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Design of cutting and conveying units of mini-sugarcane harvester

Nikhil D. Kamalkar[1], Sunil J. Kadam[2], Sachin j. Patil[3],

Sandeep A. Padavale[4]

[1]Department of Mechanical engg

,Bharati Vidyapeeth's College of Engineering, Kolhapur,(India)

[2]HOD of Department of Mechanical engg,

Bharati Vidyapeeth's College of Engineering, Kolhapur,(India)

[3]Lecturer in Department of Mechanical engg New Polytechnic, kolhapur(India)

4Lecturer in Department of Mechanical engg New Polytechnic, kolhapur(India)

ABSTRACT

India has largest area under sugarcane and second largest country in the world in sugarcaneproduction, India produced 341.2 million tones in 2013 where world-wide production ofsugarcane was 1877.1 million tones. Land preparation, Plantation, Water and Fertilizer, management, Weed management and harvesting are important cultivation practice forsugarcane production, among which manual sugarcane harvesting is a very labour-intensiveand laborious activity.This paper is dealing with the Calculations followed to design cutting and conveying units of mini-sugarcane harvester and development of laboratory setup for testing of cutting unit

Keywords:,Force required in cutting ,Sugarcane harvesting,Total Power requirement

I.INTRODUCTION

Sugarcane is major crop in India. Majority of Indian farmer have small lands i.e. 3 to 4 hectares in average. Sugarcane planting and harvesting are major activities. In India till date these activities are mostly done manually which is time consuming and laborious job. Harvest labourers can easily fatigue due to excessive stress on the joints and muscles and are exposed to harmful pests from plantations, creating safety concerns. The advent of mechanical harvesting systems frees harvest labourers from the drudgery of field Operations. Available sugarcane harvesters are very large in size and of huge cutting capacity. Due to their size it is next to impossible to use these huge harvesters in dense and narrow row spacing crop as well as small land holding farmers can't afford costly such machines so there is a need to design and development of mini-sugarcane harvester which is helpful for both whom having small or big farms. In this article we are focus on calculations of cutting and conveying units as well as Power requirement for self-propelling ofmini-sugarcane harvester.

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II.CAD MODAL OF LABORATORY SETUP OF CUTTING UNIT

This is conceptual CAD modal of Laboratory setup for Cutting unit for estimated optimum rpm and force coming on cutting disc for smooth and good quality cutting of sugarcane. Farther calculations like Force required in cutting the sugarcane by shearing,Power requirement for respective conveyor and total Power requirement of machine are purposed with respect to following model.

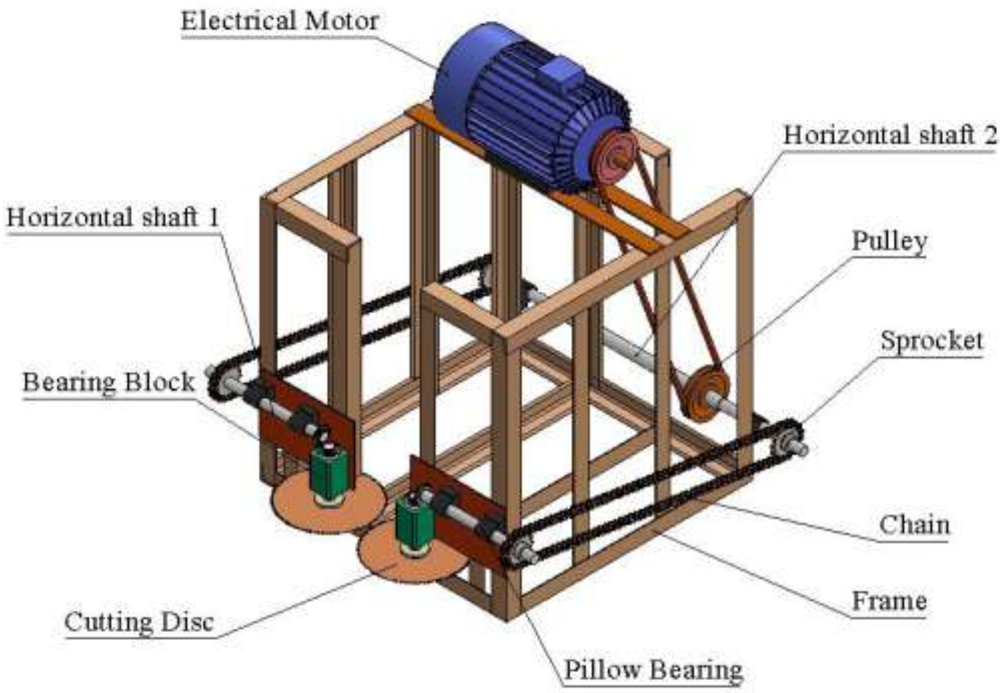

Fig 1 :CAD Model of laboratory setup

III.CALCULATIONS

3.1 Force required in cutting the sugarcane by shearing.

Shearing strength of sugarcane: 3.03 to 4.43 MPa (AVG 3.64 MPa)

Area of sugarcane stalk cutting at a time = Diameter of stalk × length of serration

= 40mm × 1mm

= 40 mm2

Shearing force required = Shear strength × Cutting area

= 4.43 × 40 (Taking maximum shear strength)

= 177.2 N (Taghijarah *et al*., 2011)

3.2 Power required to cut the Sugarcane

The optimal combination of parameters was: blade cutting velocity of 13.8 m/s, oblique

Angle of ~ 35° and disc tilt angle of ~ 27°. (Gupta and Oduori, 1992; Liu *et al*., 2007a; Song *et al*., 2006)

Diameter of Cutting Disc = 200mm

Optimal rpm for cutting sugarcane = Blade cutting velocity×60Radius×2π

$$\text{Optimal rpm for cutting sugarcane} = \frac{\text{Blade cutting velocity} \times 60}{\text{Radius} \times 2\pi}$$

$$= \frac{13.8 \times 60}{0.1 \times 2\pi}$$

= 1318.47 ~ 1320 rpm

Power Required for Cutting = $\tau \times \omega$ (4.2)

= Cutting Force×Radius $\times \frac{2\pi N}{60}$

= 172×0.1×2π×$\frac{1320}{60}$

= 2376.35 ~2380W

3.3 Power requirement for conveyor A

Effective length of belt = 22.5+41.5+37 = 101 cm

Width of belt = 5 cm; Thickness of belt = 0.5 cm.

Volume of belt = 101×5×0.5 = 252.5 cm3 = 252.5×10-6 m3

Density of belt material (cotton belt) = 1540 kg/m3

Weight of belt = 252.5×10-6 × 1540 = 0.38 kg

Volume of plastic extension on belt = 10×5×5×0.5 =125 cm3 = 125×10-6 m3

(Numbers of extensions = 10, Length×Width = 5×5 cm2, Thickness = 0.5 cm)

Weight of plastic extension = 125×10-6 × 1200 = 0.15 kg

(Density of plastic = 1200 kg/m3)

Total weight of conveyor A = 0.38+0.15 = 0.53kg = 5.2 N

Force required for bending/collecting sugarcane

Effective length of belt which drag sugarcane = 41.6 cm = 0.416 m

Number of canes to be handle by conveyor = 0.416×30 = 12.48 ~ 12

Two belts are used in conveyor; Number of canes to be handle by each belt = 6

Now,

$$E = \frac{\text{PL}^3}{3\text{DI}}$$

Where,

E - Young's modulus, Pa (85 Pa); P - Applied force (N)

L - Beam length (m); D – Deflection (m); I - Area moment of inertia

Area moment of Inertia for sugarcane having diameter of 4 cm,

$I = \frac{\pi D^4}{64}$= 1.2566×10-7 m4

Now,

L = 22 cm = 0.22 m, D = 10 cm = 0.1 m and E = 85 Pa = 85×10-6 N/m2

P = 300 N (Calculated by using equation no. 4.3)

For 6 canes, required dragging force = 6×300 = 1500 N

Total force = 5.2+1500 = 1505.2 N 13

Power required for collecting sugarcane by each belt = Force × Linear speed of belt

= 1505.2 × 0.1

= 150.52 W

Power required for conveyor A = 150.52 × 2 = 301.04 W (Bastian *et al*., 2014)

3.4 Power requirement for conveyor B

Effective length of belt which convey sugarcane = 40 cm = 0.4 m

Number of canes to be handle = 0.4×30 = 12

Average weight of a sugarcane = 1.5 kg

Weight of sugarcane to be handle by conveyor = 12×1.5 = 18 kg = 176.58 N

Now, Conveyor belt volume = 82×10×0.5 = 410 cm3 = 410×10-6 m3

(Length = 82 cm, Width = 10 cm, Thickness = 0.5 cm)

Weight of conveyor belt = 410×10-6 × 1540 = 0.63 kg

(Density of belt material = 1540 kg/m3)

Volume of plastic extension = 17×10×5×0.5 = 425 cm3 = 425×10-6 m3

(Numbers of extensions = 17, Length × Width = 10×5 cm2, Thickness = 0.5 cm)

Weight of plastic used = 425×10-6 × 1200 = 0.51 kg

Total weight of belt = 0.63 + 0.51 = 1.14 kg = 11.18 N

Total force to be applied by belt = 176.58 + 11.18 N = 187.76 N

Power required for belt = Force × Linear velocity of belt

= 187.76 × 0.556

= 104.39 W

Power requirement for conveyor B = 104.39 × 2 = 208.789 W

3.5 Power requirement for self-propelling ofmachine

We know, Brixius equation,

$$\text{MRR} = \frac{RR}{W} = \frac{1}{Bn} + 0.04 + \frac{0.5S}{\sqrt{\text{Bn}}}$$

$$Bn = \frac{\text{CIbd}}{\text{w}} \times \frac{[1 + 5(\delta/\text{h})]}{[1 + 3(\text{b/d})]}$$

Where,

MRR = Motion Resistance Ratio,

RR = Rolling Resistance,

Bn = Mobility number

CI = cone index, soil penetration resistance at a certain depth, kPa

B = tyre section width, m

d = tyre diameter, m

W = tyre load, kN

S = slip

δ = tyre deflection, m, generally on hard surface

h = tyre section height, m

Now, for tyre 90/90-19;

d = 64.46 cm = 0.6446 m, b= 9 cm = 0.09 m, δ /h= 0.2,

Let, CI = 800 kPa,

Weight of machine is about 120 kg, hence weight coming on each wheel = 60 kg = 588.6 N

Now, from equation,

$$Bn = \frac{800 \times 103 \times 0.09 \times 0.6446}{588.6} \times \frac{[1 + 5(0.2)]}{[1 + 3(0.1396)]}$$

Bn = 111.14

Now, from equation no

$$\text{MRR} = \frac{RR}{W} = \frac{1}{111.14} + 0.04 + \frac{0.5 \times 0.1}{\sqrt{111.14\ 15}}$$

RR = 0.05374 × 588.6 = 31.627 N

Now, Power requirement for self-propelling of wheel = RR × Forward velocity

= 31.627 × 0.556

= 17.58 W

Power requirement for self-propelling of machine = 17.58 ×2 = 35.16 W

[1.] 3.6 Total Power requirement of machine

[2.] Total Power requirement of machine=Power required for cutting sugarcane + Power required for conveyor A + Power required for conveyor B + Power required for self-propelling ofmachine.

a. = 2376 + 301.04 + 208.789 + 35.16

[3.] = 2920.989 W = 2.92 kW = 3.9155 hp

[4.] Now, Considering 1.25 Factor of safety,

[5.] Total Power requirement of machine = 4.89 hp

IV.CONCLUSION

Harvesting is a crucial operation of a sugarcane production system. In this article we concluded that small sugar cane harvester is suitable for small area farms and total power requirement of mini sugar cane harvesting machine should be 4.89 hp.Due its low power consumption it require less energy and less maintenance.

REFERENCES

1. Shelke, G. D., Borikar, S. S., Awathale, M. P., Khante, A. P., & Zode, M. P. (2015). Design of Sugarcane Harvesting Machine. *International Journal for Innovative Research in Science and Technology*, *1*(11), 122-127.

2. Gupta, C., &Oduori, M. (1992).Design of the revolving knife-type sugarcane basecutter. Trans. ASAE, 35(6), 1747-1752

3. Masute, R. J., Chaudhari, S. S., Khedkar, S. S., & Deshmukh, B. D. (2014). Review paper on different aspects of Sugarcane harvesting methods for Optimum performance. *International Journal of Research in Engineering and Applied Sciences IJREAS*, *2*(01), 52-55.

4. Abdel-Mawla, H. A. (2014). State of the art: Sugarcane mechanical harvesting-discussion of efforts in Egypt.

5. Patil, M., & Patil, P. D. (2013). Optimization of blade angle for cutting system of sugar cane harvester. *International indexed and referred research journal*.

6. Li, S., Shen, Z., Ma, F., Gao, J., & Yu, X. (2013). SIMULATION AND EXPERIMENT ON CONVEYING DEVICE OF CUTTING SYSTEM OF SMALL SUGARCANE HARVESTER (RESEARCH NOTE). *International Journal of Engineering-Transactions C: Aspects*, *26*(9), 975.

7. Rasul, A. (2011). *AGRICULTURAL ENTOMOLOGY* (Doctoral dissertation, UNIVERSITY OF AGRICULTURE, FAISALABAD).

8. Lin, J., Yan, W., & Lin, J. (2012). The Large-Scale Sugarcane Stripper with Automatic Feeding.

9. Siddaling, S., & Ravaikiran, B. S. Design and Fabrication of Small Scale Sugarcane Harvesting Machine.

10. Samaila, S., Al-Sharief, H. M., & Abdulkadir, S. A. (2012). Development of a Tool to Determine the Energy Required to Cut and Top Sugarcane. *AU JT,16*(1), 59-62.

11. Li, S. P., Meng, Y. M., Ma, F. L., Tan, H. H., & Chen, W. X. (2002). Research on the working mechanism and virtual design for a brush shape cleaning element of a sugarcane harvester. *Journal of materials processing technology*,*129*(1), 418-422.

12. Pilcher, J. R. (1983). The design and development of a simple cgopper harvester. *Proceedings of the South African Sugar Technologists Association–June*, 137-139.