

Research Article

Design of Nut Picked Platform in Hill Country

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Abstract: The subject target is to design agricultural production facility. Hydraulic lifting platform consists of high quality steel, hydraulic pumps, fluid cylinders, tubing, rail wheels and other combinations. The hydraulic lifting table of maximum load is 500 kg, The lifting table is composed of two parts: Mechanism body and hydraulic system. Lifting operation and controlling system are done by a hydraulic system and hydraulic cylinders, all combinations of hydraulic system are driven by hydraulic pump. Hydraulic pump and hydraulic cylinder mainly belong to standard components. The affected maximum force of fluid cylinder is analyzed through supporting hinge frame for raising goods, torque of lifting platform is also calculated, liquid system is also studied carefully. Through comparing and checking the relative datum, the design can satisfy the demand of picking fruits.

Keywords: Hinge frame, hydraulic lifting platform, pump

INTRODUCTION

With the continuous development of current agriculture mechanization and automation, higher and higher demands of efficiency are required in the production, so the fruit hydraulic elevator, which has compact construction, convenient operation, stable lifting, is very important in the garden (Zhou *et al.*, 2014). The hydraulic lifting platform of fruit picked in the garden is a new kind elevator in China, it is mainly composed by the mechanic components and hydraulic pump, etc., the deeper research is required for it.

The dynamic and kinematic analysis should be studied in the hydraulic lifting equipment (Zhou *et al.*, 2012), the main function parameters and sizes of fluid cylinder should be determined, such as the cylinder's plunger velocity, effected time, distance of travel, etc.

Firstly, the technology parameters of hydraulic lifting needs analyzed, combining concrete examples, two kinds of fluid cylinder distribution in the mechanism are compared, according to the demand of hydraulic transporting system, the hydraulic performed component, fluid cylinder, should be calculated in the end, the loading demands of platen and fork arm are obtained through each mechanical analysis, further more, the hydraulic lifting platen could be designed according to the design demands finally.

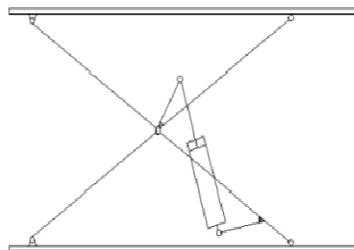


Fig. 1: First plan of hydraulic lifting platen

MATERIALS AND METHODS

Analysis of first plan: The figure is shown as Fig. 1, both ends of hydraulic cylinder which adapted in the lifting platen could move smoothly in some space, thus radial shearing force and bigger bending moment affect on the fluid cylinder, it needs the higher stability of compression bar. From the configuration, the calculation of size design and force are both complicated, it needs the bigger fluid cylinder stroke, the maximum and minimum height should be satisfied while the platen lifting and descending. On the one hand, from the consideration of safety (Castro-Garcia *et al.*, 2007), the rib part which jointing with the top action spot will effect on the axle connecting hinge frame and the axle will affect higher force on the cross of hinge frame, on the logically (Whitney *et al.*, 2000), the cross will become dangerous. On the other hand,

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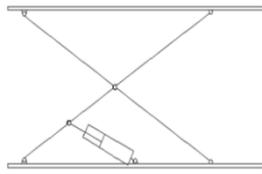


Fig. 2: Second plan of hydraulic lifting platform

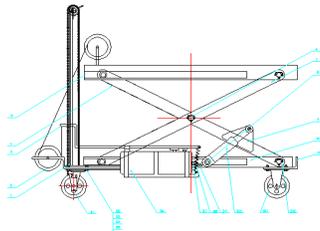


Fig. 3: Construction of hydraulic lifting platform cart
 1: Steel frame of chain wheel; 2: Pulley; 3: Hydraulic telescoping mechanism; 4: Inner tripod; 5: Loading platform; 6: Hinge connecting shaft; 7: Outer hinge frame; 8: Rotating shaft of fluid cylinder; 9: Rib plate; 10: Slide; 11: Lampstand

while the plunger of fluid cylinder is in the bottom, the higher height of lifting platen maybe need, this couldn't satisfy the design demand of lifting platen.

Analysis of second plan: The figure is shown as Fig. 2, one of the difference of second plan from first plan is: one end of fluid cylinder is fixed on the foundation through axis, the other end is fixed on the hinge frame through rib, thus the cylinder's one end can revolve round the other end in some small angles, this could ensure fluid cylinder has better stability of compression bar and the cylinder affects on the solid cross of hinge frame is relative regular.

Furthermore, in the second plan, the force affected point of cylinder is lower, so the cylinder's route only needs smaller variation, wider band promotion and demotion of object stage could be realized (Aristizabal *et al.*, 2003), the design demands could be satisfied easily, so it can save workers' physical strength and improve working efficiency.

From the above analysis of plans, the second plan of lifting platform of fruit picked machine was adopted.

Structure of hydraulic lifting platform cart and its' moving theory: Hydraulic lifting platform mainly consists of power source and machine frame, energy source part mainly contains pump and single acting cylinder, frame part is mainly composed of working platform, internal and external scissors kind hinge-frame-plate, guide groove of lamp stand, retaining plate, etc., the construction is as Fig. 3.

The moving theory of garden fruit picked hydraulic lifting platform is as bellow: Firstly, telescopic movement of the hydraulic cylinder promotes and demotes lifting platform, one end of cylinder connects

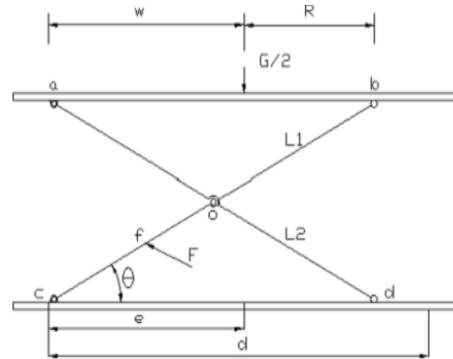


Fig. 4: General force analysis of platform

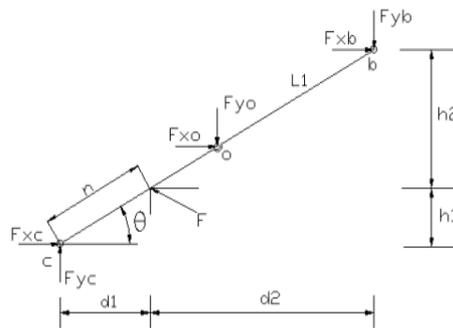


Fig. 5: Force analysis of outer-hinge-frame

with outer hinge frame through shaft and two ribs, the other end is fixed in the middle of lamp stand guide-track groove; Secondly, the connecting kind of inner and outer hinge frame with guide-track groove is as follows: In the Fig. 3, the hinge frame right end connects with up and down guide-track groove through roller fixed bearing, the left end connects with the left part of up and down guide-track groove through hinge; pump connects with fluid cylinder through oil pipe, while the hydraulic pump pulley is operated by hand, the oil pressure lifts cylinder to stretch plunger; while unloading, gravity of objects make rib compress plunger, so the plunger withdraws. From the above connecting method, rollers connecting with outer hinge frame 7 right side and inner hinge frame 4 right side scroll left and rightly, thus the working platform will increase and descend to lift and decrease fruits and human (Pezzi and Caprara, 2009).

Whole force analysis of the lifting platform: The lifting platform is affected by force as Fig. 4.

Force analysis of outer-hinge-frame: Outer-hinge-frame L1 is affected by forces as Fig. 5.

In the Fig. 5: $d_1 = n \cos \theta$, $d_2 = (2l - n) \cos \theta$; $h_1 = n \sin \theta$, $h_2 = (2l - n) \sin \theta$.

Force analysis of inner-hinge-frame: Inner-hinge-frame L2 is affected by forces as Fig. 6. In the Fig. 6: $x = l \cos \theta$, $y = l \sin \theta$; $y = x \tan \theta$.

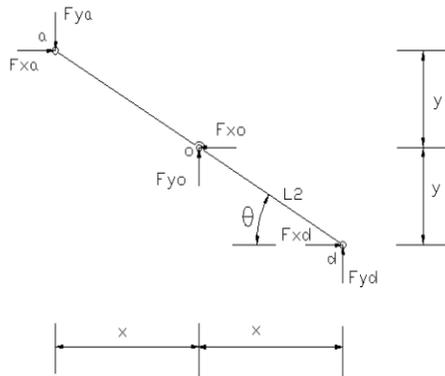


Fig. 6: Force analysis of inner-hinge-frame

The force direction is assumed at first, the upright of horizontal direction (X direction) is positive, the downright direction is negative; the right direction of verticality is positive, the left direction is negative.

RESULTS AND DISCUSSION

Maximum force of fluid cylinder and suitable angle:

While analyzing maximum force of fluid cylinder, hinge frame and foundation's angle θ is stable, when θ is different, each relative hinge joint force is different, thus the force of fluid cylinder is also different. On the otherwise, through more accuracy calculation, the force curve of fluid cylinder is as Fig. 7.

From above Figures, if the lifting platform is the lowest place, that is $\theta = 12^\circ$, the force of fluid cylinder is biggest and $T = 20635 \text{ N}$, considering the quality of working platform, platform guide-track groove, inner and outer hinge frame, etc., $K_S = 1.3$, the maximum press force of fluid cylinder is:

$$T_{max} = K_S T = 20635 \times 1.3 = 26825.5 \approx 26826 \text{ N}$$

Analysis of liquid system: The working recycle process of liquid lifting platform is: While the working platform is the lowest place, pulling hydraulic lifting mechanism by hand, the lifting platform raises, while it is the highest place, lifting platform stops raising, liquid system becomes to the keeping pressure period; While the period of platform lifting, the tilting angle of lifting platform changes continuously; when the lifting platform becomes to decrease, decreasing to the lowest point and stopping movement, to this point, a working recycle of lifting platform finishes. In the general working recycle process of lifting platform, the thrust force of fluid cylinder is biggest in the lowest place. The higher the platform, the less thrust force of fluid cylinder.

Combined with design demand, power components of liquid lifting platform cart is handled by liquid pump, execute component is single action liquid cylinder, in

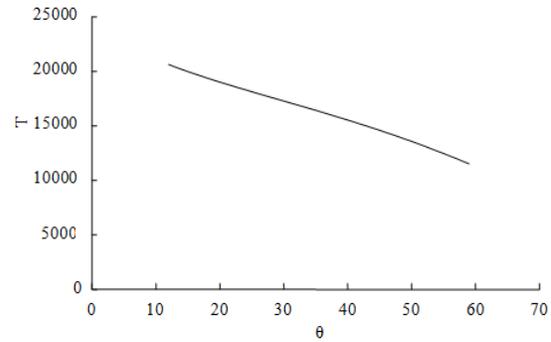


Fig. 7: Force curve of fluid cylinder

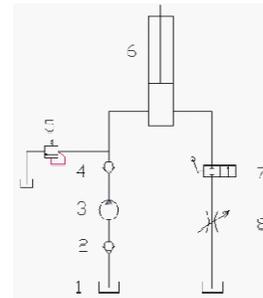


Fig. 8: Principle of liquid system

- 1: Oil tank; 2: One-way valve; 3: Handled liquid pump; 4: One-way valve; 5: Overflow valve; 6: Fluid cylinder; 7: Handled change valve; 8: Throttle valve

the meanwhile, handled liquid pump owns oil tank and unloading valve by itself, it has a part hydraulic circuit, the principle is as follows: if the working platform raises, the left of change valve 7 is connected, oil of pump 3, tank 1 fluids into the bottom end of cylinder, thus plunger of cylinder pushes out, the platform raises. if the working platform decreases, the right of change valve 7 is connected, the oil of cylinder 6 is pressed out by the gravity of weight, the oil fluids back into the tank through change valve and throttle valve, throttle valve 8 controls the velocity of oil, thus it can make lifting platform unload slowly, the principle is shown as Fig. 8.

In the meanwhile, 1, 2, 3, 4, 5, 7 and 8, respectively are concentrated on the liquid pump.

Selection of cylindle: From the above calculation, when the platform of the lifting cart is in the lowest height, $\theta = 12^\circ$, the cylinder's force is the biggest, $T_{max} = 26826 \text{ N}$, the diameter of cylinder is selected as $\phi 50 \text{ mm}$, the biggest pushing force $T_g = 31420 \text{ N}$, the outputting pressure $P = 700 \text{ kgf/cm}^2$, capacity of oil is 1 L, the cylinder weight is 12 kg, the pump owns 1 m length of higher-pressure oil pipe/joint.

Stress calculation and strength checking: Force, shearing force, bending moment of inner-hinge frame shaft are shown as Fig. 9 to 12.

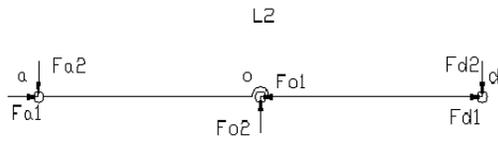


Fig. 9: Force analysis of inner-hinge frame L2

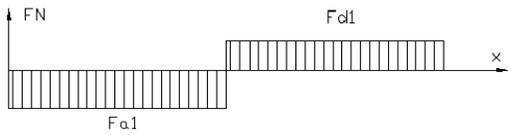


Fig. 10: Force of shaft of inner-hinge frame L2

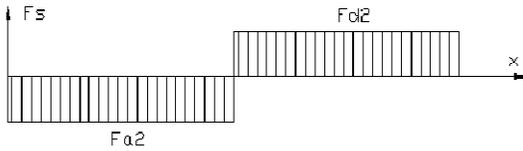


Fig. 11: Longitudinal shearing force of inner-hinge frame L2

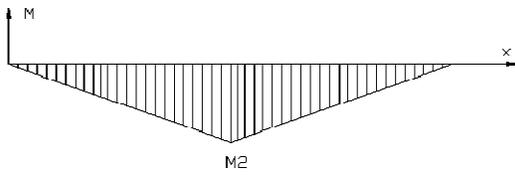


Fig. 12: Longitudinal bending moment of inner-hinge frame L2

From the above figures:

$$\sigma_2 = \frac{M_2}{W_2} = \frac{F_{a2} \cdot n}{W_2}$$

$$W_2 = \frac{b}{12} \cdot (h_1^3 - h_2^3) / \frac{h_1}{2} = \frac{b \cdot (h_1^3 - h_2^3)}{6h_1}$$

The biggest tension stress of inner-hinge frame L2:

$$\sigma_{\max 1} = \sigma_2 + \sigma_{d1}; \sigma_{d1} = \frac{F_{d1}}{b (h_1 - h_2)}$$

The biggest compression stress of inner-hinge frame L2:

$$\sigma_{\max 2} = \sigma_2 + \sigma_{a1}; \sigma_{a1} = \frac{F_{a1}}{b (h_1 - h_2)}$$

CONCLUSION

The selected material Q235 is plain carbon steel, its' yield limit $\sigma_s = 216\sim 235$ Mpa, if the selected safety factor $n_s = 2$, the allowable stress of hinge frame $[\sigma] = \frac{\sigma_s}{n_s} = 108\sim 117.5$ Mpa.

Comparing the datum, $\sigma_{m1} < [\sigma]$ and $\sigma_{m2} < [\sigma]$, from the checked results, affected stresses of inner and outer hinge frame are smaller than the allowable stress, so they can satisfy the strength demands of inner and outer hinge frame supporting the goods and the hinge frame won't fracture at least, so the selected hinge frame can satisfy design demands.

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REFERENCES

- Aristizabal, T.I.D., T.C.E. Oliveros and M.F. Alvarez, 2003. Mechanical harvest of coffee applying circular and multidirectional vibrations. T. ASAE, 46(2): 205-209.
- Castro-Garcia, S., J.A. Gil-Ribes and G.L. Blanco-Roldan, 2007. Mode shapes evaluation of trunk shakers used in oil olive harvesting. T. ASABE, 50(3): 727-732.
- Pezzi, F. and C. Caprara, 2009. Mechanical grape harvesting: Investigation of the transmission of vibrations. Biosyst. Eng., 103(3): 281-286.
- Whitney, J.D., U. Hartmond and W.J. Kender, 2000. Orange removal with trunk shakers and abscission chemicals. Appl. Eng. Agric., 16(4): 367-371.
- Zhou, J., L. Lijun and Y. Xue, 2014. Dynamic simulation analysis of forest-fruit vibratory harvester arm. Adv. J. Food Sci. Technol., 6(1): 130-134.
- Zhou, J., L. Lijun, Z. Yang, Y. Xue and S. Peng, 2012. Study of one physical property of oil-tea camellia heated by microwave. Adv. J. Food Sci. Technol., 4(4): 195-198.