Design & Development of Digging & Conveyor System for Self-Propelled Onion Harvester

Prof. K. C. Budhale1, A. G. Patil 2, V. S. Shirole3, S. S. Patil4, R. S. Desai5, S. B. Salavi6

1Asstt. Professor, Dept. of Mechanical Engineering, D. Y. Patil College of Engg & Technology, Kolhapur, Maharashtra, India.

Abstract – Harvesting of onion is rigorous and required huge amount of manpower and time. One of the reasons for lower productivity is insufficient power availability power availability on the farm and low level of farm mechanization. Therefore, with the intention of bringing mechanization, self-propelled onion harvester will have good performance in terms of productivity, fuel economy, less damage to crop and operator comfort. Digging system to loosen the soil and digout the onion bulb from the soil without damaging the onion. Conveying system to convey the onions from digging system to windowing system with separation of onion from soil and other foreign objects. Various factors considered for designing are depth of harvesting, size of bulbs, and most important to damage to onion bulbs.

Key Words: 1 Productivity, 2 less damage to crop, 3 Fuel economy, 4 Self-propelled, etc

1. INTRODUCTION

Digging system to loosen the soil and dig out the onion bulb from the soil without damaging the onion. Digging unit consist of blade which digs onions with soil mass, lifts it and transport to soil separation unit. A ‘V-shaped’ digging blade was design based on the draft acting on it while harvesting of onion. The working depth of blade will mainly depends upon the depth of onion in soil bed. The conveying system should be such designed that it picks the onion leaves at predetermined height and then passes to the other end of the conveying unit. The soil separating unit was attached just behind the blade to receive the dig out onions and soil-mass.

2. Digging and Conveying system

2.1 Digging Mechanism

Digging unit consist of blade which digs onions with soil mass, lifts it and transfers it to a soil separating unit. Design of the digging blade is based on draft acting on it while harvesting of onions. For harvesting of onions the depth of harvesting was depend upon depth of onion in soil bed. As per considering average biometric properties of onion the depth of harvesting are in range of 7-10 cm. So, for harvesting without damage to onion crop the depth of operation was selected as 10 cm.

The Eq. 1 is used to find out the blade geometry. Thus eqn takes different value of soil properties and tool geometry

\[ p_p = \gamma z_1^2 N_Y + c_z z_1 N_C + c_a z_1 N_C + q z_1 N_q \] ........................ (1)

Where

\[ p_p \] = Passive resistance of the soil acting at an angle of soil metal friction with the normal to interface, kN per meter width
\[ \gamma = \text{Bulk density of soil, kN m}^{-3} \]
\[ z_1 = \text{Depth of operation, m} \]
\[ c = \text{Cohesion of soil, kN m}^{-2} \]
\[ c_p = \text{Soil-interaction adhesion, kN m}^{-2} \]
\[ q = \text{Surcharge pressure on soil from surface above the failure plane, kN m}^{-2} \]
\[ N_Y, N_C, N_q \text{ and } N_C \text{ are dimensionless } N \text{-factors, which used to find the shape of soil failure surface and are thus function of angle of shearing resistance of soil (} \Phi \text{), angle of soil metal friction (} \delta \text{) and geometry of loaded interface. For determination of the draft the following assumptions were made.} \]

1. The adhesion of the soil is taken as zero i.e. \( c_a = 0 \) assuming soil metal friction zero as soil scouring over the blade.
2. The surcharge in front of the soil above the soil failure zone is negligible i.e. \( q = 0 \).

\[ P_p = \gamma z_1^2 N_Y + c_z z_1 N_C \] ........................ (2)

The values of N-factor for inter-mediae degree of roughness of the interface could be interpolated using the following equation

\[ N_\delta = \frac{N_\delta}{(N_\delta = 0)} \frac{\delta}{\varphi} \] ........................ (3)

Where,

1) \( N_\delta \) = the required value of the appropriate N-factors (\( N_6 \) or \( N_c \))
2) \( N_\delta = 0 \) and \( N_\delta = \Phi \) = the corresponding value of the N-
factor at \( \delta = 0 \) and \( \delta = \Phi \), respectively obtained from the appropriate chart.

The following values for the different parameters in the Eqn. 3 were used for the determination of the passive resistance of the blade.

\[
\gamma = 17.68 \, \text{kN/m}^3, \quad c = 30.18 \, \text{kN/m}^2, \quad \Phi = 15.64^\circ, \quad \delta = 29^\circ, \quad \alpha = 20^\circ \quad \text{and} \quad z_1 = 0.2 \, \text{m}
\]

calculated as follows:

\[
N_{\gamma} = 1.55 \quad \text{when} \quad \delta = 0
\]
\[
N_{\gamma} = 1.75 \quad \text{when} \quad \delta = \Phi
\]
\[
N_{c} = 1.65 \quad \text{when} \quad \delta = 0
\]
\[
N_{c} = 1.60 \quad \text{when} \quad \delta = \Phi
\]

Substituting the values of \( N_{\gamma} \) and \( N_{c} \) determined as above, in the Eqn.2 the passive resistance (\( P_{p} \)) per unit width of the blade was obtained as 4.65kN m\(^{-1}\). Therefore, \( P_{p} \) for an effective width of cut of 0.9 m of blade= 4.187kN.

The passive resistance \( P_{p} \) was acting at an angle of friction (\( \delta \)) with normal to the interface, hence the component parallel to the blade face (\( P_{p1} \)) and to the blade face (\( P_{p2} \)) was given as:

\[
P_{p1} = 4.83 \times \cos 74.36^\circ = 1.30\, \text{kN}
\]

and component perpendicular to the blade face (\( P_{p2} \)) was given as

\[
P_{p2} = 4.83 \times \cos 15.64^\circ = 4.65\, \text{kN}
\]

This calculated values of \( P_{p1} \) and \( P_{p2} \) were used to design of the digger blade. This value were used to find the value of bending moment. This bending values used to calculate thickness of blade.

### Table -1: Digging Blade Geometry

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade Geometry (mm)</td>
<td>140X100X8</td>
</tr>
<tr>
<td>Draft Calculations</td>
<td>Bending Load=495N</td>
</tr>
</tbody>
</table>

### Table -2: Specifications of Conveyor System

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of conveying unit</td>
<td>800mm</td>
</tr>
<tr>
<td>Angle of conveyor</td>
<td>20°</td>
</tr>
<tr>
<td>Velocity</td>
<td>2 m/s</td>
</tr>
<tr>
<td>Spacing between bars</td>
<td>0.025 m</td>
</tr>
<tr>
<td>No. of chain links</td>
<td>94</td>
</tr>
<tr>
<td>Supporting plate dia.</td>
<td>200<em>900</em>4</td>
</tr>
</tbody>
</table>

2.2 Conveying Mechanism

Conveying mechanism mainly used to separate the onion and soil. Spacing bars are arranged at a distance of 2.5cm from each other, this distance is decided considering the average diameter of onions as 4 to 6 cm. when onions along with soil mass travel through conveying unit soil will drop through spacing bars and only onions will reach the end of conveyor. Conveying chain was selected considering the load of soil and onions. Special type of chain was selected having provision for attachments of spacing bars. Major parameter of conveying mechanism is separating index and it depend on the length of conveyor and angle of conveyor.
2.3 Major Machine Performance Indices

1. Crop (Onion) digging ability - Digging efficiency: Digging efficiency will be calculated to know how efficiently the farm machine digs the onion bulbs from the field, using below equation

\[ \eta_{\text{dig}} = \frac{\text{Total no of dugged onion}}{\text{digged + undigged onion}} \]

2. Damage to Crop (Onion) - Damage %: This evaluation will determine how much damage is getting created to the crop while operating the farm machine, using below equation

\[ \eta_{\text{dam}} = \frac{\text{Total no of damaged onion}}{\text{Total no of digged onion}} \]

3. Crop Picking Efficiency - Picking efficiency: Picking efficiency of conveying unit will be calculated to know how efficiently conveying unit pick onions and will be done using below relation

\[ \eta_{\text{pick}} = \frac{\text{Total no onion picked up}}{\text{Total no of digged onion}} \]

3. CONCLUSIONS

Indian agriculture today is facing shortage of labour and increasing input cost and traditional harvesting is difficult. So, on the basis of the result of different harvesting test perform. It is clear that the mechanization of this sector is really needed so this self-propelled onion harvesting is developed. By designing and developing digging and conveying unit farming productivity increases and reduces expenses.

ACKNOWLEDGEMENT (Optional)

The authors can acknowledge any person/authorities in this section. This is not mandatory.

REFERENCES


BIographies

Prof. Kishor. C. Budhale working as an assistant professor in D. Y. Patil college of Engineering and Technology, Kolhapur, Maharashtra, India

Aniket G. Patil, Pursuing final year in Bachelor of Mechanical Engineering degree from D.Y. Patil college of Engineering and Technology, Kolhapur, Maharashtra, India

Vitthal. S. Shirole, Pursuing final year in Bachelor of Mechanical Engineering degree from D.Y. Patil college of Engineering and Technology, Kolhapur, Maharashtra, India
Swapnil. S. Patil, Pursuing final year in Bachelor of Mechanical Engineering degree from D.Y. Patil collage of Engineering and Technology, Kolhapur, Maharashtra, India

Roheet S. Desai, Pursuing final year in Bachelor of Mechanical Engineering degree from D.Y. Patil collage of Engineering and Technology, Kolhapur, Maharashtra, India

Sagar B. Salavi, Pursuing final year in Bachelor of Mechanical Engineering degree from D.Y. Patil collage of Engineering and Technology, Kolhapur, Maharashtra, India