimum outer turning radius of the forklift, which is the distance from the instantaneous center of the vehicle to the nearest point on the inside of the vehicle body when the forklift's steering wheel is first rotated to the vehicle's extreme turning angle position and then driven steadily at the minimum speed. In the overall design process of the vehicle, the minimum turning radius is generally determined by the drawing method. The principle of the drawing method is to place the steering wheel at the extreme turning angle position, and draw a circle with the intersection H of the steering wheel axis and the front axle axis as the center, so that the innermost point of the vehicle body is on this circumference[6,7]. The radius of this circle is the minimum turning radius of the forklift. The working schematic diagram of an articulated rubber-wheeled trackless vehicle when turning right is shown in Figure 3.

Among them, A is the relative deflection angle between the front and rear vehicle bodies;C and D are the distances between the hinge center point O and the front and rear axles, respectively.

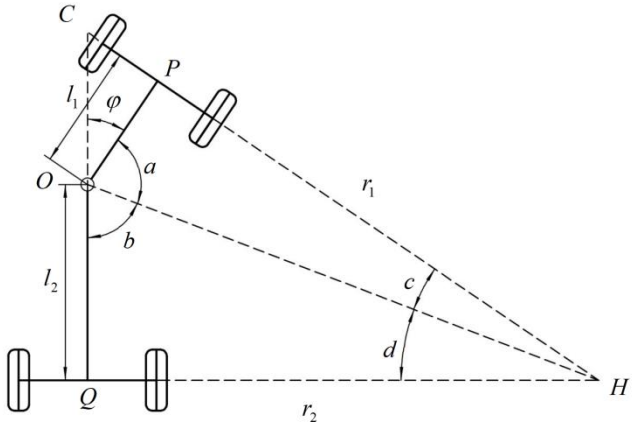


Figure 3. Forklift turning radius analysis.

It can be found in the triangle ΔHQC

$$\left(r_1 + l_1 \tan\phi\right)\sin\phi = l_2 + \frac{l_1}{\cos\phi} \tag{5}$$

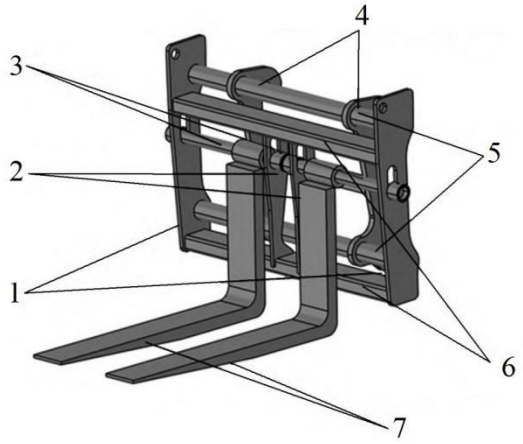
Thus can be obtained

$$r_1 = \frac{l_1 \cos \phi + l_2}{\sin \phi} \tag{6}$$

$$r_2 = \frac{l_2 \cos \phi + l_1}{\sin \phi} \tag{7}$$

5. DESIGN OF FORKLIFT WORKING DEVICE

The working device of a forklift is also called a lifting mechanism, which mainly includes a gantry system and a hydraulic system. The gantry system is mainly composed of an inner gantry, an outer gantry, a fork, a fork frame, a chain, a sprocket, etc. The main structure is shown in Figure 4 below. In order to meet the needs of a low gantry structure and a large lifting height, the inner and outer gantry of the forklift are nested inside and outside, and the up and down movement of the piston rod of the lifting hydraulic cylinder drives the inner gantry to move inside the outer gantry, making it a retractable structure. The inner and outer gantry and the fork frame are all flat frames welded from steel sections. The weight of them together with the chain, sprocket, and lifting cylinder accounts for the vast majority of the total weight of the working device, and they are all installed at the front end of the forklift according to the needs of the operation, which is also one of the important factors causing the forklift to tip forward.



1-Fork; 2-Fork frame; 3-Inner mast; 4-Side push cylinder; 5-Lifting cylinder; 6-Outer mast; 7-Leveling cylinder.

Figure 4. Fork structure layout.

The inner and outer masts are composed of two open columns and one or two welded end beams. The columns are also the guide rails for the fork frame and the inner mast to move up and down. The inner mast has only one upper end beam and a horizontal tie rod at the bottom; the outer mast has not only upper and lower end beams, but also a reinforced crossbeam in the middle, and there are hinge shafts on both sides of the crossbeam that can be connected to the tilt cylinder. The fork is a part of the forklift that is directly used to carry goods. The fork is installed on the fork frame. The installation distance of the fork on the fork frame can be adjusted at any time according to the needs of the actual project. The specific dimensions of the fork and fork frame are designed according to national standards. One end of the chain is fixed to the crossbeam of the outer mast, and the other end is connected to the fork frame through the pulley on the head of the lifting cylinder. The lifting cylinder allows the fork and fork frame to rise and fall along the inner mast through the chain and pulley, and the inner mast can be extended and retracted along the outer mast. The lower part of the outer mast is hinged on the front axle or frame. With the help of the tilt cylinder, the mast system can achieve a certain angle of forward or backward tilt movement. The working device is generally equipped with two sets of rollers, longitudinal and lateral, each with four, symmetrically arranged on the mast columns.

6. CONCLUSION

This paper takes a certain type of 2t articulated forklift as the research object. Compared with other industrial handling vehicles, articulated forklifts have unique working devices. Based on the reference of forklift structural design and simulation analysis related literature, this paper analyzes and calculates the development status, overall design, main performance of the vehicle, and key structures of forklifts at home and abroad, providing a theoretical basis for the design research, experimental design, and structural optimization analysis of forklifts.

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