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Car Lift Design

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Abstract: With the vigorous development of China's auto industry, the auto repair industry has ushered in a huge market demand. Therefore, the auto repair industry urgently needs a variety of high-efficiency, targeted auto repair equipment and tools. In the auto industry, the double-pillar lifting contact with the frame lift is a widely adopted lift. This article focuses on the design of the two-column lifts. The basic composition of the lift was first introduced, and then the overall plan for the lift design was devised. In the process of formulating the plan, according to the design requirements, with reference to the traditional double-column lift design plan, determine the plan to be designed, including driving lift mode, synchronization mode, insurance and protection, design parameters and the determination of the main body size.

Keywords: car lifts, lifting method, synchronously, design parameters.

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1. INTRODUCTION

The car lifter is a device for supporting a part of a car chassis or a car body to lift the car. In the process of car repair or maintenance, the car is lifted to the lifter's work place, and the car can be lifted to a certain height by manual operation, which is convenient for car repair and maintenance. As an important auxiliary equipment for the automobile maintenance service industry, it belongs to the special equipment lifting machinery category [1]. This article focuses on the design of the car lifter and provides the reader with a design idea that is of great significance to the development of the car lifter.

2. THE BASIC COMPOSITION OF THE CAR LIFT

Usually, the automobile lifter is a motor-driven mechanical device or a hydraulic system, and an elevating movement of a lifting platform along a frame is generated by an executing component to complete a lifting or falling operation of a car and is locked by a safety protection device and an attachment device to the lifting mechanism., wire rope breakage, supporting arm rotation angle and other moving parts play a role of protection or locking. Car lifts will have different configurations depending on the type. Basically, they are lift tables (frames, arms), mechanical or hydraulic transmission systems, electrical control systems, racks, safety guards, and attachments [2]. The basic composition of a typical car lift is shown in Fig.1.

Basic composition:

Lifting table (frame, arm): movable frame, supporting arm, lifting table, lifting beam, etc.

Mechanical system: power box, motor and reducer, threaded screw and work nut, hydraulic device, wire rope and pulley, etc.

Electrical systems: electrical protection devices, electrical operating devices, electrical signals and lines, etc.

Rack: Post, Scissor Rack, Gantry Rack, Fixed Bracket, Chassis, etc.

Safety protection device: support arm drop insurance, wire rope fracture protection device, support arm rotation angle locking device, etc.

Attachments: guards, support pads, rubber cushions, raised supports, etc.

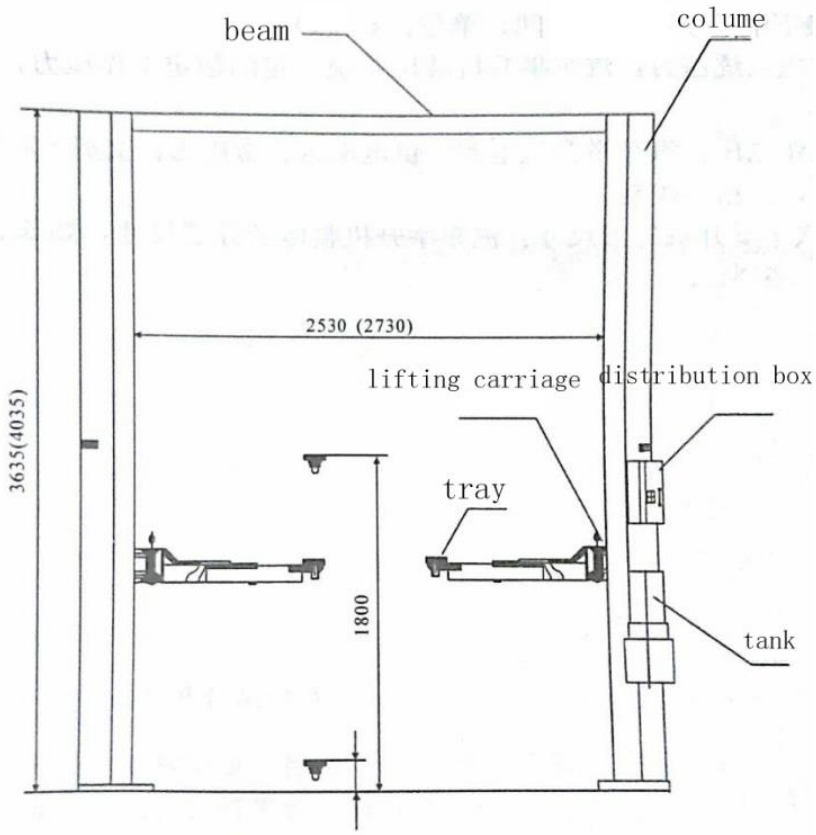

Fig 1. The basic composition of a car lift

3. FORMULATION OF OVERALL PLAN FOR LIFT DESIGN

The double-column automobile lift has many advantages such as advanced technology, simple structure, convenient operation, long service life, and simple maintenance, so this time it is planned to design a double-column car lifter.

3.1 Lift design requirements

According to the technical conditions of China's transportation industry standard JT/T155-2004 automobile lifts, the requirements for major components are:

Lift platform

The strength and rigidity of the lifting platform should meet the national standards.

When the lifting table is a diagonal L, the difference between the two diagonals of the lifting table is not more than 0.002L.

Hydraulic system

Hydraulic system design and installation shall comply with the relevant provisions of GB/T 3766.

The size of the connection of metal tubing and pipe joints shall comply with the provisions of GB/T 5653 and GB/T 3765.

Mechanical transmission section

Wire rope Lifting wire ropes shall meet the requirements of GB/T 8918 and GB/T 5972 or products of equal quality or higher. It is recommended to use wire ropes with a line contact. The safety factor should be more than seven times the maximum static tension. The breaking pressure value of the wire rope end and the wire rope end fixture should be more than seven times the maximum static tension.

Pulley The ratio of pulley diameter to wire rope diameter should be greater than 18. The pulley shall have means to prevent the rope from jumping out of the rope groove.

(3) Overall performance

A. Synchronous device Lifts with more than two lifting platforms and supporting arms shall be provided with devices that maintain simultaneous lifting. The asynchrony of the lifting and lowering of the lifting machine within the effective working range of the lifting and lowering shall be less than 3mm/10s.

B. Electrical System The electrical system of the lift shall be equipped with circuit breakers according to the size of the load, and the motor control shall have overload and phase protection devices. The control device power supply of the operating device shall use a safety voltage of 36V or less. Lifting table, support arm, up and down to the maximum stroke position should have an automatic stop device. The electrical system should have good insulation properties and the insulation resistance must not be less than 5 MΩ.

C. safety devices the lift should be equipped with a safety device that prevents the lifted vehicle from naturally descending during normal work. The hydraulic lifter shall be equipped with a safety device which suddenly breaks the steel wire rope and the chain and bursts the oil pipe, and the device shall be safe and reliable. In addition to the hydraulic system can be self-locking,

hydraulic lifts should also be equipped with mechanical locking devices. Technical parameters and technical parameters are shown in table 1:

Table 1. Technical parameters

Rated lifting mass（kg）	Maximum lifting height（mm）		Minimum support surface height from the ground（mm）	Support arm rotation angle (chassis contact type)（°）	Lift speed（mm/s）			
					Hydraulic transmission		Mechanical transmission	
	Wheel contact type	Chassis Contact			Rise	drop	Rise	drop
≦	≧		≦	≧	≧	< 40	≧	
3000	1500	1650	200	90	20		20	25
12000	1400	1600	300			>20	15	20
20000	1200	1400	350		15		10	15

When the lift is in no-load operating conditions, the operating conditions should be steady, without abnormal noise or abnormal phenomena.

Lifting machine in the rated lifting quality conditions, the operating conditions should be stable, no abnormal sound or abnormal phenomena, the various parts should not have permanent deformation, damage and other abnormal conditions.

Hydraulic system work should be stable, no vibration, no crawling phenomenon.

When the hydraulic lifter is in rated lifting mass condition, it will continuously reciprocate up and down 10 times. The oil temperature shall not be higher than the ambient temperature 40℃.

Under the condition of rated lifting mass, the whole stroke of the lifting machine is reciprocated 1000 times, parts and components must not fail, no welds are to be welded, and the motor has no failure [3].

In thermal processing of residual materials with a various origin and predominantly for fire treatment of hazardous wastes rotary kiln are employed. In metallurgy they serve for heating of solid particles like oxide ores reduction, limestone calcination, cleaning of dwarfs from machine oil.

3.2 Typical scheme of traditional double column lift design

Double-column automobile lifts can be classified into mechanical transmission type and hydraulic transmission type according to transmission methods.

3.2.1 Mechanical transmission type double column car lifter

The mechanical transmission type lifting machine is mainly driven by a threaded screw and a working nut. The structure is simple and the price is low. However, the required maintenance work is more. For example, the number of the working nut is checked every week, and the maintenance of the whole machine is performed on a monthly basis. Bar-type lifts have poor

safety and slipping of working screws or working nuts are more likely to occur, which can lead to falling accidents of the lifted cars and stuck screws. Therefore, the simple mechanical transmission lifter has the drawback that it is difficult to avoid, and it has gradually been replaced by a hydraulic lifter [3].

3.2.2 Hydraulic Transmission Double Column Car Lifter

The hydraulic lifter is the current mainstream lift product type. It has the advantages of good safety performance, stable operation, simple maintenance, and high work efficiency. General hydraulic two-column car lifters are respectively installed with hydraulic cylinders in two columns. When the hydraulic pump presses hydraulic oil into the lower chamber of the oil cylinder, the piston rod moves upwards, and then the sprocket on the top of the piston rod drives the chain to raise the slide. in addition, in order to solve the problem of the unsynchronized hydraulic cylinders in the two columns, the double-column automobile lifts are equipped with synchronization devices. The commonly used synchronization methods include wire rope mechanical balancing method, hydraulic cylinder synchronization balancing method, and motor synchronous balancing method. in China, Prof. Li Baoshun of the Institute of Electromechanical and Automotive Engineering at Yantai University conducted an in-depth study of the synchronizer of the hydraulic lift. Using the principle of three-gear structure and equal flow of its branches, it designed and developed a hydraulic synchronizer for double hydraulic cylinders. The hydraulic synchronizer has ingenious design principles, concise structure and convenient installation. It has been proved by experiments that its performance indicators are all excellent, and the synchronization accuracy has completely met and exceeded the requirements for use [4].

3.3 Technical difficulties in design

The overall structure of a double-column automobile lift is relatively simple and relatively easy to design. However, there are still some technical difficulties, mainly including the following aspects:

(1) Impact load problem

Safety is one of the important issues to be considered in the design of an automobile lift. When the wire rope or the chain breaks, the lift body, the locking device, and the anchor bolts and the foundation will all receive a huge shock load. Therefore, the size of this load must be considered in the design calculation of these parts.

(2) Stabilization problems of struts with unequal cross sections

When the car lifter ascends, the rising thrust is generated by the cylinder rod or the lead screw. They are all slender rods. Therefore, the stability of the slender rod must be calculated. Once entered (or exceeded) the critical state, the balance must be destroyed. However, when the hydraulic cylinder is extended, it is a stabilizing problem of a non-uniform cross-section rod (referring to the moment of inertia of the cross-section of the cylinder block and the piston rod).

(3) Balance problem when lifting

The lift must have a forced balancer to ensure the overall horizontal position of the car when it is ascending or descending.

(4) Problems with assembly, installation and debugging

As the lifts are generally assembled, installed and commissioned in situ. Therefore, these problems must be taken into account in the design, so that all the work of the lift in the assembly of the parts, the installation and debugging of the whole site is very simple and convenient.

A Rotary kiln is a cylinder which rotates around its cylindrical axis and acts as a device to exchange the heat. The construction, position and alignment of kiln are an essential factor for the smooth operation. Slight inclination with the horizontal axis makes the movement of solid bed towards the discharge head.

3.4 Determination of design plan

3.4.1 Drive lifting mode

The mechanically driven lifting system can easily form a two-column lifting system: one column is the main system, and the other column is a combination of sub-systems (slave systems). It is easy to organize production and constitute a series of products. Its main features are: good self-locking and good security. Since there is no hydraulic oil, it is cleaner than the hydraulic transmission. Since there is no hydraulic oil, it is cleaner than the hydraulic transmission. However, for the manufacturer, the mechanically driven lifting method mainly depends on the screw nut, and the screw required for the lift needs cold extrusion processing, and the longer the screw nut length, the high demand for manufacturing process. This will undoubtedly increase the requirements for manufacturing equipment, which will increase the manufacturing costs and will have poor processability.

The cost of the hydraulic cylinder lift is lower than that of the screw nut. The production of the hydraulic cylinder is simpler than that of the screw nut and is easy to produce. The hydraulic cylinder is stable in operation, easy to manufacture and manufacture, the hydraulic control is simple, easy to implement, and the service life is longer than that of the screw nut. However, in a hydraulic system, a hydraulic circuit is required, which easily leads to oil leakage and the seal tends to deteriorate due to aging. Therefore, it is easy to generate a small fault during use and must be regularly maintained and maintained. It is recommended that the seals be imported to reduce such failures.

After comparing the advantages and disadvantages of the two drive lifting methods, a variety of factors were combined to determine the use of hydraulically actuated lifting.

3.4.2 Synchronization mode

The wire rope mechanical synchronization method is self-locking, the transmission is relatively clean, and there is no hydraulic oil. At the same time, as long as it generally meets certain strength and stiffness requirements, pay attention to the loss of friction, its long service life, and good safety. Maintenance is more convenient. When imbalance is found, adjustments can be made by adjusting the wire rope. In view of this, this design intends to use the steel wire rope to carry on the synchronization, the concrete synchronization principle sees in the wire rope's winding.

3.4.3 Insurance and protection

In the event of a failure, such as a sudden power outage, sudden loss of oil pressure, there should be a lock-up device so that the car on the lift will not fall when the above-mentioned emergency occurs. Therefore, insurance and protection measures are essential in the system of the lift. And, there are at least two more insurance measures. Therefore, this design adopts insurance measures such as pressure retention of the hydraulic circuit, mechanical locking safety device, mechanical self-locking device, lifting overload protection, jacking protection, etc. The specific design is embodied in each structural design.

3.4.4 Selection of design parameters

(1) Selection of rated lifting weight

According to the survey and statistics, the current domestic parameters of some cars are shown in table 2 below:

According to the data in table 2, the rated lifting weight of the car lift designed this time is 3500kg.

Table 2. Domestic car parameters

car model parameter	Overall vehicle weight (kg)	Dimensions (Length × width × height) mm	Minimum height above ground (mm)
Porsche 911 2016 models Carrera 3.0T	1525	4499×1808×1294	
BMW 7 Series 2017 730Li leading type	1830	5250×1902×1498	
Guangzhou Flag GL	1215	4579×1737	140
(Day) Mazda 929Luce	1520	4905×1699	140
Changan Ford 1.5L	1321	4342×1840×1500	
Dongfeng Nissan Hacker 2017 1.2T	1358	4384×1837×1594	
Dongfeng Nissan Loulan 2017 2.5L	1652	4897×1908×1691	
GAC Toyota Highlander 2017 2.0T	1900	4855×1925×1720	
BYD 2017 2017 1.5L	1325	4360×1785×1650	
Shanghai GM Chevrolet Corvette 2016	1185	4544×1779×1467	

(2) Selection of other related parameters

After investigation and statistics, the relevant parameters of the two-column car lifts on the market are shown in the following table 3:

According to the data in Table 2.3, the other parameters of the lift designed this time are initially selected as:

Full rise time: t1=60s

Full fall time: t2≦45s

Lifting height: 1900mm

Table 3. Partial double column car lift parameters

model Para -meter	Lifting ability (kg)	Lift arm rotation angle (°)	Motor Power (kw)	Rated oil pressure (Mpa)	Rise Time (s)	Fall time (s)	Maximum lifting height (mm)
LX-240DZC (Upgrade)	4000	90	2.2	22	≦60	≤25	1900
WX-715	4000	90	2.2	22	≦60	≤25	1900
S350	3500	-	2.2	-	≦50	≦50	1820
-	4500	90	-	-	45~60	45~60	1750
QJY3.0	3000	-	2.2	-	< 40	>20	1500

3.4.5 Formulation of body size

After statistical analysis of the structural dimensions of the two-column automobile lifts on the market today, combined with the requirements of this design, the main dimensions of the lifts are tentatively prepared as shown in Fig 2.

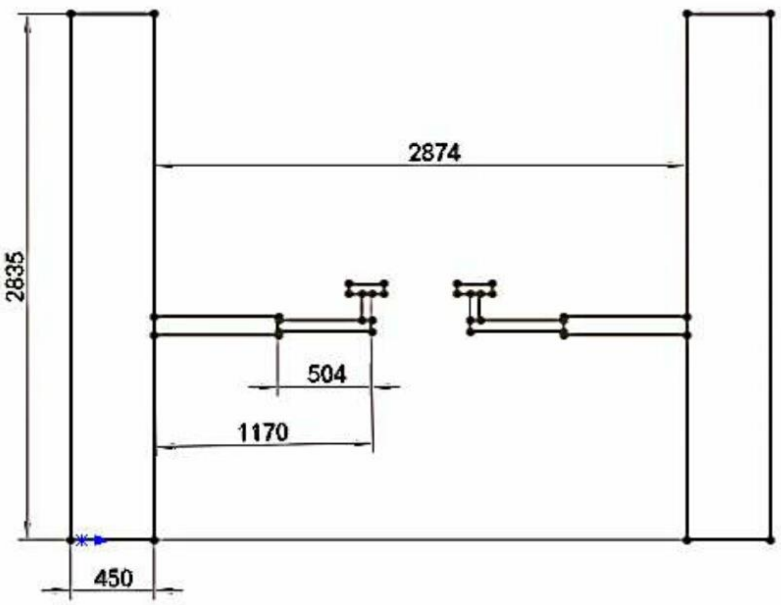

Fig 2. Main dimensions of a two-post car lift

4. CONCLUSION

At the beginning of this design, we first carried out extensive investigations and researches on the car lifts on the market. We simply understood their structural composition, working principles, and their respective advantages and disadvantages, and decided to design hydraulic double column car lift after comprehensive consideration and comparison. This article focuses

on the design of two-column lifts. First, it introduces the basic concepts of the car lifter and its structural composition. Afterwards, the overall plan for lift design is formulated. In the process of formulating the plan, according to the design requirements, the design plan of the traditional double-column lift shall be consulted to determine the plan to be designed, including driving lift mode, synchronization mode, insurance and protection, design parameters and main body size.

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REFERENCES

[1] W. D. Zhua and L. J. Teppo. Design and analysis of a scaled model of a high-rise, high-speedelevator [J]. Journal of Sound and Vibration, Volume 264, Issue 3, 10 July.

[2] P. E. Uysa, K. Jarmaia, b and J. Farkas. Optimal design of a hoist structure frame[J]. Applied Mathematical Modelling, Volume27, Issuel2, December2003:963~98.

[3] Zhang Yingjie. Automotive lift safety technology [M]. Beijing: China Measurement Press, 2005.1~3.

[4] Li Baoshun. Structural design of hydraulic lift synchronizer [J]. Hydraulics and Pneumatics, 2005, 4: 12~13.