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Development of Power Tiller Operated Harvester for Small Onion (Allium Cepa var. Aggregatum)

[1] N.Nisha, [2] B.Shridar
[1] Ph.D Research Scholar, Agricultural Engineering College and Research Institute, Kumulur, 621 712- Tamil Nadu, India
[2] Professor (FMP), Agricultural Machinery Research Centre, TNAU, Coimbatore.

Abstract: **Harvesting of small onion crop from the field is an important operation in the cultivation of small onion. In our country, few models of small onion harvesters are developed in which damage of bulbs are more so it is not used by farmers. Non-availability of matching equipment for different farm operations limits the versatility of the power tillers. Hence a small onion harvester is developed as an attachment to power tiller which will increase the annual usage of power tiller in the farmers holding in addition to make the power tiller a versatile power source. The structural analysis was carried out using SolidWorks software to predict the behavior of the digging tool while working in soil using the design parameters. The performance of power tiller operated small onion harvester was field tested for harvesting CO (On) 5 variety. The field capacity was found to be 0.08 ha h-1. The cost of harvesting with the small onion harvester was Rs. 918/- ha-1. The saving in cost and time were 59.2 and 93.75 per cent respectively as compared to conventional method of manual harvesting. The break-even point (BEP) of the small onion harvester costing Rs. 9000 was 60.13 h of operation per annum. The harvesting, conveying and soil separation efficiency of the developed harvester is 97.4, 86.9 and 84 per cent..**

Keywords**: Harvesting, Small onion, power tiller, Digging tool, SOLIDWORKS, field capacity.**

I. INTRODUCTION

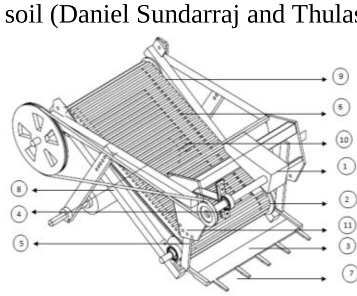
Manual harvesting of onions is a tedious, time consuming, labor intensive and costlier operation so mechanization of harvesting is essentially needed. Mechanization of onion harvesting is needed as traditionally, the well-matured bulbs are harvested by hand shovel (khurpa) which requires 21.4 per cent of total expenditure of onion cultivation. About 12.5 man hours are required in manual detopping operation of 1 MT onion bulbs hence mechanical detopping is required (Ashwini et al, 2014).. Also it is necessary to complete the harvesting operation within specified time limits for reducing harvest losses and increasing storage life (Bosoi, 1990).

II. METHODOLOGY

The power tiller of 8-13 hp is used for the development and field tests of the small onion harvester. In all the field tests the small onion harvester is operated in the low first gear by keeping the accelerator lever in a specific position for achieving the forward speed in the range of 1to 2 kph. The average fuel consumption recorded was 1.2 lhr-1.

The components of the developed small onion harvester are i, Main frame, ii, Side flange, iii, Conveyor mounting frame, iv, Digging tool, v, Conveyor assembly,
vi, Drive for the conveyor, vii, Levelling roller

The developed small onion harvester consists of a harvesting system and a conveying system. The harvesting mechanism consists of a digging tool which opens the land at first and helps in better digging of small onion crop without damage. The conveying mechanism is developed as an attachment to the digging tool frame. It consists of two endless canvas belts mounted on rollers. The delivery end roller is driven by the splined end of shaft of the rotary gear box of power tiller. The angle of conveyor in small onion harvester was given based on the angle of repose of small onion seeds which is 28.11 to 37.410 (Pandiselvam et al. 2013). the depth of operation was maintained at 100 mm for all the experiments within which all the bulbs remain in the soil (Daniel Sundarraj and Thulasidas, 1993).



Sl No.	NAME
1	ROTARY GEAR BOX
2	TOOL MOUNTING FRAME
3	TOOL
4	V-BELT AND PULLEY MECHANISM
5	CONVEYING ROLLER
6	CONVEYOR BELT
7	DIGGING BARS
8	LEVELLING ROLLER
9	CONVEYOR MOUNTING FRAME
10	CONVEYOR BARS
11	SIDE FLANGE

Figure 1: Power tiller operated small onion harvester

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Design considerations of small onion harvester

Table 1: Optimized parameters of harvester

S.No	Parameters	Values
1	Tool length	550 mm
2	Tool width	75 mm
3	Tool thickness	10 mm
4	Rake angle	15 deg
5	Speed of operation	1.5 kph
6	Tool geometry	Straight tool
7	Taper angle	15 deg

Design verification of power tiller operated small onion harvester using SolidWorks software

SolidWorks simulation provides core simulation tools to analyze the designs and to improve the quality of design. The designed components can be tested for strength and safety, and the kinematics were fully analyzed. SolidWorks simulation includes SolidWorks motion, non-linear analysis and structural analysis. Structural analysis enables to carry out structural simulation on parts and assemblies with finite element analysis (FEA) while they work to improve and validate performance and reduce the need for costly prototypes or design changes later on. Structural simulation covers a wide range of FEA problems from the performance of a part under a constant load to the stress analysis of a moving assembly under dynamic loading. The structural analysis was carried out to predict the behavior of the real structure, under the action of external forces. The design model of the digging blade with the optimized parameters from statistical analysis was used for structural analysis. The basic requirements of the blade like material property and the draft were applied during the analysis.

The digging tool was structurally analyzed for the optimized level of rake angle (15 deg) and the results were obtained in terms of stress and strain distribution in the tool. The maximum and minimum stress and strain values were obtained graphically and deformation of the tool due to resistance force created by the soil was obtained. The stress and strain distribution under the given draft force, the deformation of digging tool and the details of structural analysis carried out are given in Table 2

Table 2: Study properties

Analysis type	Static
Mesh type	Solid mesh
Zero strain temperature	298 kelvin
Units	
Unit system	SI (MKS)
Length/Displacement	mm
Temperature	kelvin
Angular velocity	Rad s-1
Pressure/Stress	N m-2
Volumetric properties	
Mass	**4.82272 kg**
Volume	**0.00061425 m-3**
Density	**7850 kg m-3**
Weight	**47.2913 N**
Material properties	
Name	**Mild Steel**
Model type	**Linear Elastic Isotropic**
Yield strength	**6.20422e+008 N m-2**
Tensile strength	**7.23826e+008 N m-2**
Elastic modulus	**2.1e+011 N m-2**
Poisson's ratio	**0.30**
Mass density	**7850 kg m-3**
Shear modulus	**7.9e+010 N m-2**
Thermal expansion coefficient	**1.3e-005 /Kelvin**
Loads and fixtures	
Entities	**2 face**
Type	**Fixed geometry**
Value	**833.85 N**

A, Stress Distribution Over The Digging Tool

The stress analysis of the digging tool was carried out at 15 deg rake angle and 85 kg draft force acting on the tool. A maximum stress of 258189 N m-2 and minimum stress of 1045.2 N m-2 were obtained and the results are shown in Table 3. The stress at each point of the blade for 15 deg rake angle is indicated in Fig 2.

Table 3 Stress analysis results

Name	Type	Minimum stress	Maximum stress
Stress	VON: von Mises Stress	1045.2 N m-2 Node: 7446	258189 N m-2 Node: 13286

B, Strain Distribution Over The Digging Tool

The strain analysis of the digging tool was carried out at 15 deg rake angle and 85 kg draft force acting on the tool. A minimum strain of 2.86127e-009 and maximum strain of 8.12813e-007 were obtained and the results are shown in Table 4. The strain at each point of the blade for 15 deg rake angle is indicated in Fig 2.

Table 4. Strain analysis results

Name	Type	Minimum value	Maximum value
Strain	ESTRN: Equivalent Strain	2.86127e-009 Element: 4667	8.12813e-007 Element: 448

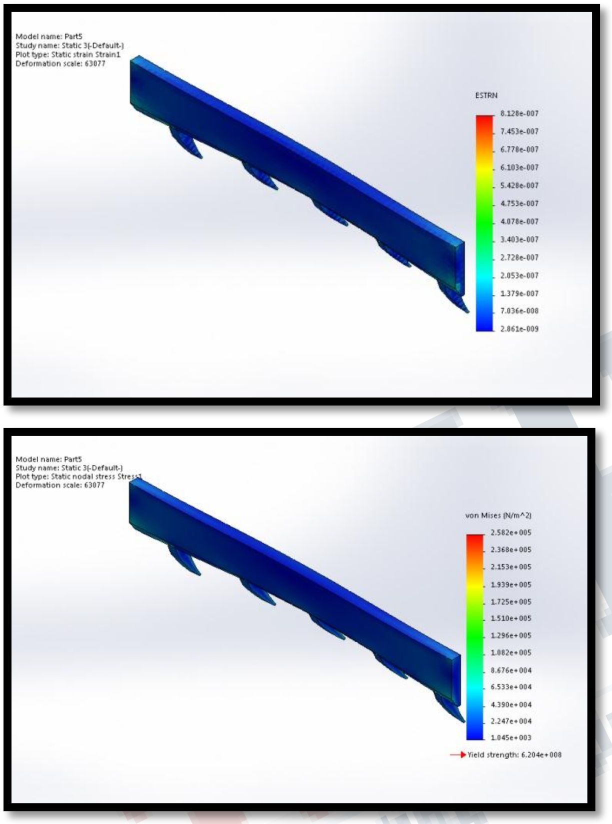

Figure 2: Distribution of stress and strain over the digging tool at 15 deg rake angle

From the structural analysis it is shown that the digging tool performs well under the optimized design considerations with minimum stress and strain with no damage to digging tool.

IV. RESULTS AND DISCUSSION

The requirement of labour for manual harvesting one hectare is 15woman days. The cost of harvesting is Rs.2250 per ha at the prevailing wage rate of Rs.150 per labour per day. From the field capacity of the unit, the cost of operation per ha is calculated as Rs.918 /-. Comparing harvesting of small onion using power tiller operated small onion harvester with manual harvesting, 59.2 per cent of cost and 93.75 per cent of time is saved. The break-even point (BEP) of the power tiller operated small onion harvester is 60.13 h per annum and 4.8 years.

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