Design of Dedicated Elevator for 4S Shop Car Maintenance

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Bachelor's Thesis

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SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS**
Abstract

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Abstract

The topic in the thesis is designing of one kind of dedicated elevator. Because hydraulic synchronizing lifting platform currently used in automobile repair plays an important role in automobile repairing, by improving aspects such as innovation of various hydraulic valves, synchronous lifting platform hydraulic cylinder, hydraulic station, hydraulic synchronizing lifting platform with the smooth running, low noise, fast response speed, synchronous precision. It aim at designing one outgoing elevator, which will play an irreplaceable role in the repair and maintenance of cars in China. And it is still an extensive application prospect was to make more profit from it.

Therefore, on the basis of present application, double-hinged scissors lift was the main design target of the previous scissors lifts because of its flexibility, security, economy and other indicators. And its structural flexibility meets higher requirements of vehicle maintenance, and the response of different models to meet vehicle maintenance, and other performance requirements. However, it is necessary to use scientific data to describe every aspect of the following three problems: What kind of driving methods need to be chosen, which arrangement needs to be set, and what kind of structure need to be designed.

At last, the double-hinged scissors lift position parameter and the dynamic parameters of technology, and specific examples these three aspects make the agency improved in the hydraulic cylinder layout analysis and comparison, and in accordance with the requirements of part of a hydraulic system design and calculation of final pressure implementation components - hydraulic cylinder, through analysis of the fork-defined plate and fork-load requirements, the final completion of scissors hydraulic lifts the design requirement.

As a result, every calculation of this topic was finished and I hope my design could scope the new field of maintenance work.

Keywords
lifting platform ,scissors forks ,configuration design, hydraulic pressure

CONTENTS

1 Introduction

Car elevator is necessary equipment of auto 4s shops for maintenance operations. Its main function is to supply convenience for the engine, chassis, transmission repairing and maintenance, etc. The design of elevator in this thesis is about the car elevator performance analysis and calculation, and then the final car elevator blueprint can be drawn, which is concluded that the longest service life, the most effective and cheapest materials. However before this thesis starting, I would like to describe what 4S shop is. 4S means Series, Spare part, Service, and Survey in auto maintenance shops, where many works need to use a dedicated elevator is needed to lift the car under safe circumstance. So the quality of the elevator demand us consider and the adaptability for work environment limit the design of elevator appearance.

1.1 Target of thesis

In the information age, cars have been stepping into many houses due to rapid economic development. So the 4S shops have turned into main mechanical direction of many university students. More demands need more supplies, but the elevator still stays a low level in 4S shops. The maintenance of elevator took a huge part of investment in 4S shops, they shops always need to buy a new elevator after a short period usage. Thesis will design a better elevator for car maintenance with great quality, long time service time, adaptable work ability and more profit from investment. And then more and more 4S shops will choose our product, and establish a good relationship in business to business case. The new field of industry is scoped in this thesis. !

2 Concept of car elevator

Car elevator plays an indispensable role in the automobile maintenance, convenient for automobile chassis, engine, transmission and components, such as inspection and maintenance. But the different structure means different efficiency, which means it needs many aspects need to be considered before 4S shops can use it.

2.1 The development of the elevator

Auto lift have been appearing so long time. The first elevator was born in the 1930 s in America. Because the large cylinder and sealing conditions are limited, occasional emergency always occurs when cylinder compresses air. It was not until a decade later gradually before it spread outside of the United States.

The first double-column lifter appeared in Germany thirty years later, however, this kind didn't appear in other countries until 1977. And stay a low level with four-post lift vary until now, the following will be concise. Elevator is basically motionless. Cars must rely on the elevator.

In mobile lift the emphasis is on typical scissor lifts and other types. But the drawbacks must rely on the car, and in the workshop mobile elevators sometimes is not convenient. However, free change position is a distinct characteristic. But this kind of elevator cannot be widely to use

At the beginning car is simple and huge, repairing needs a large site, Then the car became smaller and more portable, it was not convenient to repair vehicle because of it was too close to elevator components. In South America there still were not small vehicles. Perhaps that is the reason why single-column lift is still popular there.

The special advantages of single-column lifter are: There is no barrier impact repairing when the elevator falls; and car is able to turn free in the elevator. Single-column elevator’s main drawbacks are that: firstly, the installation to repair the building surface needs to be dug deep and small hole groove; Secondly, it can only provide the wheel support; Thirdly, it is not easy in the implementation of the key at the bottom with the car repairing. Oil cylinder hidden in the underground lifting also has two primary problems: the first is repairing these parts is more troublesome. The second is the underground environment of oil cylinder is extremely bad, elements will be oxidized.

Double-column lifter also has the following advantages: firstly, the base completely closes to the car bottom during maintenance; secondly, use the free wheel type to support vehicles, not with the aid of other auxiliary lifting measures; Thirdly, do not take up area. Double-column lifter’s disadvantages are: firstly, in order to prevent the lifting process of turbulence rocking, elevator installation process is very strict; Secondly, the elevator such as wheel alignment inspection, check the suspension system

supports various unstable factors; Thirdly, due to all the stress and often wear, the double-column lifter has shorter safe use time .

The wheel support type four-post lift has many good functions: firstly, the simple car loading operation; Secondly, the stable bearing; thirdly, the load is relatively small, relatively less stress, greatly increased the service life; fourthly, the economic value; fifthly, easy to maintenance. Four-post lifter's disadvantage is that: it is too appropriation of space, for car maintenance it is not ideal

2.2 Design characteristics of the elevator

(1) In order to make the lift table close to the ground surface, it needs to take pit slot, so we have to put more work, at the same time it would cause the workshop a lot of inconvenience. To this end, both strength and rigid are required in place, and putting down the bedplate beam. In this case not only car conveniently entered the elevator, but workshop cover area is reduced.

(2) In the proper selection of transmission mode: Driving by motor which belongs to mechanical drive (nut, screw) or hydraulic transmission (cylinder). The mechanical drive specific costs more and wastes energy, just for reducing the characteristics of the danger. However experiments show hydraulic transmission costs in the same case that is half of mechanical transmission, mechanical requires constant care. Because the basic parts can be bought, so hydraulic elevator has high technical difficulty but it is not a big problem, of course we must choose optimal investment products.

(3) The choice of the wire rope. In order to reduce the pulley diameter to narrow the section size we should choose high flexibility of steel wire rope. Wire rope should have a higher safety factor; generally it should be up to eight. Therefore, we should increase the number of steel wire rope. A British company 3 t series elevator chose 9 mm diameter wire rope, two roots, 37 shares for each root, and six wires for each share. Pulleys are usually made of steel, but the company made them of glass fiber mixed with 50% nylon glass fiber, nylon (50%). In this way, it is not only cheap, but also reduces the wear of steel wire rope, and prolong its service life.

2.3 Safety guarantee measures of car elevator

Today all over the world more great attention is paid to the safety of workers who work in dangerous environment. There are some with potential dangers with auto lift, because people work under the car. If people are not careful, the hand, foot will be

bruised by elevator. In recent years, many countries have established specialized laws and regulations, in order to prevent or at least reduce the possibility of accidents to the minimum.

Car elevator safety assurance measures are mainly from two aspects: on the one hand, from the aspects of design and manufacture of measures to improve automobile elevator is safe by concentrating on technical characteristics; On the other hand strict operating procedures should be followed in the process of using maintenance, to ensure that the car lifting mechanism is in a good technical state and run correctly.

2.3.1 Safety guarantee measures of design and manufacture

There are many advanced technologies in nowadays world, such as automatic control, photoelectric switch, etc., which have been widely applied to the design of various kinds of security devices, therefore in designing and manufacturing to elevator, the characteristics of the products should be combine of, then actively adopt advanced covers and reliable to cater for practical modern security technology. The following list only adopted widely in most of the elevator safety measures:

(1) The elevator should be able to stand overload test (including lifting and supporting), the general data should be 125% of the maximum lifting capacity, the elevator component shall not have any permanent deformation and damage.

(2) All of the operation control mechanisms adopt "double insurance", in case of wrong operation, namely it is necessary for elevator to drive before operating two control mechanisms (or push button switch).

(3) All of the control circuits adopt failure protection, or any single component failure will not make the elevator drop or rise causing a very dangerous situation.

(4) All elevator components should have second support system. When the ascension of the original system fails, it can effectively support load automatically.

(5) All of the flexible methods of promotion, such as steel wire rope, chain, etc., shall have sufficient safety factors, and transmit components within the confinement settled by factory.

(6) All the movement of the parts should have protection device, in order to avoid the impact of any part of the operating person, especially hand, foot, clothes, etc.

(7) All the designs of the elevator should reduce the possibility of lifting the weight slip to the minimum

2.3.2 Safety guarantee measures of maintenance

Using the maintenance of safety assurance measures gets involved in range is very wide, including several aspects such as elevator has the preparing work before use, pay attention when lifting a car, the stability about bearing down the matters need attention, daily and regular maintenance checks, etc. Although the car elevator has about 70 years history, its design principle has little changed; But only little ignoring safety requirements, overload using, carelessness, can still cause serious accidents, and even loss of life or personal injury occurred. So security problem must be drawn great attention to using units and operators. First of all, we should choose those car elevator with good safety performance, in addition, we still should earnestly study and understand the instructions of the security considerations and carefully carry them out. Just in usage of the elevator maintenance generally attention should be paid into instructions as in the following.

(1) The elevator within usage should be checked every day. If a fault or damaged parts are found, it shall not be used again. Maintenance should use accessories provided by the elevator factory, and that process is not arbitrarily or homemade.

(2) The elevator shall not be overloaded. In each lift the rated load is marked on the nameplate of equipment. Special attention should be paid to prevent partial load, namely, the whole machine is not overloaded but a lifting arm has indeed exceed the permitted load rating. Therefore when lifting those seriously uneven distributions of automobile front axle load should be paid special attention to, load has to meet the requirements.

(3) Person who placed the car and uses the elevator shall be trained and tested.

(4) There must be no one inside the car when lifting. During elevator lifting and using, customers and irrelevant persons should be far away from the elevator.

(5) The elevator area shall not have any obstacles, such as oil, waste and debris and so on.

(6) Before cars drove on elevator, workers should clear channel, not past or hit the lifting arm, connectors, axle supporting device, etc., to prevent damage to the elevators or cars.

(7) The elevator should be operated carefully when it carrying a car. Locate lift support placed in manufacturers recommend contact point. It only can be raised when the support point contact with the car bearing close to the elevator; after checking rigor of the contact carefully, auto can be lifted height to work then.

(8) Workers should pay attention to some car parts because of the different move or installation position causes the center of gravity of dramatic change, leading to it is not stable when lifting a car.

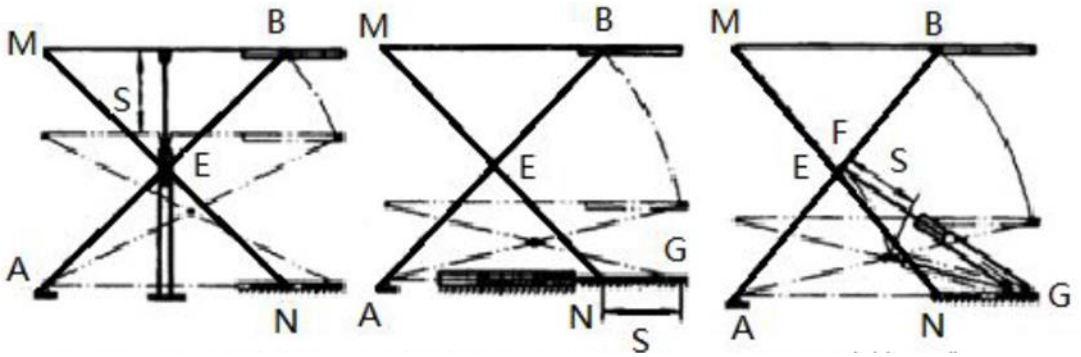
(9) Before the elevator descending, the toolbox, bench and other equipment below the car should be all removed. Before falling the elevator, loosen locking device must also be important. Note: if you would like to do maintenance operations underneath the car, the height of the elevator should be promoted to enough, so that the locking device can be meshing.

3 Analysis of platform structure and choosing the position of hydraulic cylinder

The purpose of choosing the position of hydraulic cylinder in this discussion based on the analysis of the gas and liquid dynamic class scissor lift platform mechanism characteristics, this paper discusses the problems that should be paid attention to when designing and its application scope

3.1 Three kinds of structure forms of shear fork lift platform

. Gas hydraulic shear fork lift platform is easy to manufacture, low cost, solid and durable, easy for maintenance, etc. In civil aviation, transportation, metallurgy, automobile manufacturing and other industries it has been used widely gradually. This design mainly focuses on small household hydraulic lift platform. In the design of gas and liquid in the process of dynamic shear fork lift platform, generally we will consider the following three kinds of design schemes, as shown in diagram.



a b c

Figure 1.a. Vertical fixed scissor b. Horizontal fixed scissor c. Double hinged scissor [1]

In the gas-liquid dynamic scissor lift platform with three kinds of structure forms is shown. The two support bars of the equal length AB and MN hinged on the halfway point E of the two poles, And two M, A ends respectively hinged on the plate and frame, two shots of B and N end respectively with two hinged roller, and rolling on the tablet and the guide groove rack. The difference of the three kinds of structure forms in figure is different installation position of a hydraulic cylinder.

Figure (a) the bottom of the driving hydraulic cylinder fixed on the frame, And the top pole of the piston rod contact with ball head and ball socket. Flat vertical lifts under hydraulic cylinder by the piston rod.

In figure (b) horizontal hydraulic cylinder piston rod and support bar MN articulated in N. Hydraulic cylinder driven piston rod controls platform to vertical lift.

In figure (c) hydraulic cylinder body tail and frame hinged in G place, the piston rod head and support bar AB articulated in F. Hydraulic cylinder driving piston rod can control platform to veridical lift.

According to the installation of the hydraulic cylinder form, called the graph (a) in the form of vertical fixed shear fork structure, figure (b)the form of a horizontal shear fork, figure (c) in the form of t two hinged scissor fork structure.

Vertical fixed shear fork structure, hydraulic cylinder stroke is equal to the lifting platform stroke, the overall structure has large size, and the spherical hinge processing load, which contribute to there is less prospects in actual application.

Horizontal fixed fork scissors mechanism, through the analysis and calculation, the platform lifting stroke is greater than the hydraulic cylinder stroke, can achieve rapid control in the process of application , but the shortcoming is the role of the piston rod under transverse force will affect the service life of seals. And the piston rod on the load force platform of load force is larger than it actually is. So that it is practical and rarely used.

Two hinged shear fork structure avoided the above shortcomings. Structure is reasonable, the platform of movements itinerary can achieve hydraulic cylinder stroke more than two times. Therefore, it gradually has been widely used in engineering practice. This design is the key of double hinged scissor structure analysis in this thesis.,

3.2 The calculation of location parameters of the two hinged shear fork lift platform mechanism

In order to describe the calculation, this As showed in the figure as follow

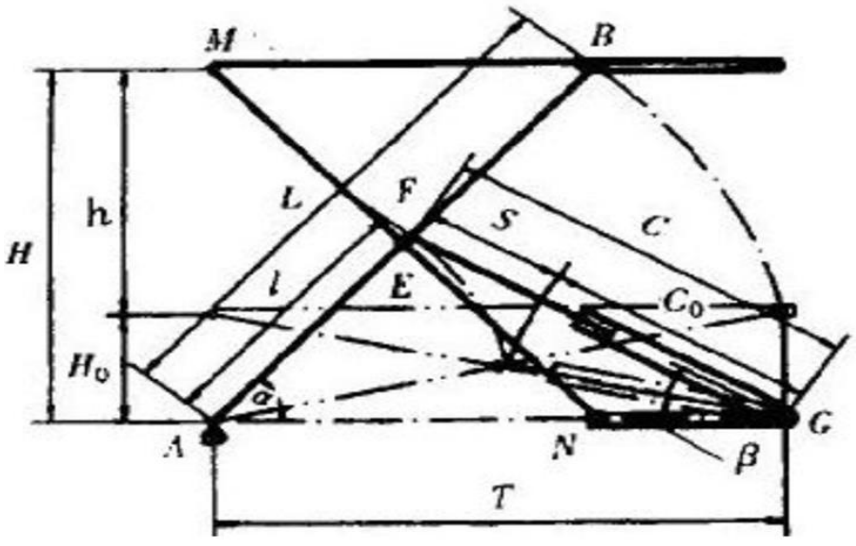


Figure 2 . Double hinged scissor lift [2]

$$\mathrm{H} = \frac{CLsin\beta}{l} = \frac{CL(1-cos^2\beta)^{\frac{1}{2}}}{l} \qquad (1)$$

$$\cos\beta = \frac{(T^2+C^2-l^2)}{2TC} \qquad (2) \quad [4]$$

In the type:

H = any position when the height of the lift platform;（mm）

C = any position distance between articulated point F to the hydraulic hinge point G;(mm)

L = the length of the support bar;(mm)

l =distance between support bar fixed hinge support A to the articulated point F.(mm)

T=frame length (the distance of A to G);(mm)

β= included angle between piston rod and horizontal(°)

The following is the same

Combine these two formulas and we can get

$$\frac{H}{C} = \frac{H}{L}\left[1 - \left(\frac{T^2+C^2-l^2}{2TC}\right)^2\right]^{\frac{1}{2}} \qquad (3)$$

Establish λ =C/C$_\circ$ θ =H/H$_\circ$ and take them into formula above then

$$\frac{\theta H_0}{\lambda C_0} = \frac{L}{l}\left[1 - \left(\frac{T^2+(\lambda C_0)-l^2}{2T\lambda C_0}\right)^2\right]^{\frac{1}{2}} \qquad (4)$$

H$_\circ$ =the initial height of the lift platform C$_\circ$ =initial length of hydraulic cylinder

Two hinged scissor lift platform mechanism motion parameters calculation

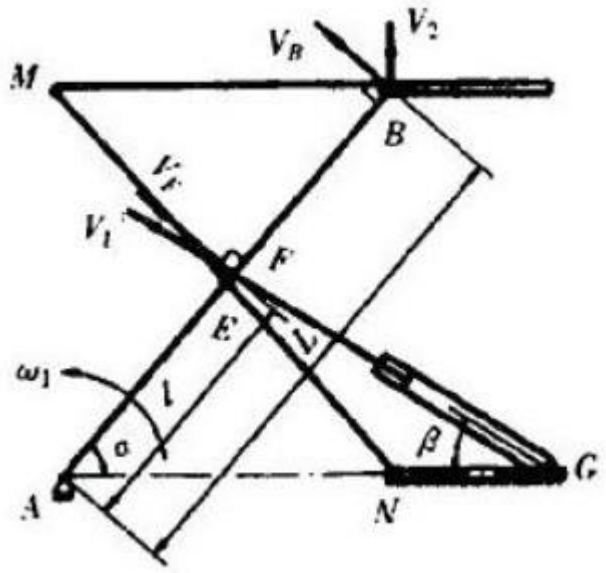


Figure 3. Double hinged scissor lift [1]

The following is the same

Then we can get result from diagram above

$$V_F = \omega_1 l$$

$$V_1 = V_F sin(\alpha + \beta) = \omega_1 l sin(\alpha + \beta)$$

$$V_B = \omega_1 L = \frac{V_1 L}{l sin(\alpha+\beta)}$$

$$V_2 = V_B cos\alpha = \frac{V_1 L cos\alpha}{l sin(\alpha+\beta)}$$

$$\frac{V_1}{V_2} = \frac{L cos\alpha}{l sin(\alpha+\beta)} \qquad (5)$$

V_F = absolute speed of point F,(m/min)

V_B = absolute speed of point B,(m/min)

ω_1 = speed of AB support bar;(m/min)

V_1 = the hydraulic cylinder piston average relative speed.(m/min)

V_2 = lift platform lifting speed (m/min)

α :Included angle between support bar with the horizontal

3.3 The dynamic parameters of double hinged scissor lift platform mechanism for calculation

Then we assume the hydraulic cylinder has settled in right side. And calculation of the whole action about rise and decline in detail as follow.

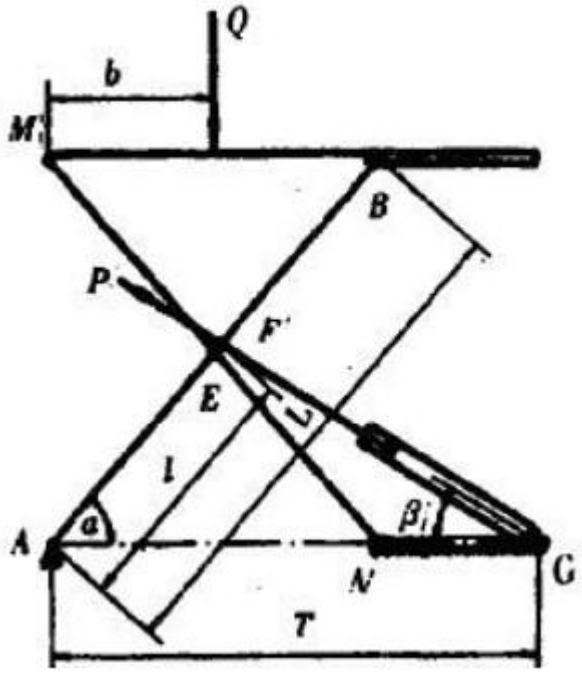


Figure 4 . Double hinged scissor lift [1]

In the diagram, P is thrust applied from the piston rod in the hydraulic cylinder, Q is gravity load of lift platform. Through the analysis of stress distribution and to calculate process (omitted) then we get the result as follow:

When the lift platform rises

$$\mathrm{P}=\frac{Q}{Isin(\alpha+\beta)}\left[\frac{Lcos\alpha}{2}+b+fbtan\alpha+\left(\frac{cos\alpha}{2}+\frac{fsin\alpha}{2}\right)\left(\frac{Lcos\alpha-b+fbtan\alpha}{cos\alpha-fsin\alpha}-\frac{b}{cos\alpha}\right)\right] \quad (6)$$

When the lift platform descends

$$\mathrm{P}=\frac{Q}{Isin(\alpha+\beta)}\left[\frac{Lcos\alpha}{2}+b+fbtan\alpha+\left(\frac{cos\alpha}{2}+\frac{fsin\alpha}{2}\right)\left(\frac{Lcos\alpha-b+fbtan\alpha}{cos\alpha-fsin\alpha}-\frac{b}{cos\alpha}\right)\right] \quad (7)$$

P=The thrust of hydraulic cylinder acts on the piston rod (N)

Q=The gravity load on lift platform (N)

f=Rolling friction coefficient

b=Load Q on the role of the line to flat left hinge pivot M horizontal distance(mm)

Because of the scroll wheel and groove belongs to rolling friction, the friction coefficient is small (f = 0.01), and to simplify the calculation we ignored.

Then we get this formula

$$\frac{P}{Q}=\frac{Lcos\alpha}{lsin(\alpha+\beta)} \quad (8)$$

3.4 Design problems of scissor lift platform mechanism

Though formulas 1 and 2 we can get result: When the α, β increases, the V2 / V1 value get less; When decrease α and β , P/Q value increase. Then determine the overall structure get less; When decrease α and β, and increase P/Q value, on the basis of the hydraulic cylinder stroke, the lifting platform lifting stroke decreased; On the contrary, it can make the hydraulic cylinder stroke loading stress increase. Therefore the design should be considered two movements of rises and descend and the hydraulic cylinder force factors. In meet movements under the premise of the overall structure size, choose higher α_0 and β_0 initial value. And AB support bar is the main force in the whole body bar, bear has the largest bending moment, so should focus on its intensity.

The hydraulic cylinder can use the single-acting cylinder, and it can also use the double-acting cylinder, but it depends on the specific circumstances. Generally, we are using monoculture cylinder because this plunger cylinder is more economic, and a general leakage quantity is little, and long seal life. With single-acting piston cylinders to take into account when it empty load, the tablet weight should be able to overcome the hydraulic cylinder seal between the piston and cylinder body resistance. Otherwise, it would not lead to lift platform is able to drop itself down.

3.5 Specific instances

As an automatic production line, it is necessary to design a lift platform, request lift platform movements itinerary should be greater than 620 mm,

Lift platform surface minimum height should be less than 300 mm, maximum bearing load is 10050 kg

According to the actual application requirements, we selected the single-acting piston cylinder type of hydraulic cylinder. Initial length of hydraulic cylinder 0 C = 595 mm; Range of Max S = 320 mm. Lifting mechanism size: lift mesa minimum altitude 0 H = 281 mm; Frame length T = 1, 200;

Support bar length L = 1, 230.5 mm.

Respectively according to the size, the calculation combine with the above formula of double hinged shear fork and horizontal fixed shear fork type two kinds of structure forms. The calculation results are shown in table 1, table 2 and statistical figure 2-5 the rolling friction is neglected. Horizontal fixed shear fork structure formula is as follows:

$$\mathrm{H} = [L^2 - (T - S)^2]^{\frac{1}{2}} \tag{9}$$

$$\frac{P}{Q} = \frac{1}{tan\alpha} + \frac{2fb}{Lcos\alpha} \tag{10}$$ [4]

Among them, the S - the actual stroke of the hydraulic cylinder, T - frame length distance (From A to G)

Table 1Two hinged shear fork structure calculation results **mm**

s	α	β	H	h	P/Q	h/s
0	**13.18**	**14.20**	**281**	**0**	**4.08**	**0**
40	**19.67**	**19.83**	**414.8**	**133.8**	**2.85**	**2.35**
80	**24.83**	**23.46**	**517.6**	**236.6**	**2.34**	**2.96**
120	**29.38**	**26.05**	**604.7**	**323.7**	**2.04**	**2.70**
160	**33.59**	**27.96**	**681.8**	**400.8**	**1.82**	**2.51**
200	**37.56**	**29.93**	**751.3**	**470.3**	**1.66**	**2.35**
240	**41.39**	**30.45**	**814.9**	**533.9**	**1.52**	**2.22**
280	**45.11**	**31.21**	**873.2**	**592.2**	**1.40**	**2.12**
320	**48.77**	**31.74**	**926.8**	**645.8**	**1.29**	**2.02**

(S=hydraulic cylinder of the actual itinerary. H= lift's actual itinerary, the same below. **)**

Table 2 Horizontal fixed shear fork structure calculation results mm

s	α	H	h	P/Q	h/s
0	**13.8**	**281**	**0**	**4.27**	**0**
40	**19.74**	**416.4**	**135.4**	**2.79**	**3.39**
80	**24.67**	**514.4**	**233.4**	**2.18**	**2.92**
120	**28.80**	**593.8**	**312.8**	**1.82**	**2.61**
160	**32.45**	**661.3**	**380.3**	**1.57**	**2.37**
200	**35.77**	**720.4**	**439.4**	**1.39**	**2.20**
240	**38.84**	**772.9**	**491.9**	**1.24**	**2.05**
280	**41.71**	**820.1**	**539.1**	**1.12**	**1.93**
320	**44.44**	**862.9**	**581.9**	**1.02**	**1.82**

As can be seen from the results: under the premise of same overall structure size and the same hydraulic cylinder stroke, as for Pmax the maximum thrust acting in the hydraulic cylinder piston rod, whose horizontal fixed shear fork structure is more than two hinged shear fork structure; And lifting platform range hmax, two hinged fork scissor structure is greater than the level of the fixed shear fork structure.

Due to applying type structure of the two hinged hydraulic lift platform, avoided dig a pit in the equipment installation, not only save the cost, also bring convenience for equipment maintenance and repairing in the future.

Above all, gas hydraulic double hinged shear fork structure hydraulic lifting platform, whose the overall size is small, simple and compact structure which save the invest-

ment; The rise and fall of cylinder block can be obtained more than two times the formation; It is very suitable for space with small size, and large movements itinerary occasions is recommended to use lifting mechanism

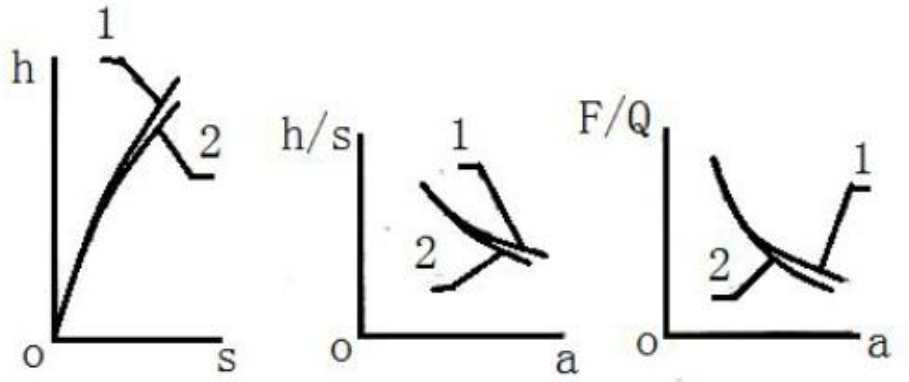


Figure 5. Two kinds of structural calculation result contrast [2]
(Curve 1: calculation results of table 1 Curve 2: calculation results of table 2)

3.6 Analysis and comparison of two hinged scissor with two kinds of hydraulic cylinder arrangements

We just have a simple analysis and discuss the difference about two hinged scissor hydraulic lift platform structure with two others. Besides, the advantages and disadvantages of the existing in the practical application, but given the situation if various conditions such as the single-acting piston hydraulic cylinder, two hinged connection, double support bar, the same lift platform does not change, whether it will carry out further optimize design? To prove it, we can consider the arrangement in the agency, and change the structure slightly.

As showed in diagram as follow

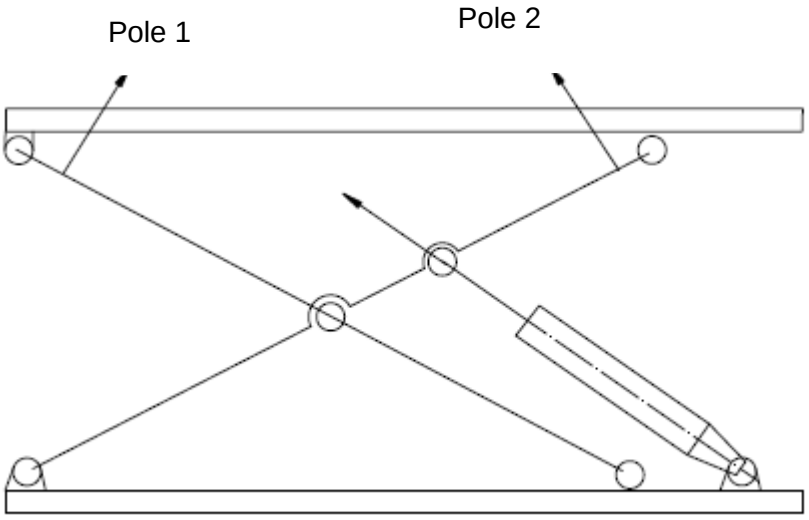


Figure 6. Working schematic diagram of the hydraulic cylinder [2]

We can see from the graph, the tail end of the hydraulic cylinder is connected to the support bar on the right side activity area, the hydraulic cylinder head is connected to the pole 1 right side (to lever pole 1 active hinged connection) .Therefore, we aimed at the he problems existing in the actual lifting table scissor fork structure, whose relative hydraulic cylinder arrangement. We try to put forward the hydraulic cylinder relatively symmetrical left side, namely the fixed protection of fork scissor structure and its cylinder set in the same side in order to further analysing. Using the method of instantaneous speed centre law and virtual displacement principle, deduces the two kinds of arrangement of the hydraulic cylinder piston movement speed and mesa of the relation between the lifting speed and the piston thrust and the relation between the load, and analyses two kinds of arrangement of comparison, points out their respective advantages and disadvantages and applicable occasions. Based on the lifting table fork scissors mechanism of engineering examples, we selected the geometry, movement and the comparison of power parameter and proper structural parameters of hydraulic cylinder after calculation.

3.7 Analysis and comparison of two kinds of arrangements

In order to solve the above questions, that the hydraulic cylinder can be reverse arrangement (i.e., using the first design), calculate the related parameters of the scheme and then will be to compare the two methods.

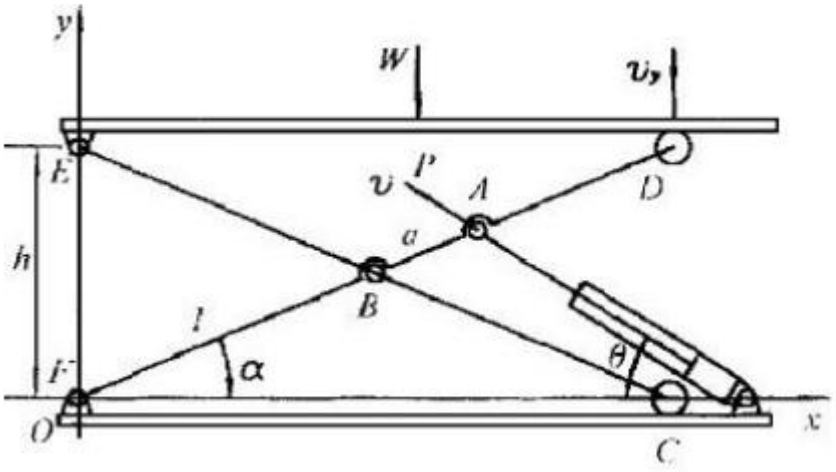


Figure 7. Hydraulic cylinder arrange in right side [2]

Here are still using the instantaneous velocity centre method to solve the piston movement speed. D point, A point on the rod FD of the instantaneous centre of rotation F, D point, speed of A point is:

$V_D = 2\omega l$

$V_A = \omega(l + \alpha)$

Mesa lifting speed: $V_y = V_D cos\alpha = 2\omega l cos\alpha$ [5]

The rate of movement of the point A: $(l+\alpha)V_y \Big/ (2lcos\alpha)$

The piston movement speed:

$$\mathrm{v} = V_A cos\beta = \frac{(l+\alpha)\sin(\theta+\alpha)}{2lcosa}$$

$$\alpha = \sin^{-1}\frac{h}{2l}\theta = \tan^{-1}\frac{(l+a)sina}{L-(l+a)cosa} \quad (10)$$

Based on the virtual displacement principle and we can get:

$\sum(F_i\delta x_i + F_{ix}\delta y_i + F_{ix}\delta z_i) = 0 - (P_x\delta x_P + P_y\delta y_P - W\delta y_W) = 0$ [5]

$$P_x = Pcosa \qquad P_y = Psina$$

$x_P = (l+a)cosa \qquad y_P = (l+a)sina \qquad y_W = 2lsina \qquad (11)$ [4]

After variation then we get

$$\delta x_P = -(l+a)sina\delta a$$

$$\delta y_P = (l+a)cosa\delta a$$

$$\delta y_W = 2lcosa\delta a$$

Plug these three results into formula 11 then we get thrust of piston

$$\mathrm{P} = \frac{2lcosa}{(l+a)\sin(\theta+a)}W \qquad [4] \qquad (12)$$

The correctness of the formula 11 and 12 can use conservation of mechanical energy principle to prove it, namely

$v_P = v_y W$ [4]

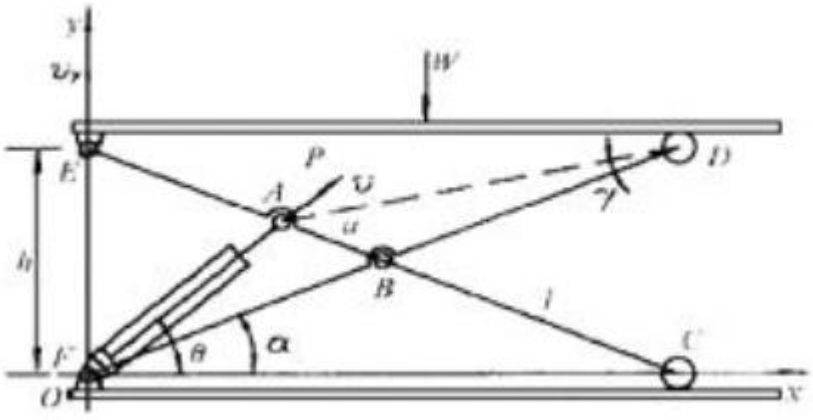


Figure 8.Hydraulic cylinder arrange in left side

The hydraulic cylinder piston movement speed and the relation between the vertical speeds of mesa

$$\mathrm{v} = \frac{\sqrt{a^2+l^2+2alcos2a}\sin(\theta-a+y)}{2lcosa}v_y \qquad (13)$$

The relation between the load on the mesa and piston thrust

$$\mathrm{p} = \frac{2lcosa}{\mathrm{asin}(\theta + a) + lsin(\theta - a)} W$$

$$\alpha = \sin^{-1}\frac{h}{2l} \qquad \theta = \tan^{-1}\left[\frac{l+a}{l-a}tana\right] \quad y = \sin^{-1}(\frac{a}{d}sin2a) \quad (14)\ [4]$$

That is commonly used in the above two type is derived based on the engineering hydraulic cylinder arrangement, namely the hydraulic cylinder under fixed pivot and fork scissors mechanism settled in same side, as shown above picture. The advantage of this arrangement is effective stroke of the hydraulic cylinder is shorter; the lift range is larger in mesa of the occasion which was suitable. Problem is after fork scissors mechanism is equivalent to the height of the h (i.e., smaller Angle α。) under the condition of rather smaller, the thrust of the hydraulic cylinder required will greatly increase. Under the condition of the hydraulic cylinder maximum working pressure limit, this will allow the increase of the diameter of the hydraulic cylinder, so that after the conversion it is difficult to arrange into fork scissors mechanism; Or use two smaller diameter hydraulic cylinder instead of a large diameter hydraulic cylinder, but this will add a pair of hydraulic cylinder bearing, at the same time bring mechanical processing, the hydraulic cylinder installation and the complexity of the hydraulic system, and increase the cost of the entire unit.

Hydraulic cylinder arranged on the right side of the fork scissors mechanism, making the hydraulic cylinder piston thrust decreases, so that we can choose a smaller diameter hydraulic cylinder, which is good at hydraulic cylinder arrangement in the fork scissors mechanism; Problems is an effective stroke of the hydraulic cylinder is getting longer, if the table lift range is not big, the increase of the hydraulic cylinder stroke is also limited.

3.8 Practical calculations

According to the result of the above analysis, in combination with taking an example, comparing instance structure diagram as shown in figure, the left and the right Side, respectively for the two kinds of arrangement

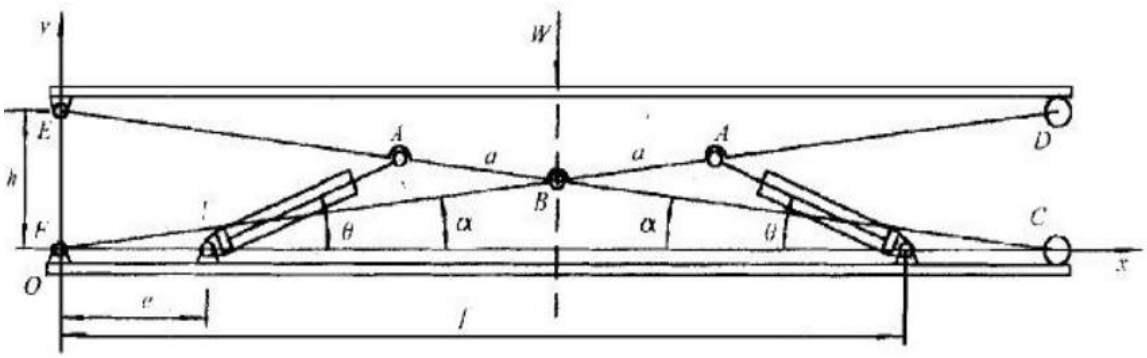


Figure 9. Respectively for the two kinds of arrangement [1]

The structure of the fork scissors mechanism size:

H = 400 ~ 1 200 mm, ι =2000mm, a = 535 mm, e = 770 mm, f= 3210 mm. The two kinds of arrangement of main parameter calculation results as showed in table.

Table 10 Two kinds of arrangement of main parameter calculation results

Parameters	Left side		Right side	
Pole FD angle α	$\sin^{-1}$	h	$\sin^{-1}$	h
		2ι		2ι
Hydraulic cylinder angle θ		$(\iota+\alpha)\sin\alpha$		$(\iota+\alpha)\sin\alpha$
	$\tan^{-1}$	$(\iota-\alpha)\cos\alpha$-e	$\tan^{-1}$	$f-(\iota-\alpha)\cos\alpha$
Starting angle αo	5.739		5.739	
Starting angle θo	20.236		20.236	
Starting piston speedVo	0.158Vy		0.279Vy	
Starting piston thrustPo	5.42W		3.58W	
Termination of the Angle α_{max}	17.458		17.458	
Termination of the Angle θ_{max}	50.473		22.262	
Effective piston stoke length	253		365	

As can be seen from the numerical comparison of statistics, the hydraulic cylinder in the fork scissors mechanism arrangement makes difference with its motion and dynamic parameters obviously. When starting Angles are α_o and θ_o, and the piston thrust is maximum P_o. Load W under the same situation in mesa, the thrust of hydraulic cylinder when layout on the right side is lower than the hydraulic cylinder arrangement on the left side, and their ratio is 0.66. However, the effective stroke of the piston L when it is decorated on the right side is longer than on the left side 112 mm. If the load quantity is not very big (namely, the load quantity W < 1.5 kN), then we can consider to use the left side of the layout plan, because it can shorten the length of the elongation of the hydraulic cylinder. If large elongation through, not only material will be wasted, somewhat in and at the same time in the load over a long period of time will also increase the corresponding hydraulic cylinder and the bending stress of the piston..

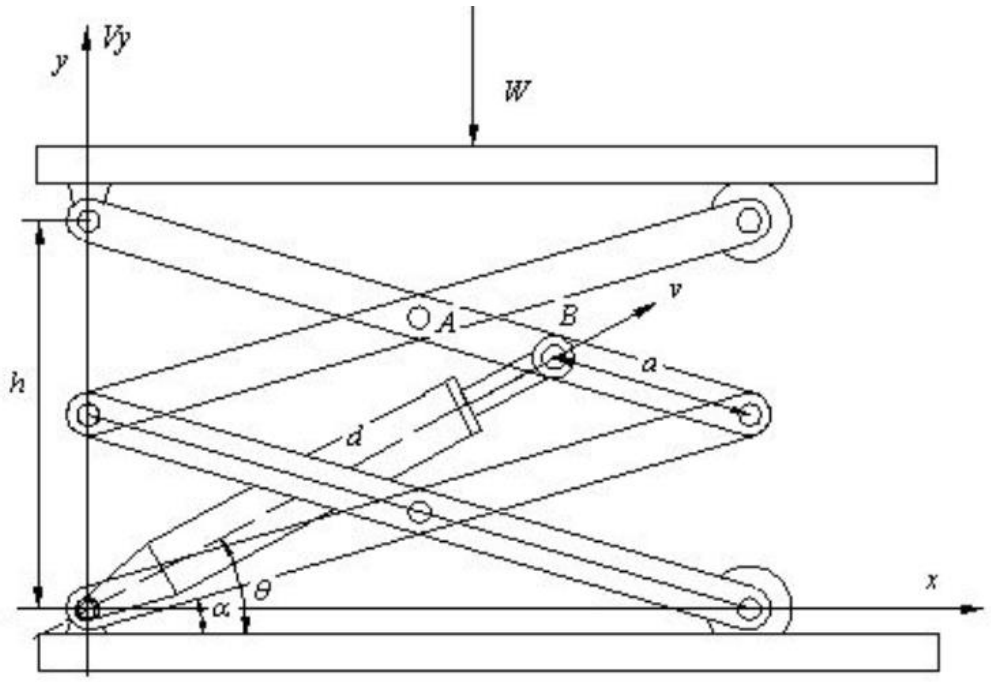


Figure 10. All the parameters of institution [1]

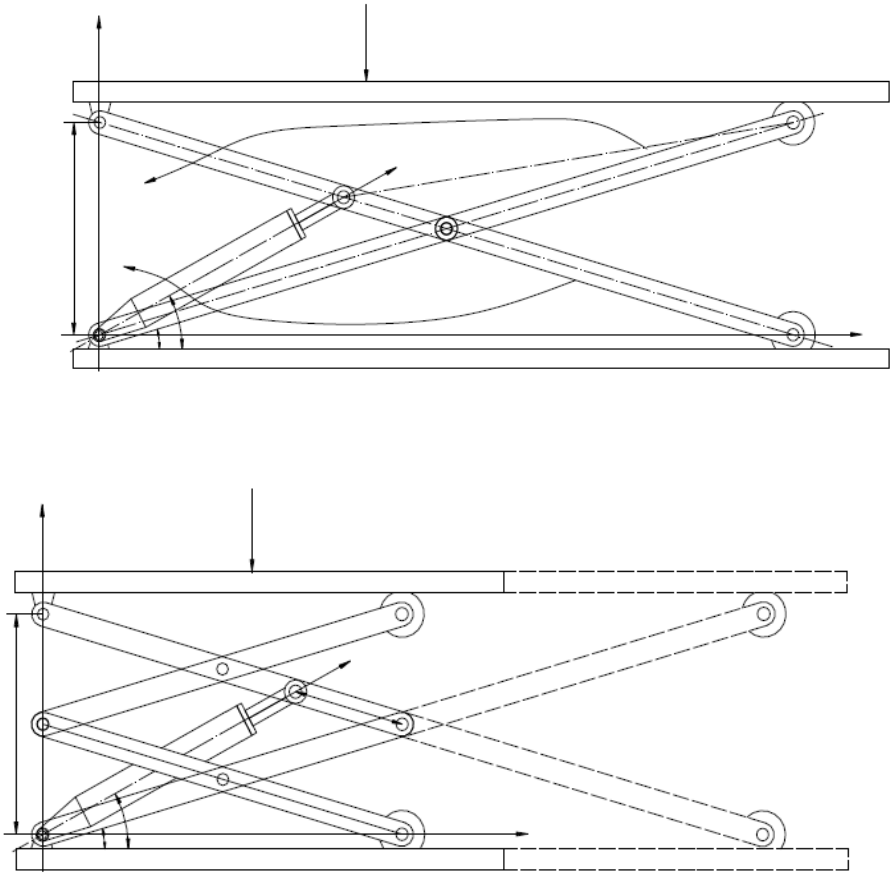


Figure 11.Motion transformation process from up to down [1]

Comprehensive above consideration, can preliminary adopts hydraulic cylinder arrangement on the left side. And the start of the piston in the scheme speed is less than

the speed of hydraulic cylinder when layout on the right side, the ratio of V_{left}/V_{right}= 0.66. In order to make up for the lack of speed, and reduce the volume of the whole lift, we can consider to adopt two-stage support rod lifting platform together in order to achieve the purpose of speed.

As shown in figure 10: the conversion process as shown in figure above, if we turn two root part of the support bar on the right side to the left, then we will get four relatively short support bar and achieve a goal.

So first we shall calculate the design schemes of the hydraulic cylinder used in the various parameters, and then according to the various parameters have been obtained specific confirm whether this solution is reasonable.

According to the basic requirements of this design below, choose the appropriate lay-out of further. In order to make the elevator using a wide range, load more representatives. This design firstly established a car model, its related parameters are: vehicle weight of 1.5 t, 1.42 m wide, 1.4 m high and 2.4 m wheelbase. Not beyond the allowed range, in terms of load can be use of the scheme. To work on the safe side, asked to lift on the height should be self-locking at work, when completed can the original speed or slow down, when the light also can realize fast drop, this will be discussed in the circuit analysis of the hydraulic system below.

To facilitate the maintenance personnel in the lifting table maintenance, not only need to be rationalized in terms of lifting height during maintenance also need position to let maintenance person stand. To do this, we can choose double lifting table synchronization lifting and adopt the way of common base plate to meet the requirements; the layout scheme requires two hydraulic cylinders, 16 root support bar lifting. In order to enhance the safety and reliability, and we may set the total capacity W total=2tx1000x9.8=19600N, and every mesa load capacity is 9800N (19600N/2=9800N). Due to the average hydraulic cylinder under this load is 9800 N, so arranged on the left side of the hydraulic cylinder is completely possible.

4 Design and calculation of the bedplate and fork rod

Counter located in the top of lifting platform, which is part of the support member. Bedplate plays a key role on parking smoothly cars on the lift tables. Car must be drive on the counter before the repair work. To be sure the platen is not a simple steel plate, but there are some slides at the bottom, because there are pulleys on the lifting table fork lever arm, the track's role is to make the pulley sliding back and forth within the chute, to achieve the lifting platform lifting and falling movement

Figure 12. The floor structure diagram [2]

For the pulley on the lifting table fork lever arm, the track's role is to make the pulley sliding back and forth within the chute, the lifting platform achieve lifting and falling action according to the above size parameters of the car. It is determined the length of the bedplate is 2600 mm, width 450 mm, material is made of hot rolled steel plate. And its shape is as shown above. To be sure the platen is not a simple steel plate, but in the following ways, because the lifting platform fork lever arm has the pulley, the track's role is to make the pulley sliding back and forth inside the track, the lifting platform achieves lifting and falling movement. Fork lever is one of the main lifting platform lifting parts, which is the main force. For the success of its design relates to the success or failure of the whole design work, materials is NO.45 steel, hot rolled steel plates

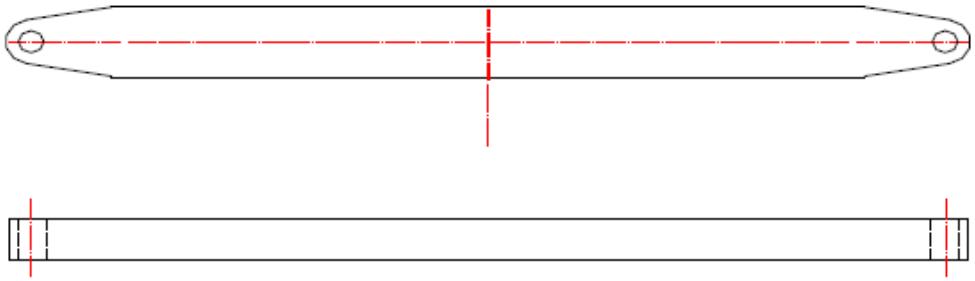


Figure 13 .The appearance of fork lever [2]

4.1 Determining material and size of the fork lever structure

Support the fork lever force analysis

Firstly define each rod name with number

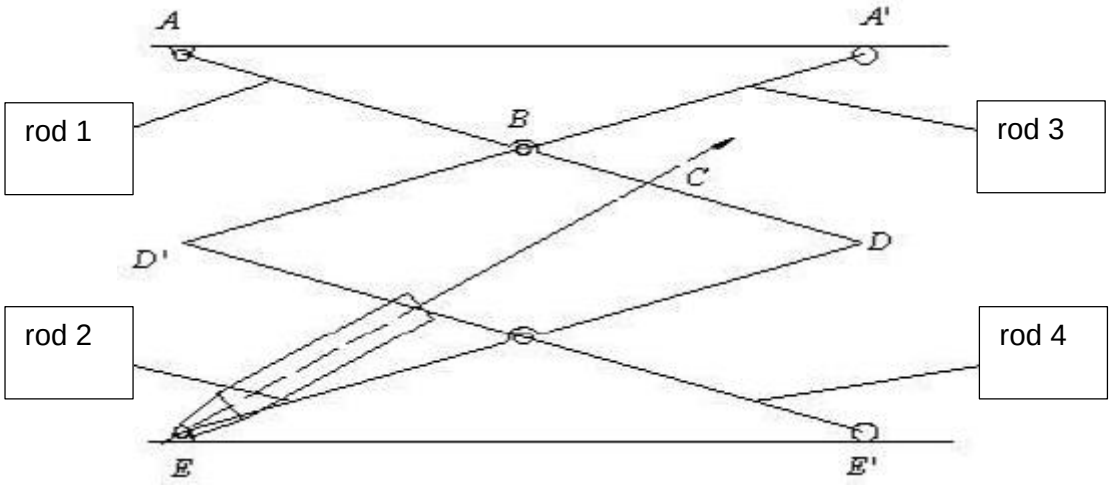


Figure 14 . Fork lever's support force analysis diagram [2]

For rod 3, 4 active hinge connected rod in horizontal direction, there is no other outside force in addition to the friction on, which you can ignore, now we only consider its stress on the vertical direction. Through analysis of stem force as shown in figure as follow:

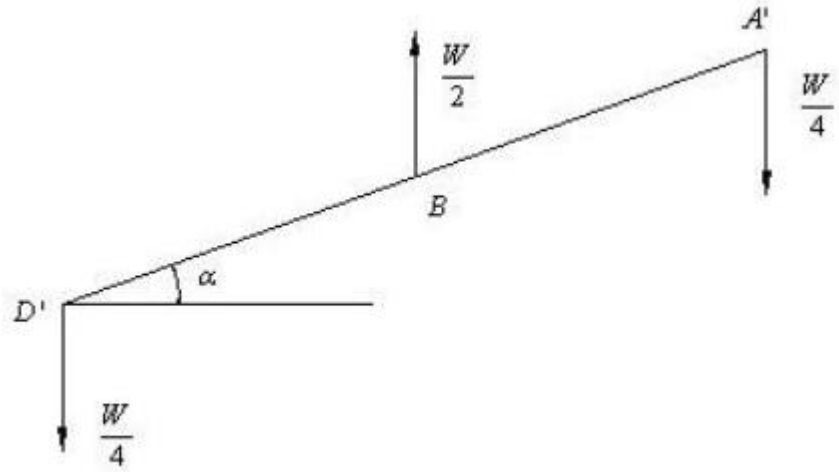


Figure 15 .Force analysis diagram[2]

Calculating the maximum bending moment force and axial force

By mechanical analysis, when the lifting platform in the lowest position

When theα=5°, the bending moment is the biggest moment.

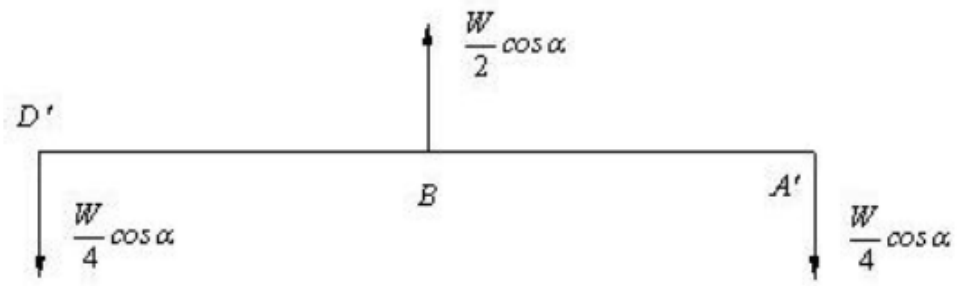


Figure 16 . Force analysis diagram [2]

$$M_{max}\frac{\frac{W}{2}cosa\frac{l}{2}\frac{l}{2}}{l}=\frac{Wcosal}{8}=2562.7Nm \quad (15)$$

When the lifting platform in the highest position, the axial force is the largest (α= 30°)

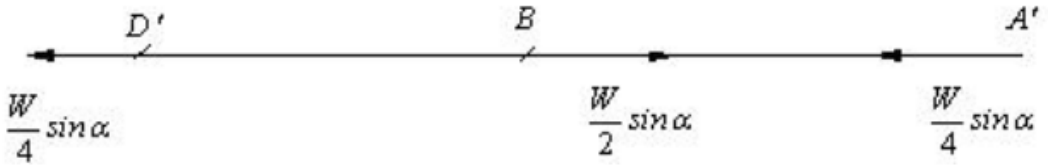


Figure 17. Force analysis diagram [2]

$N_{D'B}$ =w/4 sinα= 1225N, $N_{BA'}$=-1225N

Rod 4 is same as rod 3

Analysis the lever again rod 1 and stress analysis as showed follow

D

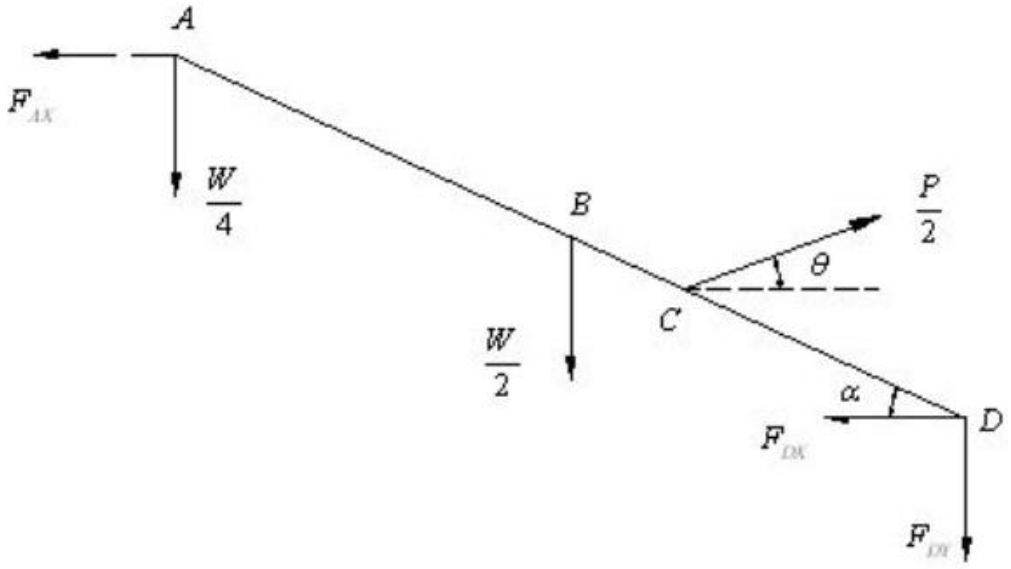


Figure 18. Force analysis diagram [5]

Analysis of the moment about D point:

$$F_{Ax}lsina + \frac{W}{4}lcosa + \frac{W}{2}\frac{l}{2}cosa = \frac{P}{2}\frac{l}{3}\sin(a+\theta),$$

Then we can get result from this formula namely $F_{Ax} = -110.1N$

The picture above can be converted into chart to analysis to calculate bending moment.

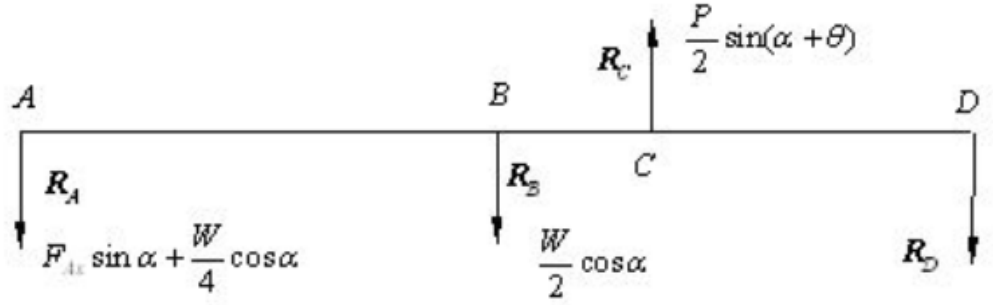


Figure 19. Force analysis diagram [2]

According to the above conditions then we can get bending moment diagram

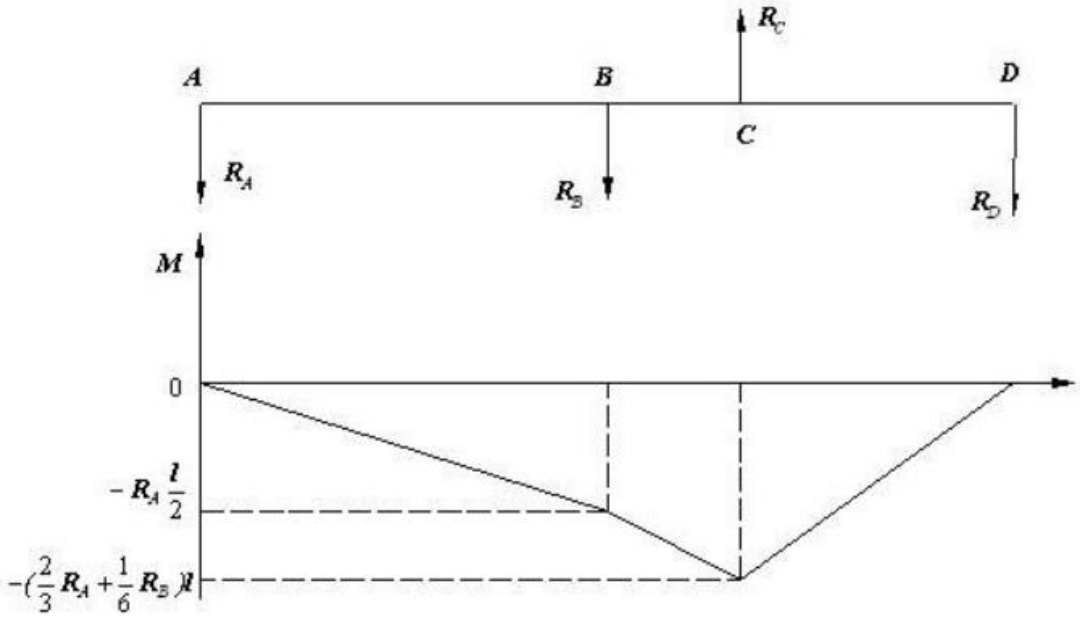


Figure 20. Bending moment diagram of Pole 1 [5]

From this figure, the lever of maximum bending moment is point C. After calculation, when α=5°.Rc is maximum value namely the biggest moment point and at the same time it also has the largest axial force. Initially take the α=5°, W=9800N,P=11.6W into formula $\mathrm{P} = \frac{2lcosa}{asina(\theta+a)+lsin(\theta-a)}W$ Then we get results as follow

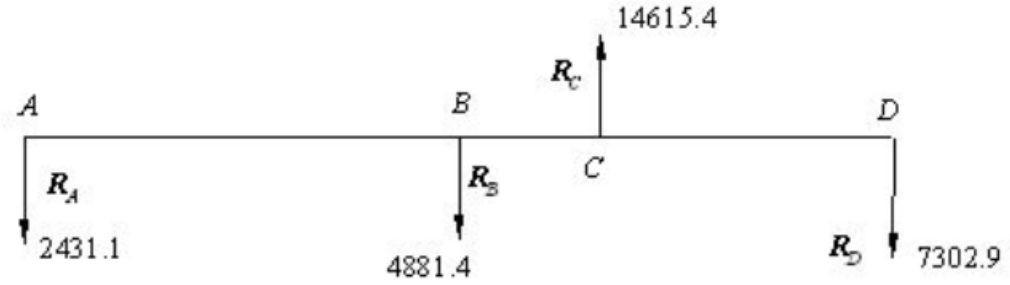


Figure 21. Force analysis diagram [2]

Then$M_{max} = -\left(\frac{2}{3}R_A + \frac{1}{6}R_B\right)l = -5112Nm$

Calculate the axial force and stress analysis of rod

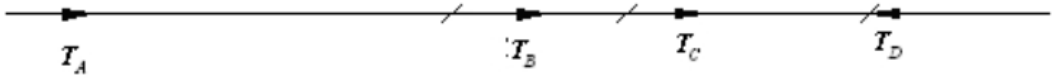


Figure 22. Axial force and stress analysis of rod [5]

By the analysis and calculation, the CD bear axial compression force is the largest T_{CD}=54929N. Due to just calculate the rod 3 and rod 4 maximum bending moment and maximum axial force both are less than the value of pole 1. So we don't calculate pole 3, and pole 4 working stress. But we calculate pole 1 working stress in this situation. Establish fork lever cross-sectional area is A=bh as showing follow

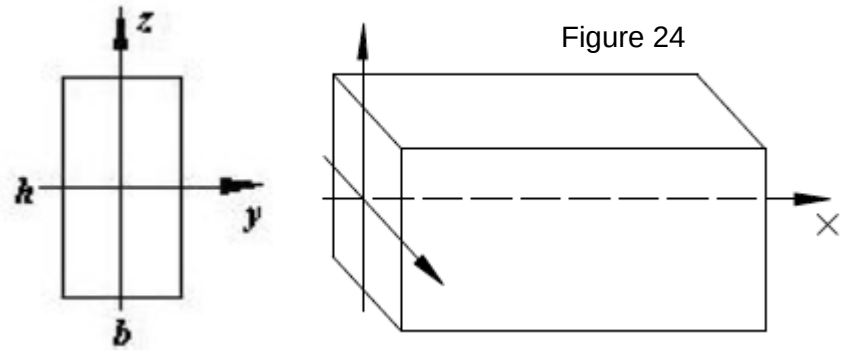


Figure 24

Figure 23. Fork lever cross-sectional area diagram [5]

The working stress in this situation is

$$M_{max}\frac{6}{bh^2} + \frac{N_c}{A} = \frac{5112 \times 6 + 54929h}{bh^2} \leq [\delta]$$

$$[\delta] = \frac{\delta_s}{n} \quad (16)$$

δ = Fork rod actual working stress (N)

[δ] =Material allowable stress (N)

δ_s=Material stress limit as for NO. 45 steel it is 340Mpa

n =Security coefficient. As general this value is greater than 1 we take 2 here. According to the experience primarily choose h= 0.1m

As you can see the type bending moment influence on working stress σ is much more significant than axial force, so we compute the largest bending moment as the main computing object. Stem 1 bear the maximum working stress. Stem 1 C section has the largest bending moment, namely C section has the largest working stress. According to the maximum stress we choose the right fork rod cross section. Plug h = 0.1 m into formula

Max working stress is $\sigma=36165/0.01b\leq 170Mpa \Rightarrow b\geq 21.3mm$.then we choose b is 25 mm, namely fork rod cross section area is hxb=100x25mm².

4.2 The selection of driving mode

Select set of connected piston rod end of the horizontal axis, according to the requirements of the overall structure layout to determine the transverse length 220 mm, because it is a single connection, its inner CD = 50, transverse diameter also should be 50 mm, but given the need to relative sliding, we should make the transverse diameter is slightly less than 50 mm, take d = 48 mm here. The width of the single earring value EW = 60 mm. Will fork lever to join to the horizontal axis of the orifice extended processing, make the increase of contact area between the appropriate to reduce the bending stress and shear stress. So according to the following figure 26 analysis of horizontal axis by stress

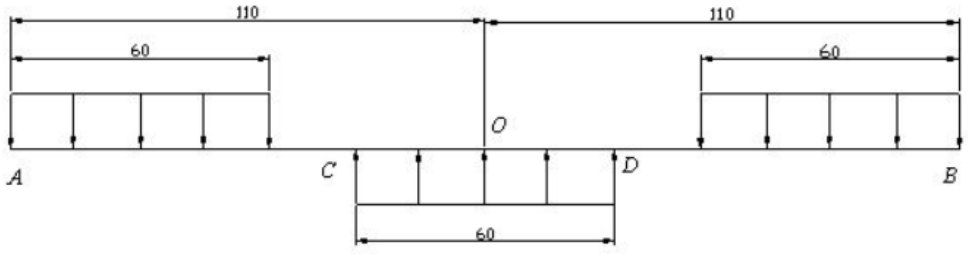


Figure 24. The horizontal axis stress diagram [1]

When the α=5°,P=113680N, then we can get result $R_A=R_B=P/2=56840N$. The force acting on the horizontal axis P is evenly distributed, and distribution distance is 60mm

. So the collection degree is q=113689/0.06N/m, and the maximum bending moment of the cross section O is M=R_Ax0.08-qx0.03x0.03/2=5402.4Nm. The shear stress of section C and D Q=R_A=56840N

The bending stress is

$$\delta = \mathrm{M}\frac{32}{\pi d^3} = 5402.4 = 161Mpa < [\delta]$$

Shear stress is

$$\mathrm{t} = \frac{Q}{\frac{\pi}{4}d^2} = \frac{56840}{\frac{\pi}{4}48^2} = 31.4Mpa < [t]$$

This formulas is from[5]<< Mechanical engineering Edited by Murat Gokcek >> As for several other pin, because the stresses of theirs are less than the value above, without changing the material selection on the basis of the diameter choosing 35 mm or 40 mm is completely possible, we do not check one by one here.

5 Marketing

Market competitiveness namely the reason customers would rather to choose my design or advantages of my design.

5.1 Market competitiveness

- Cheaper materials for manufacture

Made with glass fibre mixed with nylon (50% of glass fibre,
50% nylon). In this way, not only its price is cheap, also can reduce the wear of steel wire rope, prolong its service life, which I mentioned in 1.2 (The development of the elevator). More profits and less investment, you never be a business man if you ensure this condition of this design.

- Marketing demands

  With the rapid development in information explosion age, the number of usage of cars has been increasing with population especially in crowded China. This means there are plenty of 4S shops rising in the same time. Actually they never stop working in China and there are always traffic jams in high way even. In this case, customers need more 4s shops to repair their cars survived after traffic accidents. It is a truth joke actually.

  Besides, more car means more companies need to corporate with 4S shops in order to fasten the business, the guarantee never consider the maintenance of the stuff in 4S shops so that the quality of lifts is vital important as much as you can imagine.

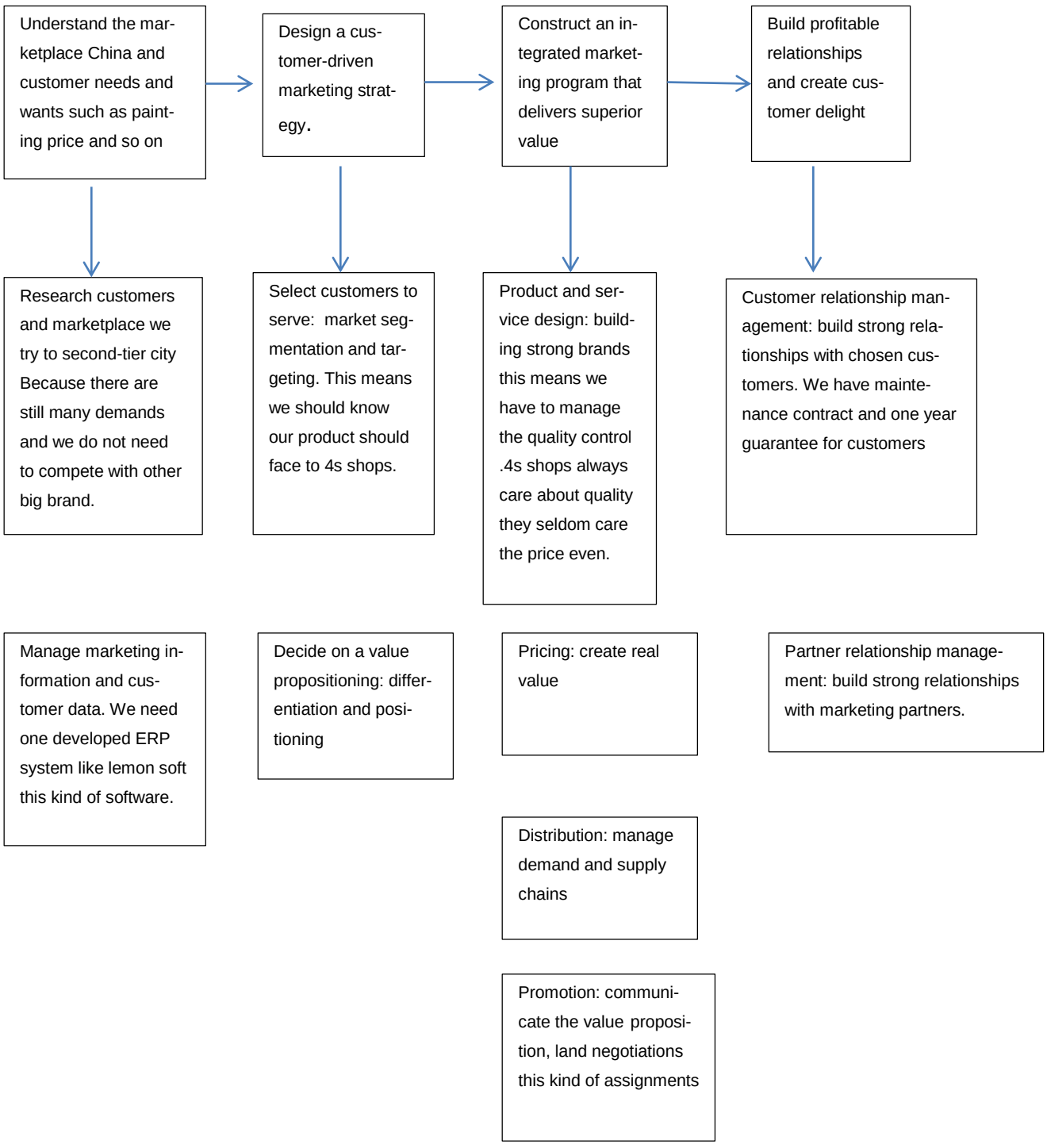
5.2 Business to business

At the beginning of business to customer we have to deal with customers relationships firstly and prepare an integrated marketing plan and program. The company's market strategy outlines which customers it will serve and how it will create value for these customers. Next, the market develops an integrated marketing program that will actually deliver the intended value to target customers. The marketing program builds customer relationships by transforming the marketing strategy into action. It consists of the firm's marketing mix, the set of marketing tools the firm uses to implement its marketing strategy [3].

5.2.1 Customer relationships

The overall process of building and maintaining profitable customer relationships is by delivering superior customer value and satisfaction. It deals with all aspects of acquiring, keeping, and growing customers especially China this kind of large people population country.

Create value for customers and build customer relationships



After we managed the customer relationship, then we start to create direct and satisfying online customer experiences we choose AliExpress to show our product to worldwide people. Because one new design means low investment to manufacture so that AliExpress is better choice, which is cheap and fast logistics.

Online Marketing

Much of the world's business today is carried out over digital networks that connect people and companies. The Internet, a vast public web of computer networks, connects users of all types all around world to each other and an amazingly large information repository. The Internet has fundamentally changed customers' notions of convenience, speed, price, product information, and service. As a result, it has given marketers a whole new way to create value for customers and build relationship with them.

We have three platforms to sell our products Taobao, Alibaba, and Tianmao. They are typical and commonly used.

5.3 Pricing

As for setting price of this machine, we should reference the price in the Internet mail. And this picture from screenshot in the Alibaba net market.

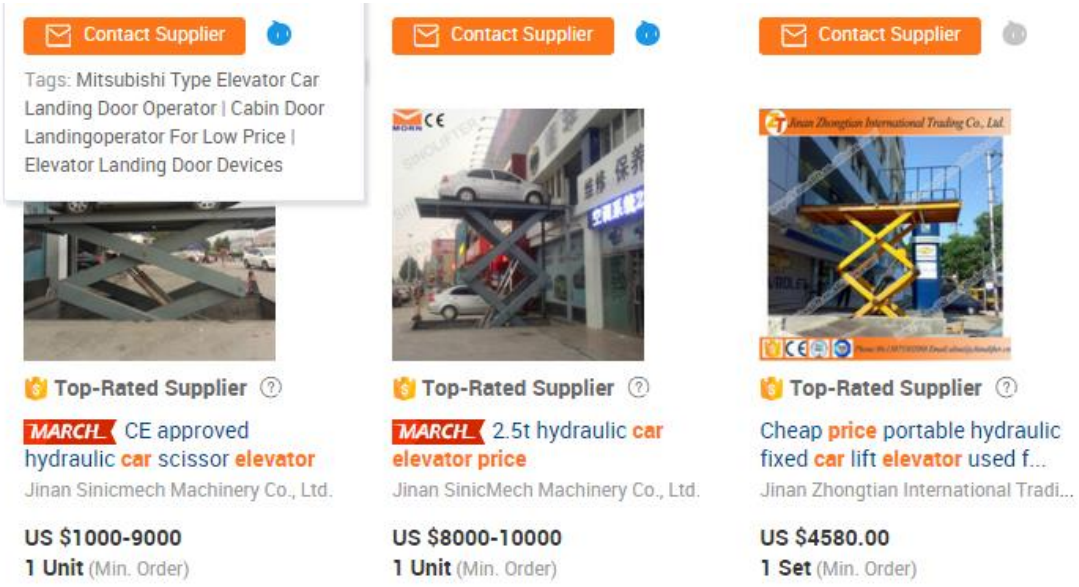


Figure 25. Normal price in market online

I choose one product from them and this picture as follow must show structure clearly.

Figure 28 real car elevator

A car lift is installed where ramps are considered space-in conservative for smaller buildings (usually in apartment buildings where frequent access is not an issue, Car workshop where judicious space usage is very important). The car platforms are raised and lowered in the similar fashion as freight elevator except for the fact that size and load carrying capacity of Lift platform is in accordance with the dimensions & weight of largest vehicle to be transported between floors. Beacon offers all types of vehicle elevator from 1500 kg for smaller cars to 5000 kg for bigger cars like SUVs and tempos.

Over the last decade Beacon has specialized the concept of vertical transportation of material through its innovative techniques and designs. One of the landmark achievements has been development of Flameproof Limit Switches to provide our client with the elevator that is suitable for hazardous area. Till date beacon has installed more than 40 flameproof elevators working at different plant locations of top pharmaceutical / chemical companies.

6 Conclusion

The design of two hinged fork scissor logistics hydraulic elevator platform, is hydraulic lifting platform in original, aims to enhancing its universality, flexibility, safety, economy and other indicators. Then it meet the needs of the flexibility to demand higher vehicle maintenance and repair the premise, through different models and accessories to meet the different corresponding logistics, manufacturing systems, car maintenance performance requirements.

By calculation of double hinged scissor lift platform service location through used parameters and dynamic parameters, and combined with concrete examples, two kinds of hydraulic cylinder arrangements of institution analysis and comparison, the final hydraulic actuators can be divided into the hydraulic cylinder or hydraulic pump. As for the former to achieve linear motion, which completes the rotary motion for pure and simple linear and rotary movement of the body these aspects, we can choose the gear type hydraulic pump and hydraulic cylinder piston rod.

In the process of design, the calculation of main parameter of system is the most important, which is directly related to the stability of the system and performance. Finally, I complete the design of simple hydraulic lifting platform.

Due to the lack of data and design time, the whole design still has some problems; some sizes precision is still not enough. About practical application it is after many adjustments to achieve the desired effect, I hope the teacher comment.

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