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MECHANISM DESIGN OF COTTON PICKING GRIPPER

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Abstract

Cotton is most important commodity in world and it cultivate by large areas in India .cottons are pick from cotton ball by human hand which is costly and time consuming so automation of cotton picking is one way to increase profit. In this paper A mechanism of cotton picking gripper is designed for automatic picking robot. This gripper mechanism is design such that it can perform operation like holding cotton bolls stem, grasping cotton and plucking that cotton. The various dimension of gripper are obtained from virtual model. This designed gripper mechanism will used in various gripper parts design and assembly also it will use in fabrication of gripper.

Key word: four finger pivoted type grasping mechanism, slider-crank mechanism and power screw linear actuator.

I. INTRODUCTION

In this paper main goal is to design a mechanism for gripper which should be used for picking cotton from cotton bolls. Cotton is a natural cellulose fiber, has a lot of characteristics such as comfortable soft hand, good absorbency, colour retention, print well, machine-washable, dry-cleanable, good strength, drapes well, easy to handle and sew, low elasticity [1].

Figure 1: front view and top view of cotton boll

As shown in figure 1 white part which is cotton should be pick from cotton bolls for that gripper and its mechanism should be design such that goal can be achieve.

II. DESIGN METHODOLOGY

- Studying process of cotton picking from cotton bolls
- Generate idea to manual hand picking into automated gripper picking.
- Selection of mechanisms for gripper.
- According idea creates and mechanisms selected make the virtual model for holding, grasping and plucking.
- Sample Collection of cotton bolls.
- Analyse and define dimension of cotton bolls and measure sample dimensions.
- Define the parameter, opening and closing and calculation of gripper mechanism.

1. Studying process of cotton picking from cotton bolls

study was carried out of the picking motion of farmer at time of cotton picked from cotton bolls. Among that motion best motion observing is to hold the cotton bolls from stem after holding use three fingers and thumb for grasping cotton bolls and applying arm force cotton can be pluck from cotton bolls.

Figure 2: **method of cotton picking from cotton bolls**

As shown in figure 2 first holding the stem with two finger after holding grasping cotton form cotton bolls with help of four finger after holding pluck the cotton boll and put it in cotton bag.

2. Studying process of cotton picking from cotton bolls

Gripper was generated to automate above cotton picking methods for that gripper should perform three operation holding, grasping and plucking. To

perform above operation gripper require two fingers for holding, four fingers for grasping and plucking mechanism for pluck the cotton from cotton bolls.

3. Selection of mechanisms for gripper

There is various type of gripper mechanism available from that pivoted type four finger mechanisms selected for grasping operation. Fingers are open –closed with help of power screw linear actuator. A slider crank type mechanism used for plucking operation and for holding operation two finger pivoted type mechanism selected [2].

4. Virtual model of gripper

According to idea generated and selection of mechanism a virtual model was generated in creo parametric 2.0.this model was generated on weak dimension after getting design parameter model will generate with strong dimension. It has four fingers pivoted type grasping model with power screw linear actuator. It has slider crank mechanism for plucking operation and for holding it has two finger in which one is fixed and second is movable by pivot.

Figure 3: gripper model with weak dimension

5. SAMPLE COLLECTION OF COTTON BOLLS

Samples were collected from 20 farms where cotton was cultivated by farmer.

6. ANALYSE AND DEFINE DIMENSION OF COTTON BOLLS AND MEASURE SAMPLE DIMENSIONS

After sample collection sample was analysed and define some dimension which are as below,

Figure 4: cotton boll with dimension

d= diameter of cotton boll

h=height of cotton boll

l=length of cotton boll stem

b=length of cotton buds

a=length of cotton buds slot

a1=length of cotton buds slot at stem

t=thickness of steam

A 20 sample selected for measure the above dimension. A vernier calliper measurement instrument used to measure dimension of cotton bolls.

sample no	D	h	l	a	a1	b	t
1	55	58	25	36	12	27	2.5
2	61	56	20	31	10	25	2
3	70	56	24	36	9	26	3
4	71	56	26	36	10	26	3
5	52	46	15	25	11	18	2
6	53	50	16	33	11	18	2.5
7	52	55	17	24	12	19	2
8	55	52	18	33	10	22	2.5
9	55	47	16	23	10	20	2.3
10	50	43	16	23	8	20	2.5
11	54	43	15	31	11	21	2.2
12	42	41	18	20	12	20	2.5
13	65	65	16	33	11	22	3
14	57	56	24	27	11	27	2.5

15	53	52	14	31	12	21	2.5
16	58	60	19	33	10	25	2.5
17	60	45	15	22	10	19	2.5
18	62	45	15	27	10	17	3
19	57	46	21	23	11	23	2.7
20	54	45	20	28	12	21	2.5
average	56.8	50.85	18.5	28.75	10.65	21.85	2.51
max	71	65	26	36	12	27	3
min	42	41	14	20	8	17	2

Table: 1 sample dimension of cotton bolls in mm

7. Define the parameter, opening and closing and calculation of gripper mechanism.

(1) Parameter for grasping mechanism

- For grasping model four finger are at 90 angle and symmetric with horizontal axes so all finger get same parameter.
- To find parameter of grasping model considering one finger of grasping model as shown in figure,

Figure 5: four finger grasping model

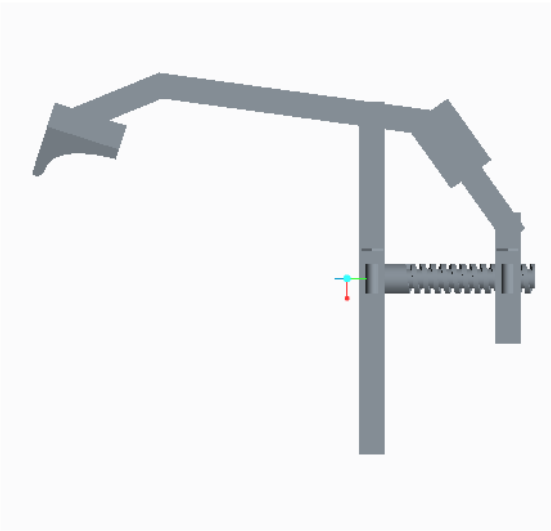

Figure 6: one finger grasping model

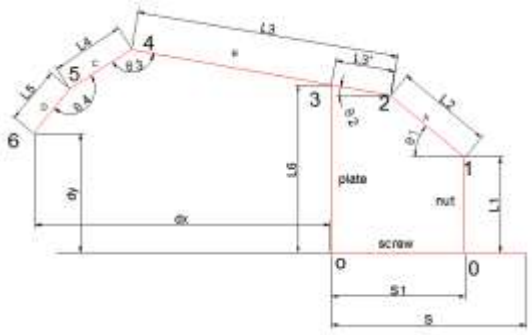

Figure 7: line diagram of one finger grasping model

Where,
L_5 = 0.5× plate length
L_1=0.5 × nut width
L_2 = length of link 2
L_3, = distance between pivot joint and link 2-3 joint
L_3 = distance between point 2-3
L_4 = distance between point 4-5
L_5 = distance between point 5-6
L_6=0.5×plate length
dy = vertical distance between center line and tips
enddx= horizontal distance between center line and tips end
Θ1= angle between link A and horizontal
Θ2= angle between link B and horizontal
Θ3= angle between link Band link C
Θ4= angle between link C and link D
S1=distance between o-0
S2=screw length
In above parameter some them are got by applying opening and closing condition of gripper and other parameter are got by trial and error method. During gripper move open to close movement following parameter change,

Θ_1 is $45 < \Theta_1 < 90$

Θ_2 is $0 < \Theta_2 < 90$

Θ_3 and Θ_4 will remain constant throughout mechanism running and it is

$\Theta_3 = 150$ $\Theta_4 = 130$

At closing position

dy=0.5× Db max=0.5×10=5 mm

dx > hmax so dx =1.5×hmax=1.5×65=97.5 ≈ 98 mm

Link E should be vertical at closing end.

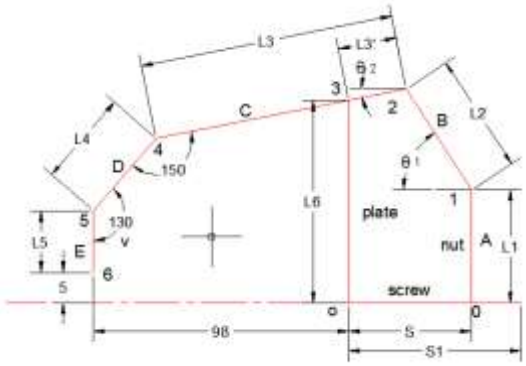

Figure 8: line diagram when gripper close

At opening position

$d_y > 0.5 \times D_{max} = 0.5 \times 71 = 35.5$ mms

$d_y = 1.5 \times 35.5 = 53.25 \approx 53$ mm

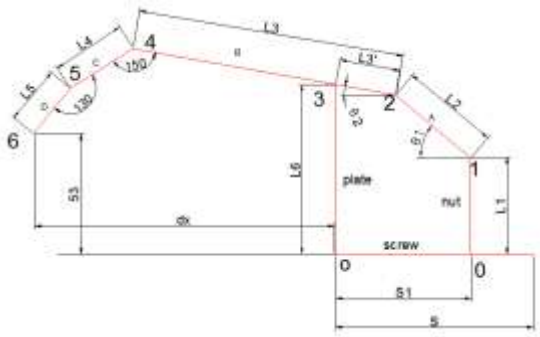

Figure 9: line diagram when gripper open

By taking above Θ_3, Θ_4, d_x, d_y value by using trial and error method with help of graphical technique other parameter are got which are shown at below figure.

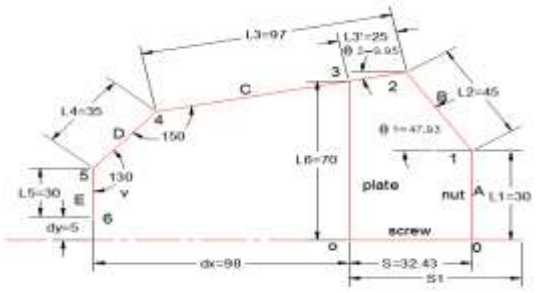

Figure 10: line diagram with parameter value when gripper close

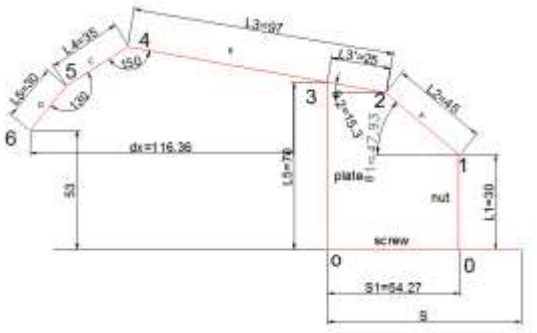

Figure 11: line diagram with parameter value when gripper is open

From above value

Linear distance movement of nut

$$S_{nut} = S_1 at\ open - S_1 at\ close = 54.27 - 32.43 = 21.81 mm$$

(2) Force calculation

The minimum grasping force is measure by experiment and it comes 6 N per finger. This force direction is vertical at the finger tips when it closes. The force requires at starting is more compare to end. In this gripper when finger going to close vertical force exerted at finger is increase with finger gets closer.

In grasping model power screw type linear actuator was selected. We have to find minimum torque require to rotate screw for that screw load must be require. In grasping mechanism design torque should apply such that more 6 N vertical force should be produce at the end for that consider 6 N vertical force apply at finger tips end as shown in figure

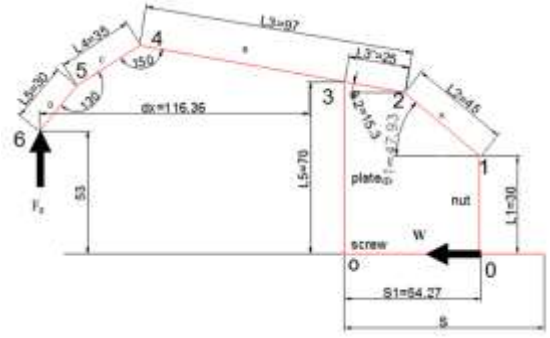

Figure 12: force acting on grasping model

Where,

F_g=grasping force per finger

W=load acting on screw

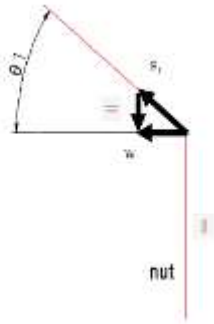

Figure 13: force acting on joint 1

Force acting on joint 1 due to load W is

$$F1 = \frac{W}{\cos(\theta_1)} = \frac{W}{\cos(47.93)} = 0.67W \qquad (1)$$

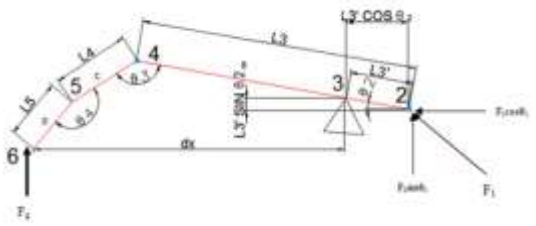

Figure 14: force acting on pivoted link

From above figure 14 taking moment about pivoted joint 3,

$$F_g \times d_x = F_1 \times COS\theta_1 (L_3 SIN\theta_2) - F_1 \times SIN\theta_1 (L_3 COS\theta_2) \quad [3]$$

$$6 \times 116.36 = F_1 \times COS(47.93)(25 \times SIN(15.3)) - F_1 \times SIN(47.93)(25 \times COS(15.3))$$

$$698.16 = 4.42F_1 - 17.9F_1$$

$$F_1 = -50.22N$$

By putting F_1 value in equation (1)

$$W = -74.96N$$

As W getting negative the direction of load is opposite side.

(3) Torque require to rotate power screw

A standard square single threaded screw with made up by untreated steel material selected which dry coefficient of friction is 0.18 [4]. screw thread size is selected according to IS-4694-1968 standard which specification as below,

nominal diameter : $d = 22\ mm$

pitch : $p = 5\ mm$

core diameter : $d_c = d - p = 22 - 5 = 17mm$

mean dia : $d_m = \frac{22+17}{2} = 19.5mm$

$$\tan\alpha = \frac{l}{\pi d_m} = \frac{5}{3.14 \times 19.5} = 0.0187$$

coefficient of friction $\mu = \tan\phi$

$$\text{power} : P = \frac{w(\tan\phi + \tan\alpha)}{(1 + \tan\phi\tan\alpha)} = \frac{w(0.18 + 0.0817)}{(1 + 0.18 \times 0.0817)} = 0.096875w$$

tork require to over come the load $T = P \times \frac{d_m}{2}$ [5]

$$T = 0.096875 \times 4 \times 74.96 = 29.047\ \text{N.mm}$$

No of motor rotation require to close the fingers

$$M_n = \frac{S_{nut}}{p} = \frac{21.81}{5} = 4.362\ rotation$$

(4) Parameter for plucking mechanism

Figure 15: plucking model

As shown in figure 3 four rounds bar is connected with grasping mechanism model. The line diagram of grasping model shown in below figure,

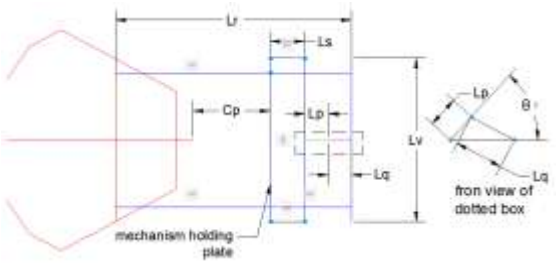

Figure 16: line diagram of plucking model

Where

L_r=length of bar

C_p=clearance between plate and screw end of plucking stock end

L_s=distance between shaft and holding plate

L_p=crank link length

Θ_r=angle between crank link and horizontal axis

L_q=connecting link length

L_v=length of mechanism holding plate

(5) Link length solution

$L_r=S+C_p+L_s+L_p+L_q$
As we know that length of screw
$S=S_{1max}$+nut width=54.27+15=69.27
S=70 mm taken
C_p=10 mm taken

Condition for slider crank mechanism
$L_s > L_p$ and $L_p < L_q$
Θ_r is 0 to 180
Plucking stork length is obtained by performing experiment and it will get 40 mm.
Lp =1.125×0.5×40=20 mm
Lq>20 so Lq=30 mm
Ls>20 so Ls=30 mm
Lr=70+10+30+20+30=160 mm
Lv=2×L5=2×70=140 mm

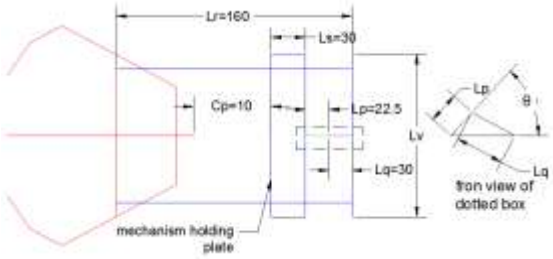

Figure 17: line diagram with dimension of plucking model

(6) Plucking force calculation

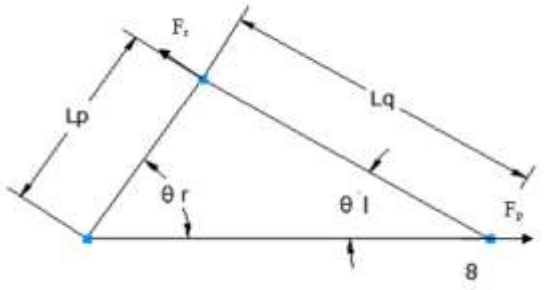

Figure 18: force acting on slider crank mechanism

F_r get maximum at $\boldsymbol{\theta}_r$ =90

Let $\boldsymbol{\theta}_l$ is the angle between connecting link and horizontal axis

$\boldsymbol{\theta}_l$ can be calculated as below,

$$\theta_l = \sin^{-1}\left(\frac{L_p}{L_q}\right)$$

$$\theta_l = \sin^{-1}\left(\frac{20}{30}\right)$$

$$\theta_l = \sin^{-1}(0.666)$$

$$\theta_l = 41.81$$

$$F_r = \frac{F_p}{COS(\theta_l)}$$

$$F_r = \frac{5}{COS(41.81)}$$

$$F_r = \frac{5}{0.7454} = 6.71N$$

Torque require to rotate crack link

$$T_c = F_r \times L_p = 6.71 \times 20 = 134.16\ N.mm$$

(7) Holding model

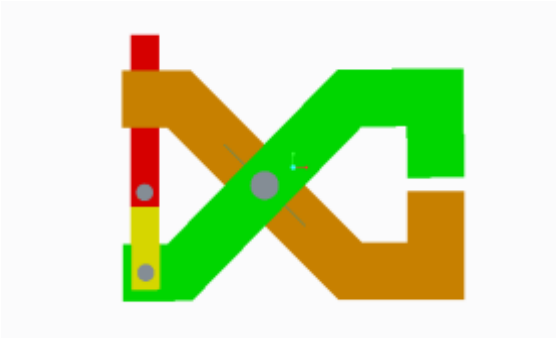

Figure 19: cotton bolls stem holding model

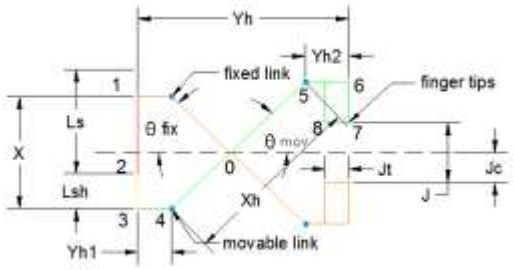

Figure 20: line diagram of holding model with parameter annotation.

A various dimension are shown in figure 20 a fixed and a movable link have same dimensions. The finger tips dimension can be obtain from cotton bolls stem dimension.

As we know b minimum =17 mm and t minimum =2 mm

From above dimension

$$J_t = 0.5 \times 17 = 8.5 \approx 8mm$$

$$J_c = 0.5 \times 2 = 1mm$$

When holding gripper closed distance between two finger tips J=2mm

When holding gripper open distance between two finger tips J=10mm

Also θ_{fix}=45 and θ_{mov} will change 45 to 90 but actually it will not change that much when gripper closed θ_{mov} =45.

As holding gripper connected at corner of holding plate from thatY_h=50 mm.

By putting above value we will get other dimension which shown in figure as below,

Taking Y_{h1}= Y_{h2}=J_t=8mm from that X_h=48 mm , J_h=17mm.

By engineering graphics method other dimension can be obtain and that dimensions are show in below figure.

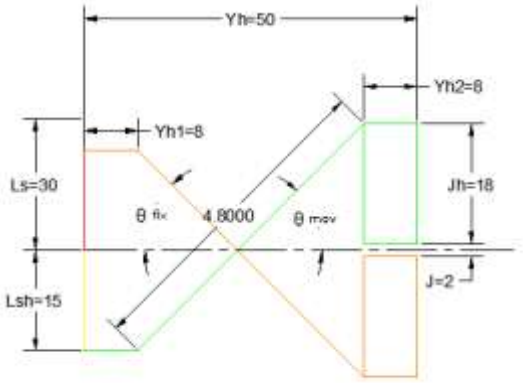

Figure 21: line diagram with dimension value when holding gripper is close.

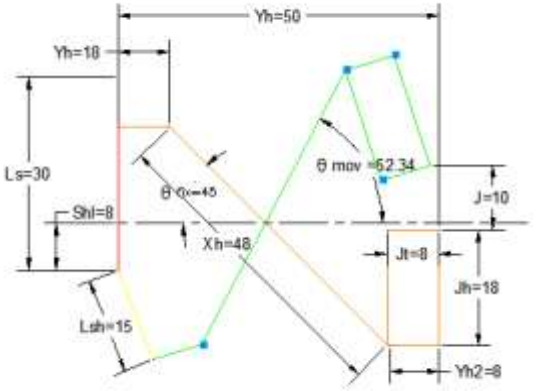

Figure 22: line diagram with dimension value when holding gripper is open.

From above figure 22 slider link distance S_{shl}=8 so slider link have move 8 mm that linear stock length for holding gripper.

This holding gripper is connected with mechanisms holding plate which is shown in below figure

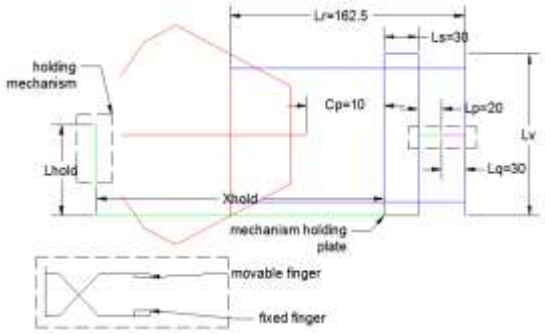

Figure 23: connection of cotton bolls stem holding mechanism with mechanism holding plate

$$X_{hold} = d_x + L_r - L_s - L_q + L_p + b_{\text{minimum}}$$

$$X_{hold} = 98 + 160 - 30 - 30 + 20 + 17 = 235mm$$

$$L_{hold} = (0.5 \times L_v) + (0.5 \times J_t)$$

$$L_{hold} = (0.5 \times 70) + (0.5 \times 8) = 39\,\text{mm}$$

CONCLUSION

By this mechanism design various parameter of gripper are achieved by which dimension of cotton picking gripper can be known and also helpful in assembling and fabrication of cotton picking gripper.

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