Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 4, Issue 3; April-June, 2017 pp. 131-135

http://www.krishisanskriti.org/Publication.html

Design and Analysis of Developed an Onion Transplanting Mechanism–A New Research Approach

Sunil R. Kewate[1], Pralhad N. Mapari[2], Vitthal R. More[3], Prasad D. Borde[4] and Suraj S. Mane[5]

[1]Mechanical Dept. Govt. College of Engg. & Research, Awasari, Dist: Pune
[2,3,4,5]Student, Mech. Dept. Govt. College of Engg. & Research, Awasari, Dist: Pune
E-mail: [1]sunilkewate@rediffmail.com, [2]pralhad.mapari@gmail.com, [3]morevitthal75@gmail.com

Abstract—*Agriculture is the most important sector of the Indian economy. Today's area is marching towards the rapid growth of agricultural as well as industrial sector. It is the most important source of employment for the majority of the work force in the country. Approximately 45 percent of the total labor force was engaged in agriculture in 1999. Releasing of work force to sectors other than agriculture is important to develop the country. The onion is one of the important commercial vegetable crops grown on a large area in India. Importation of onion will lead to drain out the economy of the country. To feed growing population is a huge challenge. So to achieve the goal of the future food demands & reduction in processing cost, the farmers have to implement the new techniques which will increase the overall crop production rate also. The comparison between the traditional sowing method and the new proposed machine is it can perform a number of simultaneous operations and has number of advantages. The main focus behind this machine is to reduce the human effort as well as problem of availability of labor & there cost of work. Mechanization of agriculture sector will lead to higher productivity with releasing of work force to other sectors. So on surveying the recent need of techniques involvement in agriculture field it is found that there is scope of development in onion transplanting process. This paper explains the proposed mechanism and design of an onion transplanting mechanism. Also it includes testing and analysis of developed mechanism to suit for small scale farmers in India. The objective of this paper is to design an onion transplanting mechanism model to transplant onion seedlings by small scale farmers in the Indian country. First research approach step was the modification of the Invention to suit for Indian farmers is that the complete design and manufacturing of mechanism model and trial has been taken for the performance.*

1. CONCEPTUAL METHODOLOGY

The operator rotates the handle and shaft 1 gets rotated through chain transmission then the vehicle moves forward. Then from the shaft 1 motion is transferred to intermediate shaft where speed is increased further using chain drive and finally to output shaft with the help of chain drive to get required reduction ratio approximately 8. Here due to this kind of mechanism speed of movement of digger i.e. plantation of plants is directly depends on the vehicle speed or speed of rotating wheels. On the output shaft there is crank plate, it is rigidly connected to output shaft and rotate with same speed of output shaft.

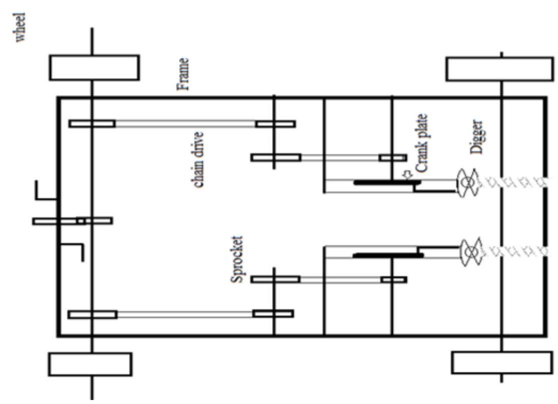

Fig. 1: Conceptual Drawing

One lever is connected to crank plate & another lever succeeding to first one is connected to digger at rear end. When one revolution of wheel is completed digger oscillates 8 times and 8 no. of seedlings are planted. Another person is required to supply seedling through hopper at proper timing.

2. DESIGN METHODOLOGY

2.1 Design of Shaft

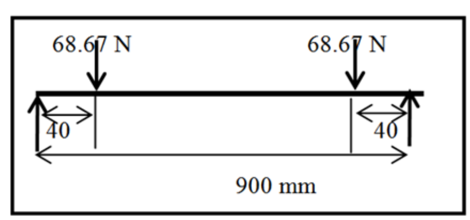

Fig. 2: Driving Shaft (Simply Supported Beam)

From PSG Design data book (Page No.69)
Considering the total weight = 28 Kg
P = 68.67 N,a = 40mm (Distance between

wheel & bearing)

Therefore, Maximum bending moment

$M_b = P \times a = 2746.8$ N-mm

Also, maximum torsional moment,

Assuming Power = 250 W & RPM (n) = 80 rpm

$M_t = \frac{(60\times10^6)\times(0.25\ KW)}{(2\pi\times80)} = 29841$ N-mm

Design of shaft based on ASME

$T_{max} = 0.18\times S_{ut} = 108$ N/mm^2

$$Tmax = \frac{16}{\pi\times d3}\sqrt{(Kb \times Mb)^2 + (Kt \times Mt)^2}$$

For gradually applied load, $K_b = 1.5$ & $K_t = 1$

d = 11.24 mm

Hence, we have selected standard shaft of diameter 12 mm.

2.2 Design of Wheel

By considering mud condition & space available

We assume diameter of wheel as 370 mm.

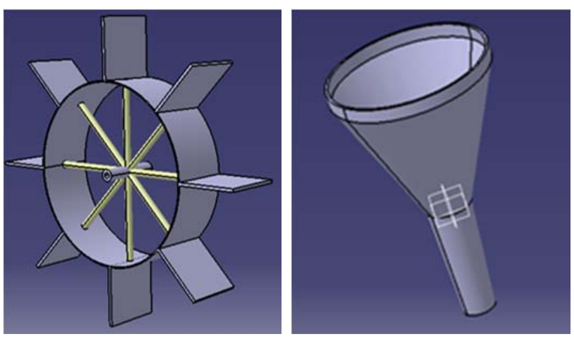

Fig. 3: Component drawing of Wheel and Hopper

Thus, Circumference = 1162.39 mm

But distance between two plants is 150 mm

No. of plants per revolution = $\frac{1162.3}{150} = 7.75$

In one oscillation of digging mechanism one seedling is planted at a time for particular digger so we need speed reduction as 1:8

2.3 Design Calculation for Digging Mechanism

The distance between two seedlings = 150 mm

Wheel diameter = 370 mm

We rotate the handle with speed = 30 rpm

Circumference of wheel = $\pi\times d$ =1162.3

Assume, No. of teeth on sprocket, $Z_1 = 32$

No. of teeth on sprocket, $Z_2 = 18$

Gear Ratio 1 = $\frac{Z1}{Z2} = 1.77$

$N_2 = (Z_1\times N_1)/Z_2 = 53.33$ rpm

Therefore, Speed of driven shaft, $N_3 = 53.33$ rpm

Now, No. of teeth on sprocket, $Z_3 = 44$

No. of teeth on sprocket, $Z_4 = 18$

Gear Ratio 2 = $\frac{Z3}{Z4} = 2.44$

$N_4 = (Z_3\times N_3)/Z_4 = 130.37$ rpm

So, Speed of center shaft, $N_4 = 130.37$ rpm

No. of teeth on sprocket, $Z_5 = 28$

No. of teeth on sprocket, $Z_6 = 9$

Gear Ratio 3 = $\frac{Z5}{Z6} = 3.11$

$N_6 = \frac{(Z5\times N5)}{Z6} = 434.56$ rpm

Here, Gear Ratio 2× Gear Ratio 3= 7.588 ≈ 8

Hence, required speed reduction 1:8 is achieved

The distance between seedlings

Theoretically Needed [T] = 150 mm

Calculated = $\frac{1162.3}{(2.44\times3.11)}$ [C]= 153 mm

Error = C – T = 3 mm

Which is negligible & within acceptable range.

2.4 Design of Chain Drive

There are total three set of chain drive transmitting motion & power from i/p to output

And in these sets there are there six types of sprockets are used having no. of tooth are

Set 1:	$Z_1 = 32$	$Z_2 = 18$
Set 2:	$Z_3 = 44$	$Z_4 = 18$
Set 3:	$Z_5 = 28$	$Z_6 = 09$

2.4.1 Design of chain for Set 1

-Standard chain selection

06B [06 = (06/16) × 25.4 = 9.525 mm pitch]

From standard table of chain series,

Series	pitch (p)	Roller dia (mm)	width
06B	9.525 mm	d_1=6.35	w = 5.72

Consider minimum Set 1 Z1 = 32 & Z2 =18

Optimum center distance C.D. = 30p to 50p

= 285 to 476 mm

And Maximum center distance = 80p = 762 mm

Assume, Center distance (a) = 750 mm

Length of chain (mm) = No. of links × pitch

$L_n = \frac{(Z1+Z2)}{2} + \frac{2a}{p} + \left[\frac{Z2-Z1}{2\pi}\right]^2 \left(\frac{p}{a}\right) = 184$ links

Now, Actual C.D. (a) [V. B. Bhandari, 548]

$$a = \frac{p}{4}\left\{\left[Ln - \frac{(Z1+Z2)}{2}\right] + \sqrt{\left[Ln - \frac{(Z1+Z2)}{2}\right]^2 - 8\left[\frac{Z2-Z1}{2\pi}\right]^2}\right] = 756.9 \text{ mm}$$

Actual no. of links, Ln = 183.9 =184 links

Actual length of chain (L) = Ln× p = 1752.6 mm

For set 2 Z_1= 44 & Z_2 = 18

For set 3 Z_1 = 28 & Z_2 = 9

Table 1: Summary of Design of chain

Set No.	Approx. C.D. Links	Actual C.D. Links	Chain Length
1	750 184	756.9 184	1752.6
2	640 166	641.7 166	1581.1
3	254 74	262.72 74	704.85

2.5 Design of Sprocket

Pitch Dia. of pinion $= \frac{p}{\sin(180/z)} = 54.85$mm

Pitch Dia. of wheel $= \frac{p}{\sin(180/z)} = 97.17$mm

Here, according to the selection of chain 06B

d_1=6.35mm & b_1=5.72mm

2.5.1 Design of Sprocket-1

D = 97.17 mm & Z = 32

1. Top diameter $(Di)_{max}$ = D+1.25p-d_1 = 102.72mm $(Di)_{min}$=D + $p\left(1 - \frac{1.6}{z}\right) - d = 91.77$mm
2. Root Diameter (D_f) = D-2r_i
   $(r_i)_{max}$ = 0.505d_1+0.069 $\sqrt[3]{d1}$
   $(r_i)_{min}$ = 0.505d_1
   D_f = 90.50 mm
3. Tooth flank radius(r_e)
   $(r_e)_{max}$ = 0.008d_1(Z^2+180 = 61.16mm $(r_e)_{min}$ = 0.12d_1(Z+2) = 25.90 mm
4. Roller seating angle = α_{max} = [120- $\frac{90}{z}$]
   = 117.18
   α_{min} = [140- $\frac{90}{z}$)] = 137.18
5. Tooth height above the pitch polygon= $h_{a\ max}$ = 0.625p-0.5d_1+0.8$\frac{p}{z}$ = 2.54mm
   $h_{a\ min}$ = 0.5(p-d_1) = 1.5875mm
6. Tooth side radius (r) = p = 9.525 mm
7. Tooth width = 0.93b_1 = 5.32 mm
8. Tooth side relief(b_a) = 0.1p to 0.15p
   = 0.9525 to 1.4286

In This way same kind of design procedure is adopted for another sprockets having no. of tooth are 44, 28, 18, 9.

2.6 Design of Bearing

We have shaft diameter = 12 mm

Therefore, inner bearing diameter = 12 mm

Select bearing of series 01

Let, outer diameter of bearing = 32 mm

Thus, 6201 type of bearing is selected

(V. B. Bhandari, page no. 575)

For this series no. of ball are 10

Also, for wheel application,

Bearing rating life = 50 million revolutions

Dynamic load capacity = C= P× (L_{10}) ^ $^{(1/3)}$

= 370 N

Static load capacity = $C_0 = \frac{d^2 Z}{5}$ = 288 N

As these load capacities are less than the capacities of bearing that we selected

So selected bearing is acceptable

2.7 Design of hopper

As the hopper is the feeding device. Its selection is depending upon the type of application. Here we have to feed a single sapling at a time having a weight of about 10 to 20 gram only so any kind of material for hopper can be used. Also requirement is to maintain minimum possible weight of digging assembly so plastic/fiber is based suitable. Also it has enough strength to hold the single plant so no chances of failure. Here on considering dimensions of plant i.e. about 20 mm in diameter & 150 to 200 mm in length we fixed the dimensions of hopper as 150 mm in diameter & 140 mm in total height.

3. ANALYSIS

Analysis means examination of mechanical structures for the safety factor or accounting the various mechanical parameters such as stresses, strains, deflection, bending moment etc. in order to obtain better performance without failure of structure.

ANSYS is most common software used for analysis of various mechanical structures.

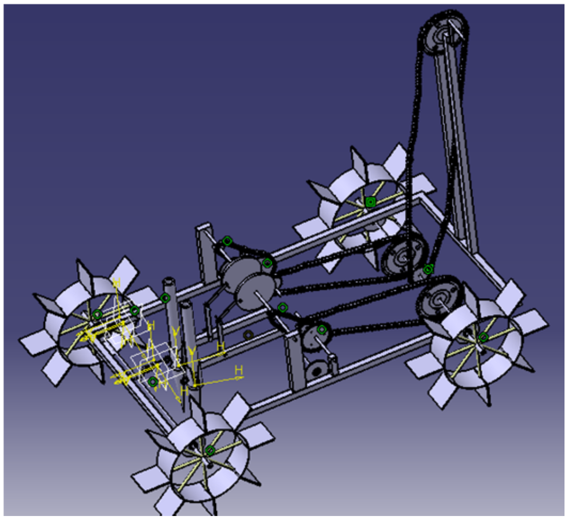

Fig. 4: Assembly of Mechanism (CATIA Drawing)

Here we have designed the various components of assembly such as shaft, bearing, sprocket, chains, hopper, etc. Among this resultant maximum stress is found to be occurring on drive shaft which is a simply supported beam, carrying wheels at ends as supports.

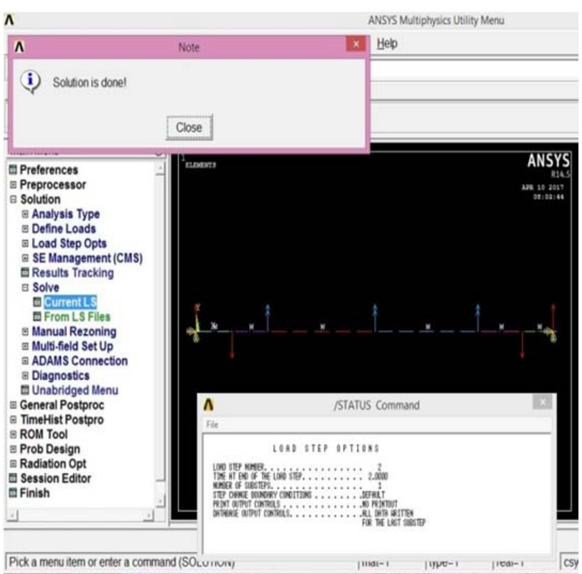

Fig. 5: Force Distribution of Drive Shaft

And therefore analysis of drive shaft is carried out using ANSYS software which shows a slight deflection of beam which is very small & can be negligible. So drivr shaft can withstand all the forces acting on it without failure happens.

Resultant analysis

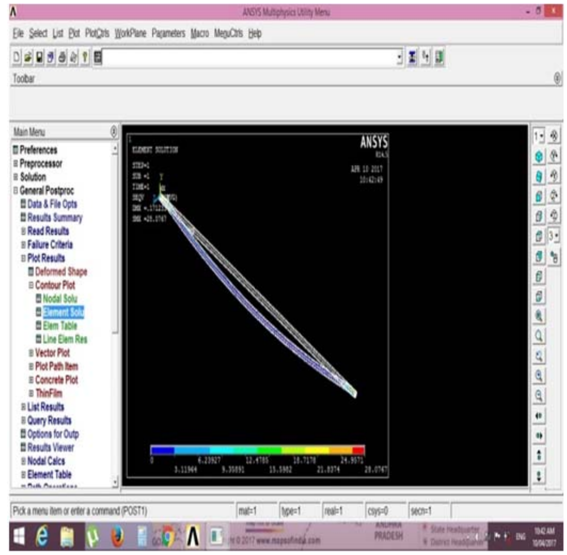

Fig. 6 Analysis of Drive Shaft

4. TESTING

4.1 Testing of different mechanisms

a) Transmission mechanism is tested successfully in which four newly design vehicles capability to rotate in muddy land is tested out. Design wheels are found to be capable to easily rotate in agricultural field due to effect of surface tension offered.

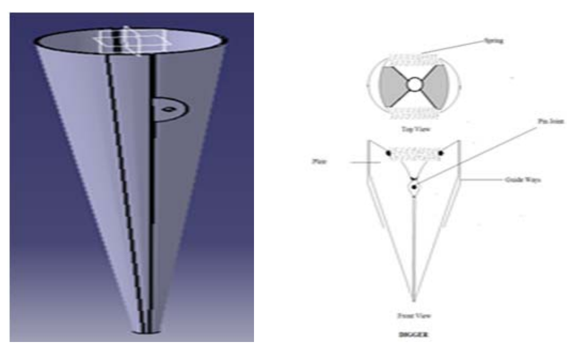

Fig. 7: Component drawing of Digger

b) In digging mechanism, digger is needed to be open in soil & close at top most position. This can be achieved with help of spring & guide way support. So that when it is at bottom most point of its length of travel then it can opens & dig the plant in soil.

c) Digger is assembly of two half cones having slots on each half cone in order to reduce resistance that will be offered by mud.

4.2 Overall Testing

Overall testing carried out in agriculture field successfully

Fig. 8: Developed mechanism Model

In this testing two men can successfully drive this machine & can plant a hector of field in 7 to 8 working hours which is 8^{th} times smaller than time required for two labors. This ultimately saves time, the cost of labors & cost of production also.

5. CONCLUSION

Research paper includes design, analysis using ANSYS for different components of an onion transplanting mechanism and various testing is carried out to adapt its suitability. On considering onion planting in wet soil by traditional method there is requirement of large no. of labor, more effort, more time and cost so there is need to have a developed mechanism which successfully satisfied all requirements of onion planting technique. First we develop conceptual mechanism which can be handling easily, maintain the row spacing with control sapling rate without wasting it, maintain the depth of plant and especially in muddy agriculture field which is specially adopted in India for plantation of onion saves labor requirement, labor cost and can be affordable for the small scale Indian farmers. With the help of this developed mechanism, we can manufacture actual onion planting machine which will fulfill the necessity of such technique.

6. ACKNOWLEDGEMENTS

"Completing a task is never a one man's effort. Several prominent people in production, academics, and administrative field have helped in this present research work. Their collective support has led in successful design and development of this work. Special thanks to the Principal and teaching staff of GCOEAR, Awasari, sponsored of this work for needful support and encouragement for making successful.

REFERENCES

[1] Design and fabrication of onion seed sowing machine by International journal on recent technologies in mechanical and automobile engineering , Volume: 2, issue:6, June2015

[2] Development and field evaluation of tractor operated onion trans planter by international journal of agriculture engineering, vol.4, no.1:52- 55 April2011

[3] Spatial distribution in a dry onion field by journal of central European agriculture vol 6 (January2005)

[4] Development And Field Evaluation Of Tractor Operated Onion Transplanter By P. A. Turbatmath, Y. C. Bhatt And P. B. Kadam Internat. J. Agric. Engg., 4(1): 52-55. Feb. 2011

[5] Tractor Driven Onion Trans Plant by Pandharinath Sarjerao More