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Design and Development Potato Harvesting Machine

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ABSTRACT

Potato has an important role in human food. It was the sixth alimentary product in the world after sugar cane, maze, rice, wheat and milk in 2011 year. In addition, potato is the third product in Iran after wheat and sugar cane in 2011 year. Therefore, any attempt in the improvement of potato harvester will be valuable. In this study, a new semi-mounted one-row potato digger with rotary blade was designed and made in the workshop of Shahrekord University. It can be connected to rotary potato graders. Potato is one of the main human alimentary resources. It was the sixth alimentary product in the world after sugar cane, maze, rice and paddy, wheat and milk (FAO, 2011) and the third product in Iran after wheat and sugar cane (Ministry of agriculture, 2011). This paper is designed based on speculative data. The future work is also considered for the development or it can be connect to any vehicle that can drive easily that upturns the productivity of the product and diminishes the human effort.

Keywords: Rotory potato, Potato, grader,

INTRODUCTION

Several field and vegetables crops, from tubers and roots below the surface of the soil. Those crops could be termed root crops and they may be classified according to the strategic important into major and minor root crops. The major root crops are potatoes, beets for sugar, sweet potatoes, onions and peanuts . Potato and peanut consider two of the major root crops. Potato is occupied in India the first position accordin g to exportation vegetables crops, yearly producing about 2.5 million ton, it is exported from about 200 to 250 ton, it is raised to 430 ton in as a fresh and frozen potatoes to Arabian and European countries, according to Agricultural Researches Station. Peanut is considered from the main summery crops, Egypt is occupied the second position at peanut production in the quantitative production was about 1.5 million ton, India is exported from about 30-35 % to Arabian and European countries, according to Agricultural Researches Station.

Developing, testing and evaluation of agricultural machines are become a big problem should be studied and that is because expanding at agricultural areas, the agricultural machines are become the main factor to increase agricultural production, mostly the agricultural machines which tested in some country is not give the same results which it obtained in another country and that is maybe because local conditions (soil, fuel, oil, workers and climate conditions), and these conditions could be influence the properties of those machines, so developing, testing and evaluation those machines again is very important under local conditions, Harvesting is one of the most critical operation for potato and peanut production. Root crops are grown below the surface of the ground, therefore it requires specially designed machines to dig and separate them from the soil. The subject of vibrating diggers has drawn the attention of many researches.

There are problems regarding potato cultivation and storage in Iran. The collection of these problems cause the cut of product yield and rise of wastage value as the mean of potato production is 24 tons/ha but this number amounts to 50 tons/ha at developed countries (Tarkesh, 2005). Head factors of low operation at harvest time and post-harvest consists in disregard to finish physiologic maturity, unavailability of labor at harvest season, unsuitable methods of harvest, gradation, transport, packing and inaccessibility on proper technical storehouse (Modareserazavi, 1996). Potato wastage values during the investigation were 48% from harvest stage to consumption and wastages of harvest implements were declared 1.72% (Nasre Isfahani, 2003). Mechanical harvest of potato relative to manual harvest causes 65% frugality at harvest time and 45% at harvest costs (Muhhamad et al., 2003).

DESIGN AND CALCULATION

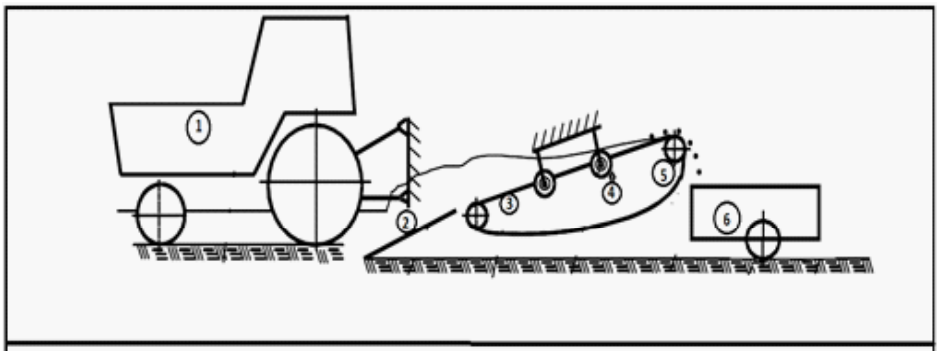

Figure1. Proposed sketch of harvesting Machine

1 – Tractor

2 – Potato Digger

3 – Elevator

4 – Vibrator/shaker

5 - Roller

6 – Collection Unit

Calculation For Digger Part

In potato harvester, maturation occurs at depth H=25cm and take clearance=5cm.

Now, angle of inclination between notches=α=40°.

Length of digger = ld =(l25+5)/sin40

ld = 47cm

No. of notches = n = 9

Clearance between notches 's' must less than diameter of potato 'Dp'.

Take s = 200mm = 2cm.

Width of digger = Bd = 90cm.

Mechanical Design of Digger

Load on digger blade = Volume of soil in digger is,

Vsoil = A×H

= (0.9×0.47) ×0.25

Vsoil = 0.12 m3

Weight of soil is,

Wsoil = Msoil × g

= ϱsoil × Vsoil × g

= 2300 ×0.12 ×9081

Wsoil = 2707.6 N.

For more safety, we assume factor of safety C 3.

Wsoil = 2707.6 × 3 = 8122.7 N V3

Moment affected on blade is, V3

M = 8122.7 × 0.45 = 3655.2 Nm

So, material used is C1118.V3

σy of C1118 = 317 Mpa.

Thickness of digger blade is,

M = (σy × Bd × t_1^2)/6

3655.2 = (317 × 10^6 × 0.9 × t^2)/6

t = 9mm.

Selection of Screw

We have selected screw material as 30C8 has a yield strength σy =400N/mm2

Now, Calculation for tensile load subjected to belt,

σt = P/A

P= π/4 D_c^2 σt

Dc= √(4P/π"σt")

From digger arrangement we got P = 8122.7N

Dc= √((4×8122.7)/(π×"400"))

Dc=5.08mm≅6mm

We selected screw of length 30 mm and core diameter as 6mm

Design of Elevator

Elevator is simple roller driven flat belt type design. Elevator elevates potatos from digger and passes it to collection unit. Design and calculation of elevator parts and material used for each part is given below with different views;

To determine this power weight of the soil is 3768N and we took 1.2 as a safety factor multiply by velocity of elevator.

$Prot.$=3768×1.2×2.5

$Prot.$=11000W

Total load on shaft W is,

W = Wsoil + Wpulley

Now,

thickness of soil on elevator,

Z = 0.57H – 0.01

= 0.57 × 0.25 – 0.01

Z = 0.1325m.

Vsoil = l × Bd × Z

= 1.4 × 0.9 × 0.1325

Vsoil = 0.167m^3

Wsoil = ϱsoil × Vsoil × g

= 0.167 × 2300 × 9.81

Wsoil = 3768 N.

Take F.S. As 2.

Wsoil = 3768 × 2 = 7536 N.

load of each flat-belt pulley Wfp

$Wf = Vpv \times \rho \times g$

$= (\pi/4) \times 0.182 \times 0.0625 \times 7861 \times 9.81$

$= 122.6\ N$

The load of soil for each shaft is equal to $(Wsoil/3)$ = 2512 N.

Vertical loads acting on the shaft

Load of soil =2512 N

Load of each flat pulley =122.6 N

Let RAV *and* RBV be the reactions at the bearings A and B respectively relative to vertical direction. We know that

$RAV + RBV = 2512 + 122.6 \times 2 = 2757.2\ N$

Taking moments about A,

$RBV \times 1 = 122.6 \times 0.95 + 2512 \times 0.5 + 122.5 \times 0.05$

$RBV = 1378.6\ N$

$RAV = 2757.2 - 1378.6 = 1378.6\ N$

We know that bending moment (B.M) at any point in fig

B.M at A, $MAV = 122.6 \times 0.05 + 2512 \times 0.5 + 122.6 \times 0.95 - 2757.2 \times 1 = = 1378.6\ N.(-)$

B.M at B, $MBV = MAV = 1378.6\ N.m$

B.M at C, $MCV = 2757.2 \times 0.95 - 1226 \times 0.9 - 2512 \times 0.45 = 1240\ N.m$

B.M at D, $MDV = 2757.2 \times 0.5 - 122.6 \times 0.45 + 122.6 \times 0.45 - 2757.2 \times 0.5 = = 0\ N.m$

B.M at E, $MEV = MCV = 1240\ N.m\ (-)$

The PTO power requirement to operate the sieve is equal to 11 KW. So tensions in each pulley

$P = (T1 - T2)V$

$11000 = (T1 - T2)\ 2.5$

$T1 - T2 = 4400N$

$T1T2 = e\mu\theta$

From standard table, for the belt and pulley selected, $\mu = 0.3$

$T1T2 = e^{*}0.3 * 3.14 = 2.6$

$T1 = 7150\ N$

$T2 = 2750\ N$

So load acting on C ,E is equal to $T1 + T2$ =7150+2750=9900 N

$RAH + BH = 9900 \times 2 = 19800\ N$

Taking moment about A ,

$RBH \times 1 = 5400 \times 0.95 + 5400 \times 0.05$

$RBH = 9900$ N ,

$RAH = 9900N$

We know that B.M at any point,

B.M at A $MAH = 9900 \times 0.05 + 9900 \times 0.95 - 9900 \times 1 = 0\ N.m$

B.M at B MBH=MAH=0

B.M at C MCH=9900×0.95−9900×0.9−9900×0.05=0 $N.m$

B.M at E MEH= MCH=0 $N.m$

Resultant B.M at C,

MC=√("MCV2+MCH2")=√("02+12402")=1240 $N.m$

and Resultant B.M at E

ME=√("MEV2+MEH2")=√("02+12402")=1240 $N.m$

We see that bending moment is maximum in C and E

Maximum bending moment M=MAV=MBV=1378.6 $N.m$

So, we choose C1045 material having σy = 407 Mpa.

〖τ〗_max=0.5 σt

〖τ〗_max=0.5 ×40

τ_max= 244.2 Mpa

From standard value table we get values of combined shock

and fatigue failure factor load is suddenly applied for minor shock as

for torsional moment, k_t =1.5

for bending moment,〖 k〗_b = 1.5

We have equation according to ASME code for shaft design as

√("(MKb)2+(TKt)2") = π/16 "×τmax×d3 "

 substituting values, we get,

√("(1378.6×1.5)2+(396×1.5)2") = π/16 "×244.2×106×d3 "

d = 0.035 m = 35mm

Since available standard shaft diameter d=35 mm

Selection of bearing for elevator shaft

Selection of Bearing :- Deep Groove Ball Bearing

Llife = (h) (N) (60 min/hr)

= (3000) (265) (60 min/hr) = 4770 × 104 rev

C=*Pd*×〖("Llife" /"(106)")〗^(1/K)

For deep groove Ball Bearing, k=3

C = 9900 ×"(477 × 104)(1/3)" /"102" = 16665.1N

From standard table, shaft diameter d=35 mm, dynamic load

rating C=16665.1(in table value is in between 15900 and 25500

So for more safety we took it as 25500)

we found the bearing designation is 6207

it has outer diameter D=72 mm, and axial width B=17 mm.

Design of Gearbox

Nin = 540 rpm

Nout = 216 rpm

Let, Zp = 19 teeth

m = 3.75

So material C1060 having σy = 813 Mpa is used.

Φ = 20°

Dp = 71.25mm

L = 80.997mm

T = 194527.7 Nmm

So we can design a bevel gear by dimensions :

Zp = 19 Teeth

Zg = 33 Teeth

Dp = 71.25mm

Dg = 145.2mm

M = 3.75

Power Required For Cutting Soil

Power requirement to cut and lift soil

$Pc = RGS \times v travel$

$RGs = a \times b \times \rho soil \times \tan(\alpha + \emptyset I)$

$RGs = 0.25 \times 0.9 \times 2300 \times \tan(40+22)$

$RGs = 974$ N

$Pc = 974 \times 1.1$

$Pc = 1072\ W$

CONCLUSIONS

It is machine which separate potatoes from soil. The vibration reaches relative seperation speed but cause less damage on potato. Mechanical harvesting of potato had a greater influence on lifted, unlifted and damaged tubers which was not favoured for crop use. The effect of the forward speed and chain speeds was remarkable on lifted and unlifted tubers. The lifted tubers tended to be increased with increasing the forward speed. While, using the forward speed of it led to the lowest lifted tubers as compared with the other forward speeds.

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