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

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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 intension 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 loosening 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 loosening 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

$$p_p = \gamma z_1^2 N_\gamma + c z_1 N_c + c_a z_1 N_{ca} + q z_1 N_q \quad \text{.......} (1)$$

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

γ= Bulk density of soil, kN m^{-3}

z_1= Depth of operation, m

c= Cohesion of soil, kN m^{-2}

c_a= Soil-interaction adhesion, kN m^{-2}

q= Surcharge pressure on soil from surface above the failure plane, kN m^{-2}

$N\gamma$, Nc, Nq and Nca are dimensionless N- factors, which used to find the shape of soil failure surface and are thus function of angle of shearing resistance of soil (Φ), angle of soil metal friction (δ) 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. ca = 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.

$$Pp = \gamma z_1^2 N\gamma + c z_1 Nc \text{.....................} (2)$$

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

$$N\delta = N\delta = 0 \frac{(N\delta = \o)}{(N\delta = 0)} \times \frac{\delta}{\o} \ldots\ldots (3)$$

Where,

1) $N\delta$ = the required value of the appropriate N-factors ($N\delta$ or Nc)
2) $N\delta$ = 0 and $N\delta$ = Φ = the corresponding value of the N-

factor at δ = 0 and δ = Φ, 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.

γ = 17.68 kN/m-3, c = 30.18 kN/ m-2, Φ = 15.64º, δ = 29º, α = 20º and z1 = 0.2 m

calculated as follows:

Nγ = 1.55 when δ = 0
Nγ = 1.75 when δ = Φ
Nc = 1.65 when δ = 0
Nc = 1.60 when δ = Φ
Substituting the values of Nγ and Nc determined as above, in the Eqn.2 the passive resistance (Pp) per unit width of the blade was obtained as 4.65kN m-1. Therefore, Pp for an effective width of cut of 0.9 m of blade= 4.187kN.

The passive resistance Pp was acting at an angle of friction (δ) with normal to the interface, hence the component parallel to the blade face (Pp) and to the blade face (Pp1) was given as:

Pp1 = 4.83 × cos 74.36º = 1.30kN
and component perpendicular to the blade face (Pp2) was given as
Pp2 = 4.83 × cos 15.64º = 4.65kN

This calculated values of Pp1 and Pp2 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.

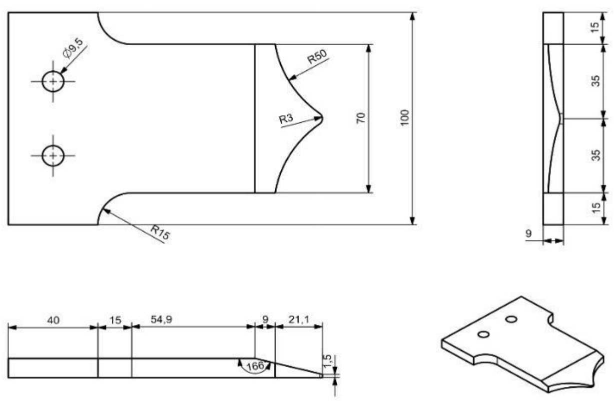
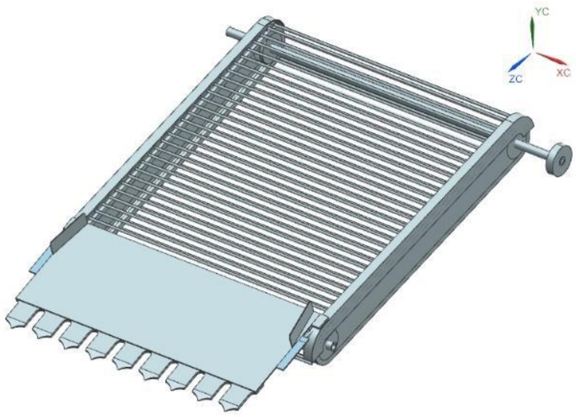


Table -1: Digging Blade Geometry

SPECIFICATION	
Blade Geometry (mm)	140X100X8
Draft Calculations	Bending Load=495N
	Soil resistance load=4916.5N
Share Blade Rake Angle	20°
Material	EN42
Material Hardness	197 HB

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.



For better separating index length of conveyor is between 700 to 1000mm and angle range between 20 to 30 degree.

Table -2: Specifications of Conveyor System

Term	Value
Length of conveying unit	800mm
Angle of conveyor	20°
Velocity	2 m/s
Spacing between bars	0.025 m
No. of chain links	94
Supporting plate dia.	200*900*4

Pitch of chain	19.5 mm
Cross section of spacing bars	OD14 & ID= mm

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

η_{dig} =(Total no of digged onion)/(digged+undigged onion)

2. Damage to Crop (Onion) -Damage %: This evaluation will determine how m0uch damage is getting created to the crop while operating the farm machine, using below equation

η_{dam} =(Total no of damaged onion)/(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

η_{pick} = (Total no onion picked up)/(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.

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