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Design and Development of Sugar Cane Bud Chipping Machine

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Abstract

Sugarcane is a vegetative propagated Crop. In India, for conventional system of sugarcane cultivation, about 6 – 8 tones seed cane /ha is used as planting material, which comprises of about 32,000 stalk pieces having 2-3 buds. Cane cuttings with one, two or three buds known as sets are used as seed. This large mass of planting material poses a great problem in transport, handling and storage of seed cane and undergoes rapid deterioration thus reducing the viability of buds and subsequently their sprouting. One alternative to reduce the mass and improve the quality of seed cane would be to plant excised axillary buds of cane stalk, popularly known as bud chips. These bud chips are less bulky, easily transportable and more economical seed material. The bud chip technology holds great promise in rapid multiplication of new cane varieties. The left-over cane can be well utilized for preparing juice or sugar or jiggery. Despite of all these benefits of bud chips for rapid multiplication of new cane, a common problem many sugar cane farmers are facing in a developing country like India is affordable (low cost) bud chipping machine. The existing (traditional) tools used for bud chipping of sugar cane are unsafe, messy and need skill and training. The risk of injury is also too high. This necessitates the development of a bud chipping machine for sugar cane. In this direction, literature survey, patent search, market survey and concept generation was carried out. Different concepts were developed using concept generation. Among the different concepts developed, the best concept was selected based on concept selection strategy. The best concept was then prototyped using 25mm by 25mm hallow steel bar joined together by arc welding The punch torque tube was swaged to reduce the cross section of the tube. The punch tool was machined using lathe. The prototype was tested and the initial results indicated that equipment has reduced /totally eliminated the manual effort, as required for generating the sugar cane buds as compared

traditional tools. The whole equipment is very compact and simple with additional safety measures.

1. Introduction

Agriculture is one of the most significant sectors of the Indian Economy. Agriculture is the only means of living for almost two thirds of the workers in India. The agriculture sector of India has occupied 43% of India's geographical area, and is contributing 16.1% of India's GDP. Agriculture still contributes significantly to India's GDP despite decline of its share in India's GDP. There are number of crops grown by farmers. These include different food crops, commercial crops, oil seeds etc., sugarcane is one of the important commercial crops grown in India.

Sugarcane is the main source of sugar in Asia and Europe. Sugarcane is grown primarily in the tropical and sub-tropical zones of the southern hemisphere. Sugarcane is the raw material for the production of white sugar, jiggery (gur) and khandsari. It is also used for chewing and extraction of juice for beverage purpose. The sugarcane cultivation and sugar industry in India plays a vital role towards socio-economic development in the rural areas by mobilizing rural resources and generating higher income and employment opportunities. About 7.5percent of the rural population, covering about 45 million sugarcane farmers, their dependents and a large number of agricultural labors are involved in sugar cane cultivation, harvesting and ancillary activities.

There are about nine States in India where sugarcane is grown on a large extent of area. There are a number of varieties that are grown in India depending on the suitability of the soil. The area, output and yield and sugarcane cultivation is subjected to fluctuate in response to policies of the government and also conditions of cultivation. Taking these into consideration, this chapter presents a detailed discussion on the cultivation practices of sugarcane, growth of area, output and yield [1].

2. CONCEPT GENERATION

A product concept generation is an approximate description of the technology, working principles and form of the product. The degree to which a product satisfies the customers and can be successfully commercialized depends on the quality of the concepts. It is a concise description of how the product will satisfy the customer needs. The concept generation process begins with a set of customer needs and targets pecifications and results in a set of product concepts[14]-[15]

Concept generation stage involves, following five steps. The five step method is focused primarily on the overall concept for a new product. The steps are useful for overall product development concept[14]-[15].

1. **Clarifying the problem:**.

- A machine to punch 400 top 500 sugar cane buds per day
- Safer
- Ergonomical
- Reduction in time from 6 minutes to 2 minutes for the punching sugar cane buds
- Within 4000 rupees

2. **Search externally:** Gathered information from lead users, experts, literate and related product users.

3. **Search internally:** Used individual and group methods to retrieve and adopt the knowledge of the customers.

4. **Explore systematically:** Organized the thinking of the customers and synthesized the solution fragments.

5. **Reflect the solution and the process:** Identified the opportunity for improvements in subsequent iterations .

3. Concept -1 Floor bed sugar cane bud chipping machine

The concept contains a punching stainless steel tube connected to a torque lever and a spring mechanism. When the torque lever is moved down, it moves the piercing rod on the sugar cane there by punching out the sugar cane buds [15].

Fig: 3.2. Two dimensional drawing of floor bed sugar cane bud chipping machine

Table: 3.1 Merits and limitation of concept-1[18]

Sl no	Merits	Limitations
1	Low cost	Leg supported required
2	Easy maintain	Unsafe as the units might slips during operations

3.4 Concept 4: Table top punch with torque lever

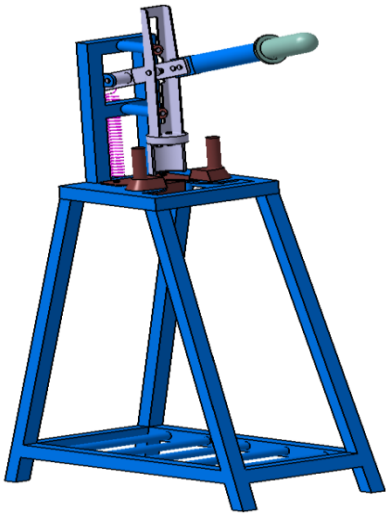


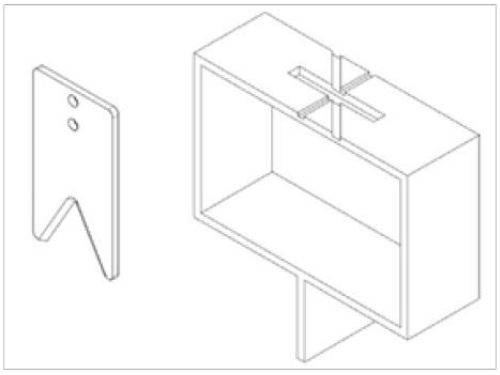
Fig: 3.6. Table top punch with Torque lever

The frame is built with hallow 25mm by 25mm hallow steel bar joined together by bolts and arc welding as shown in the figure below. The equipment mainly consists of punch operated by a lever and spring mechanism. For punching, sugar cane is placed over the holder in its

natural rest position and the punching lever is operated. The punch is so adjusted to make a - semicircular punch on the sugar cane bud [15].

4 .DESIGN

Javadtaghinezhad[16] in study of sugar cane cutting orientation for biomass products tabulated the values for peak force require to shear the sugar cane for internodes for small, medium and large sugar canes. They used a shearing device, which was originally used for cutting stalks of crops in a harvest machine. They also used a
energy efficient cuts [16] and the notch ang
blade self-centered the samples during
tension/compression testing machine (SMT-



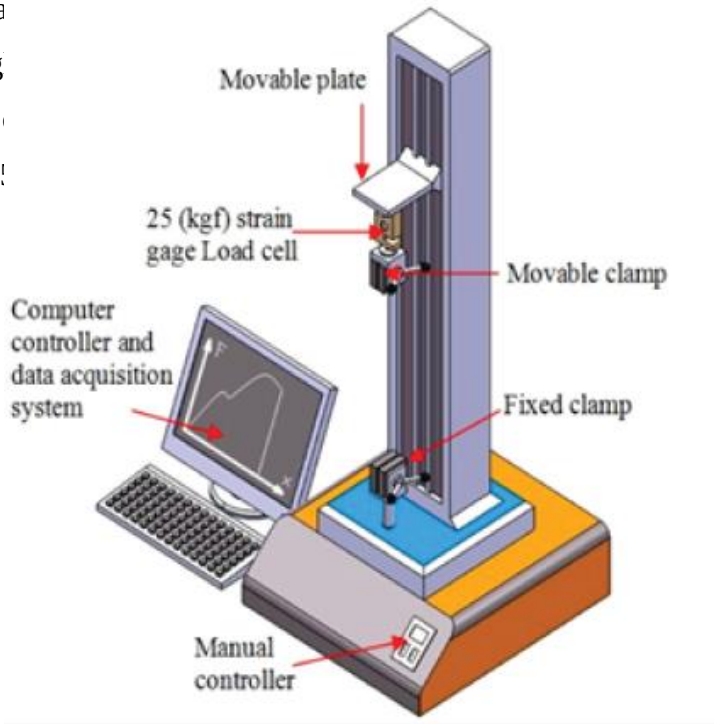


Fig: 5.1The cutting blades device and a view of fixture that used for fixing samples.AndInstron Universal Testing Machine [16].

Table 5.1:Effect of size of the cane stalks on the mechanical cutting parameters while cutting perpendicular to the stalk axis [16]

Sample	Size	Dimension(×10-3m)		Peak force (N)	Energy (kN m)	Ultimate stress (MPa)	Specific energy (kN m-1)
		2r1	2r2				
Internode	Small	17.15	17.64	313.75	2.728	1.33	11.71
	Medium	20.75	21.55	425.03	4.126	1.21	11.82
	Large	25.47	27.29	529.74	4.990	0.98	9.107
F values between sizes		0.000	0.000	0.011	0.018	0.732	0.996

5. Components design & drawings

Table 5.2 Ergonomics design for force required to punch [18]-[21]

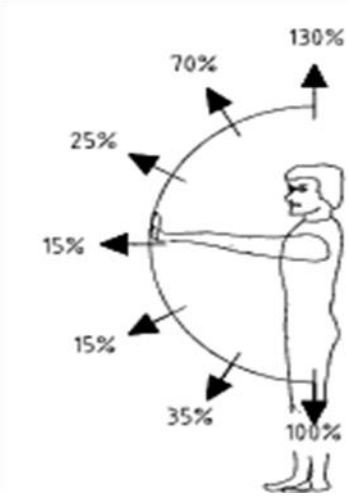


Fig:5.2 Maximum Force pushing [% Body weight]

Pushing Horizontal Bar.... age 31 - 50; Horizontal bar 20mm dia x 300 Lng 1-handed

Sex	Mean (Nm)	S.D (Nm)	Range (Nm)
Male	457,22	99,37	290,65 - 543,61
Female	314,47	136,42	215,91 - 500,26

The mean torque that can be generated by 99% percentile men is 457.22 N-m

The average force required for punching the sugar cane as per literature $F_{(pst)=}$600N [16] ,[22]-[23].

Assuming the distance from the pivot point to handle as D=450 mm

Therefore the distance from the pivot point to the handle

$T_m = F \times D$

$457 = F_{op} X\ 0.450$

$F_p = 457/0.450$

$F_p = 1015.5$ N

$F_{p>>}F_{(pst)}$

Hence the punch cater for 99% of both male and 99 % female percentile of the population

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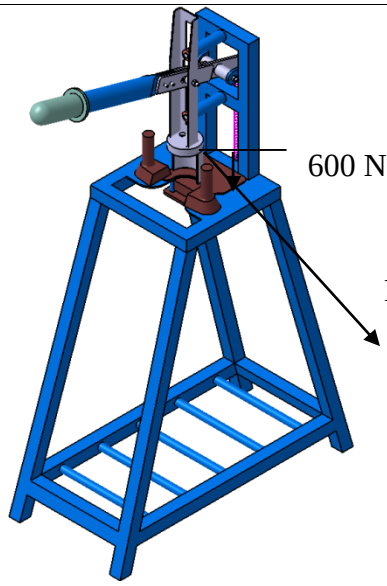

Fig:5.4punch plate under bending

σ y ,steel = 400 N/mm^2

τ y ,steel =165 N/mm^2

The average force for punching from the literature and the experiment is 600N

D_1=450mm=0.45m

$t_1 = 5\ mm$

$t_2 = 8mm$

$F_{(pst)=}$ 600 N

$M = FxD_1$

$M = 600X\ 0.450$

M = 270000N-mm

Nominal tension stress at the edge of the hole due to bending

$$\sigma_{nom} = {}^{6 * M * d}/_{t(D^3 - d^3)}$$

$$\sigma_{nom} = {}^{6 * 270000 * 60}/_{(220^3 - 60^3)}$$

$$\sigma_{nom} = {}^{2268}/_{10648000 - 216000}$$

$$\sigma_{nom} = 97200000/10432000$$

$$\sigma_{nom} = 9.13\ {}^{N}/_{mm^2}$$

$\sigma_{nom} \ll \sigma_{Allowable}$ (Hence the design is safe under bending)

Table: 5.4 Design for frame shear (punching operation) [24]-[27]

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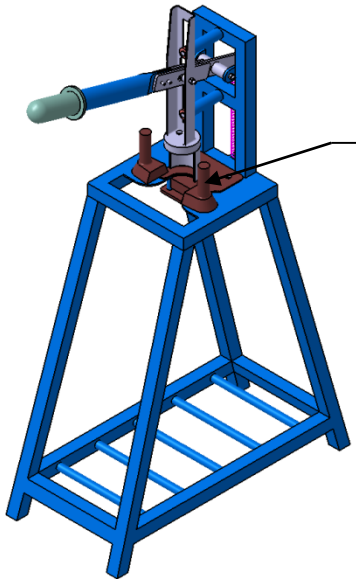

Fig:5.5.Shear stress on the plate due to punching

A= area of the frame under shear

σ y ,steel = 400 N/mm 2

τ y ,steel =165 N/mm 2

F= The average force for punching from the literature and the experiment is 600 N

$d = 60mm$

$r = 30mm$

$A = r * t$

A=30*8 mm^2

A=240 mm^2

$\tau = F/A$

τ =600/240 N/mm^2

τ =2.5 N/mm^2

$\tau << \tau_y$

Hence design is safe under shear

Table:5.5 Design for welding [26]

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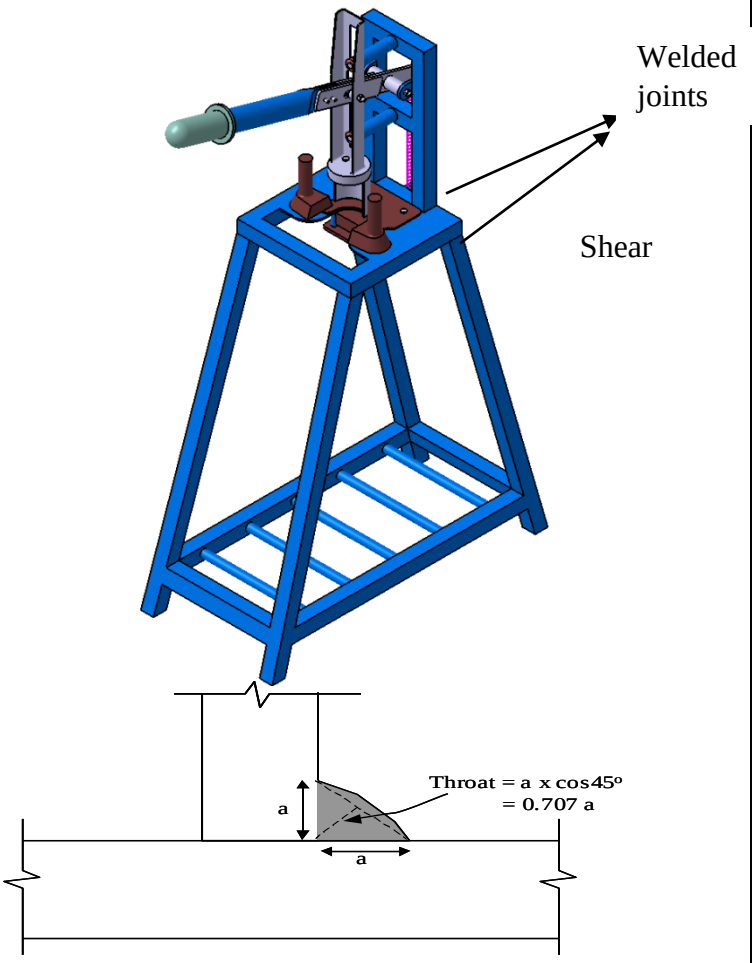

Fig:5.6 welding joints

- Fillet welds are usually fail in shear, where the shear failure occurs along a plane through the throat of the weld
- The shear strength of the fillet weld $f_s = f_e$ 0.60 f_t

  Where, f_e= 0.80

  F_t = 689.47 Mpa (The tensile strength of the weld

Electrode E70XX used in the welding process).

- Therefore, the shear strength of the fillet weld connection

a = weld thickness =4 mm

L_W=length of the weld =4*25=100

$\tau_s = f_e$x 0.60 f_t x 0.707 a L_w

τ_s = 0.80*0.60* 689.47*0.707 *4.00*100

τ_s =93591 N/mm^2 $\tau_s >> \tau_y$ Hence design is safe shear

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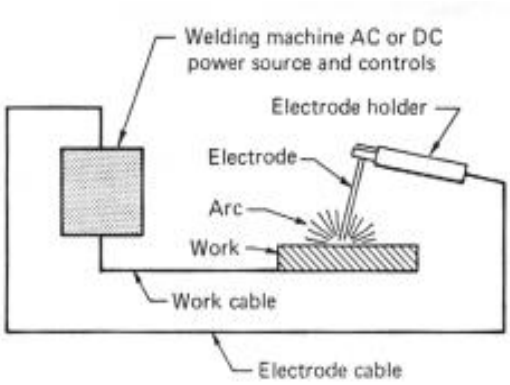
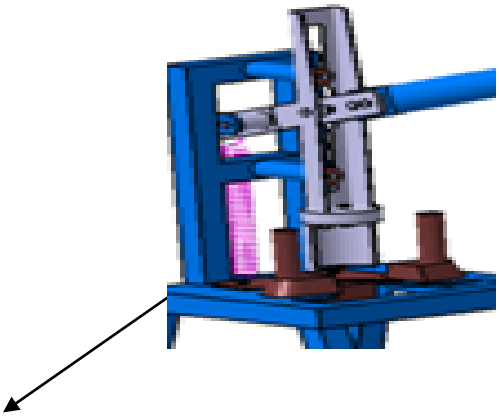
6. PROTOTYPE

6.1 Fabrication aspects of the prototype

The frame is built with hallow 25mm by 25mm hallow steel bar joined together by arc welding as shown in the figure below. The punch torque tube was swaged to reduce the cross section of the tube. The punch tool as machined using lathe.





Welding

Fig:6.1 Welding and machining of the prototype

6.2 Operating principle

The equipment mainly consists of punch operated by a lever and spring mechanism. For punching the sugar cane bud, The sugar cane is placed over the holder and the lever was lowered to generate the sugar cane bud as shown in the figure below.

Fig: 6.2. Working prototype of the sugar cane bud chipping machine

6.3 Bill of Material and costing

Table: 6.1 Bill of Material

Description	Quantity	Material
Punch	1Nos	60x60

Hallow steel bar	8 m	25x25
Weld metal filler		As required
Bolts	2Nos	Ø5
Nuts	2Nos	Ø5
Springs	1	Ø5 x10IDx40h

Note: All dimensions are in mm

6.3 Table 8.2 Prototype developments costing

Description	**Quantity**	**Material**	**Stock size**	**Cost per unit in rupees**
Punch	1Nos	60 x60	Steel	1000
Hallow steel bar	8 m	25x25	Steel	6000
Weld metal filler		As required		250
Bolts	2Nos	Ø5	Steel	30
Nuts	22Nos	Ø5	Steel	30
Springs	1	Ø5x10IDx40h	Steel	1000
Total				8310

Note: All dimensions are in mm

7. RESULTS AND DISCUSSION

In this project work extensive literature survey has been carried out to verify the originality of the concept. As a preliminary step different concepts have been developed using concept generation. Among the different concepts developed the best concept has been selected based on concept selection strategy. Also the initial results indicated that equipment has reduced

/totally eliminated the manual effort, as required for generating the sugar cane buds as compared traditional tools. The whole equipment is very compact and simple with additional safety measures.

8. CONCLUSION

When compared to the traditional sugar cane bud chipping tools the newly designed and developed sugar cane bud machine is cheaper .Also, this new machine has totally eliminated the manual effort required in punching the sugar cane machine.

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