DESIGN AND DEVELOPMENT OF SUGARCANE PEELER CUM CUTTER MACHINE

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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AGRICULTURAL ENGINEERING
(AGRICULTURAL PROCESS ENGINEERING)

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the thesis entitled **"DESIGN AND DEVELOPMENT OF SUGARCANE PEELER CUM CUTTER MACHINE"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/ publication of any University or scientific organization. The sources of material used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola **(RATHI DARPAN MANMOHAN)**

Dated: / /2021 Enrolment No: NN-339

CERTIFICATE

This is to certify that thesis entitled **"DESIGN AND DEVELOPMENT OF SUGARCANE PEELER CUM CUTTER MACHINE"** submitted in partial fulfilment of the requirement for the degree of "**Master of Technology in Agricultural Engineering (Agricultural Process Engineering)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **RATHI DARPAN MANMOHAN** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Akola
Date: / /2021

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Associate Dean
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(D) ABBREVIATIONS

%	:	per cent
Anon	:	Anonymous
ANOVA	:	Analysis of variance
Avg.	:	Average
cm	:	centimetre
c.v.	:	Coefficient of variance
dept.	:	Department
e.g.	:	For example
Engg.	:	Engineering
et al.	:	and others
etc.	:	Etcetra
Fig.	:	Figure
g	:	Gram
h	:	Hour
ha	:	hectare
hp	:	Horse power
i.e.	:	that is
IS	:	Indian Standards
kg	:	kilogram
Kw	:	kilowatt
m	:	metre
M.S.	:	mild steel
m^2	:	metre square
mg	:	milligram
min	:	minute
mm	:	millimetre
No.	:	Number
PDKV	:	Panjabrao Deshmukh Krishi Vidyapeeth
PGI	:	Post Graduate Institute
rpm	:	Revolution per minute
s	:	second

S. D.	:	Standard Deviation
Sr. No.	:	Serial number
t	:	Tonnes
viz.	:	Namely

Symbols

@	At the rate
%	Percent
&	And
Ø	Diameter
°	Degree

Greek Letters

η_p	:	Peeling Efficiency
η_c	:	Cutting Efficiency
Δ	:	Delta

(E) THESIS ABSTRACT

a) Title of the thesis	**:**	**DESIGN AND DEVELOPMENT OF SUGARCANE PEELER CUM CUTTER MACHINE**
b) Full name of student	**:**	**Rathi Darpan Manmohan**
c) Name and address of Major Advisor	**:**	**Dr. Suchita V. Gupta** Associate Professor and Head, Deptt. of Agricultural Process Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) – 444 104.
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ABSTRACT

Sugarcane Peeler cum cutter machine was designed and developed for peeling the sugarcanes and then cut it into pieces. The machine consists of peeling unit, cutting unit and power transmission unit. Rubbing action of

three pairs of wire roller brush removed the upper cover of the sugarcane. These rollers were attached to rotating disc which was attached to hollow shaft and powered with D.C. motor through V-belt. Rollers made a clearance at one end of hollow shaft. When the sugarcane passes through the clearance, it got peeled and the waste was collected from discharge unit. The clearance can be adjusted according to the diameter of the sugarcane.

Filler trials were conducted to determine optimum roller speed and roller clearance. Performance evaluation was carried out and different response parameters studied were peeling efficiency, machine output capacity and damage percentage. The machine output capacity of machine was found to be 90 Kg/h. At optimized conditions, peeling efficiency was found to be 58%. The damage percentage increased with increase in roller speed and decrease in clearance. At optimized conditions, cutting efficiency was found near 85%.

Chapter I

INTRODUCTION

1.1 Background Information

India is the land of villages. This being said the major occupation of majority of villages in India is agriculture. Near about 70% people are dependent upon agriculture. Agriculture has been the backbone of the Indian economy and it will continue to remain so for a long time. It has to support almost 17 per cent of world population from 2.3 per cent of world geographical area and 4.2 per cent of world's water resources. The economic reforms, initiated in the country during the early 1990s, have put the economy on a higher growth trajectory. Annual growth rate in GDP has accelerated from below 6 percent during the initial years of reforms to more than 8 percent in recent years. This happened mainly due to rapid growth in non-agriculture sector. The workforce engaged in agriculture in between 1980-81 and 2006-07 witnessed a very small decline; from 60.5 percent to 52 percent. [Prof. S .J. Kadam et al. 2018]

Sugarcane (*Saccharum officinarum*) is a perennial grass that thrives in hot, humid locations like Brazil and India. In tropical zone of India, Maharashtra is the major sugarcane growing state covering about 9.4 lakh ha area with production of 61.32 Million ton, whereas the productivity of Tamil Nadu is highest in tropical zones. Uttar Pradesh is the highest sugarcane producing State in sub-tropical zone having area about 22.77 Lakh ha with the production of 135.64 million tons cane whereas Haryana has highest productivity of sugarcane in sub-tropical zone. The sugar derived from sugar cane is used in syrups, juices, and molasses, but the rest of the plant can also be used in the production of environment friendly paper products and fuel such as ethanol. [S. K. Pandey et al. 2020]

The sugar cane family is made up of over 30 sugar cane varieties. The popular varieties of sugarcane in India are Co 453, Co 740, Co 997, Co 62175, Co 6304, Co 0118 and Co 0238, etc. Varieties used in Maharashtra are Co.419, Co.740, Co.M 7125 (Sampada), Co 8014 (Mahalaxmi), Co 86032 (Nira), Co- S.I.776, etc.

India is the largest producer and consumer of sugar in the World. About 45 million sugarcane farmers, their dependents and a large agricultural force, constituting 7.5 percent of the rural population, are involved in sugarcane cultivation, harvesting and ancillary activities. This enabled India to become the largest producer of sugarcane and sugar in the world leaving the other major producers Brazil and Cuba. The major sugarcane crop growing states in India are Uttar Pradesh, Bihar, Assam, Haryana, Gujarat, Maharashtra, Karnataka and Tamil Nadu. 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. [T.S. Krishnamoorthy Durgesh Nandhini 2017]

Sugarcane juice is a type of drink commonly found in Southeast Asia, South Asia and Latin America, and also in other countries where sugarcane is grown commercially. Sugarcane juice is very popular delicious drink and it is rarely available commercially in packaged form. It is extracted by crushing sugarcane between roller crusher and consumed with (or) without ice. Sugarcane juice contains water (75 to 85%), non-reducing sugars (sucrose, 10 to 21%), reducing sugars (glucose and fructose, 0.3 to 3%), organic substances (0.5 to 1), inorganic substances (0.2 to 0.6) and nitrogenous bodies (0.5 to 1). [Krishnakumar T. 2013]

It also has the highest number of calories per unit area of any plant. Fresh sugarcane juice is a popular beverage in many countries particularly in Asian region such as China, India, Malaysia and Thailand due to its taste and cheap price. It is served in many eateries from roadside stalls to five-star hotel dining halls. Additionally, sugarcane juice is used for the medication in some countries. For instance, the Indian systems of medicine have utilized it to cure jaundice and liver-related disorders. Flavonoids that can be found in sugarcane juice have the abilities to protect cells from degenerative processes and to reduce the development of health problems such as cancer and cardiovascular diseases. Although the industrial production of sugarcane juice has a business potential, the selling of sugarcane juice cannot be expanded as expected owing to its rapid quality descent. The juice concentration is deemed as a solution to lengthen the shelf-life, reduce the storage and shipping costs, and elevate the consumer safety while preserving the fresh quality of sugarcane juice. [Mr. Tagare V. S. et al. 2013]

1.2 Importance and Need of Study

Sugarcane juice is rarely available commercially in packaged form. Quality of jaggery also depends on the effectiveness of cleaning and clarification process. There are lots of impurities sticking to sugarcane stalk like trash, dust, roots, wax, gum, dry leaves, soil particles, chlorophyll and other colour compounds etc. In jaggery making, mostly sugarcane is crushed directly and all these unwanted materials go into the sugarcane juice. Although sugarcane juice clarification is performed using vegetative clarificants; yet it is advisable to clean cane prior to crushing. [Trishla Sahu and S.I. Anwar 2020]

Street vendor juices have food safety issues related to them because they are usually prepared under unhygienic conditions. Microbiological hazards that can cause serious health problems are often associated with consumption of these juices. In India, there is a constant great demand for fresh fruit juice. Street vendor juices are widely consumed by millions of people in developing countries. The demand for the production of safe food with good nutritional profile and extended shelf life is ever growing in market. Sugar cane juice is an affordable source of refreshment and energy. It is an important tool for better health due to its nutritive profile.

Sugar cane juice has many health benefits including rising innate immunity to infections. In many tropical countries, it is sold in all municipal areas, parks, bus stands and all busy market places. On vendors it is simply prepared by extracting generally by mechanical means. The final product is untreated juice ready for consumption. The cane may contain high microbial load on its surface as it is transported un-hygienically from field to the point of extraction. Inappropriate washing of sugar cane before extraction adds bacteria into extract leading to contamination. This critical process of extraction of sugar cane juice with no hygienic measures causes the occurrence of food borne diseases. [Yasir Abbas Shah et al. 2020]

In India, the process of juice extraction from cane at industrial scale involves the unwashed cane being first shredded, pressed followed by filtration of the muddy juice obtained. As a result, wax gets incorporated in the mud and it needs to be extracted and purified before application. On the other hand, sugarcane peels are first removed and then pressed for the juice in case of juice processed for the retail market. Thus, it was comprehended that if one removes peel before juice processing, extraction of wax would be a much easier and cleaner process. [Mangesh B. Inarkar and S. S. Lele 2012]

At present, sugarcane peeling is mainly by hand, Laborious, low efficiency, uneven. So, sugarcane peeling machine has been used to cut the processing time taken in order for the traders to cut cost thus gain maximum profit. Sugarcane peeling is the second process of obtaining sugarcane juice after removing the sugarcane leaf. Which is the sugarcane consisting of three parts husk enclosing shell, flesh and juice. Usually the cane is manually trimmed requires considerable physical strength and a very sharp knife and thus is dangerous procedure. Other problem associated with manual trimming process were shortage of skilled labor and the considerable amount of time that the trimming process takes. [M. M. Asim et al. 2014]

In India, peeled and chopped sugarcane has also demand for direct consumption. It is also minimally processed with the help of emerging techniques such as high pressure packaging (HPP) and modified atmosphere packaging (MAP). In these, the sugarcane is first peeled and then cut into pieces for packaging. Dentists recommend chewing of sugarcane to the persons having weak teeth as an exercise. In cities such as Hyderabad, there are roadside stalls which sell peeled and chopped sugarcane. There is very limited information is available regarding sugarcane peeling machine. Therefore, this study will be taken with the following objectives.

1.3 Objective of the study

In view of the aforesaid facts and need, this study "Design and Development of Sugarcane Peeler cum cutter" will undertake with the following objectives

1. To design and fabricate sugarcane peeler cum cutter
2. To evaluate the performance of sugarcane peeler cum cutter

1.4 Hypothesis or Assumptions:

Design, development of sugarcane peeler cum cutter and its performance evaluation can obtain the requirements of roadside stall vendors, jaggery producers and packers. Sugarcane peeler cum cutter eliminates unhygienic operations, labour and drudgery with more efficiency. This machine provides higher quality product with more profits.

1.5 Scope and Limitation:

Indigenous techniques such as hand peeling and knife peeling are very time consuming and most of the times they are unhygienic. By using sugarcane peeler cum cutter peeling technique, roadside stall vendors, jaggery producers and packers saves their cost of peeling resulting in more profit, dependence over labours and self-security from peeling knifes. This investigation includes the design of sugarcane peeler, development for cutting mechanism and its performance evaluation.

This study strongly supports entrepreneurial behavior. Because, with increase in awareness about nutritional values of sugarcane juice and raw sugarcane, there is much more trend toward the consumption of peeled sugarcane juice. Minimally processed sugarcane have demand in foreign countries so, one can start enterprise for exporting minimally processed sugarcane.

The machine should be simple in design, portable and light weight, easy in fabrication and operation. Cost of machine should be reasonable and within the range for user. The problems associated with the existing machines and processes are there is very less peeling efficiency, processes are unhygienic and do not have ergonomic approach. The machines do not have uniform peeling and they are very unhandy.

The newly developed machine should have operational flexibility in which it can be easily used with existing machines. This result into decrease in labour and the time because, the existing techniques are very time and labour consuming.

Chapter II

REVIEW OF LITERATURE

A comprehensive reviews and past relevant literature to this study are presented in the chapter review of literature. The works of various researches related to the present study have been reviewed briefly us under in following sub section.

1. Sugarcane Production, Sugarcane Juice and factors affecting its Quality
2. Design of sugarcane peeler and cutter
3. Performance Evaluation of sugarcane peeler and cutter

2.1 Sugarcane Production, Sugarcane Juice and factors affecting its Quality

Sirichai Songsermpong and Weerachet Jittanit (2010) studied on comparison of peeling, squeezing and concentration methods for the sugarcane juice production. In this research, various methods of sugarcane peeling, squeezing and juice concentration were compared. Their objective was to determine the proper peeling, squeezing and juice concentration techniques for the sugarcane juice production. The experimental results indicated that the sugarcane should be peeled by the abrasive tool and squeezed by the roller in order to achieve high yields with shorter process time. It also appeared that the freeze concentration method applied in this work could not manufacture the high concentrated sugarcane juice.

Krishnakumar T. (2013) conducted study to determine the quality of sugarcane juice extracted from stored canes, as well as changes in quality of fresh juice stored at different temperatures. Cane stems were stored at 10 and 30°C, while the fresh juice was stored at 5 and 30°C. The parameters studied were juice yield, total soluble solids, total sugar content, titratable acidity, pH, viscosity, total microbial count and sensory evaluation for colour and flavor. Results showed that low temperature storage (10° C) of canes was able to maintain the quality of juice for 10 days, while low temperature storage

(5°C) of juice could last for only 4 days. Spoilage of cane stored at 30°C occurred faster than that stored at 10°C. Fresh sugarcane juice became spoilt within a day when stored at 30°C. Microbial count (bacteria, yeast, fungi) especially lactic acid bacteria count increased, during storage of cane juice.

Amandeep Singh et al., (2015) conducted study on phytochemical profile of sugarcane and its potential health aspects. They summarized the different phytoconstituents and health benefits of sugarcane and its valuable products. The phytochemistry of sugarcane wax (obtained from the leaves and stalks of sugarcane), leaves, juice, and its products has revealed the presence of various fatty acid, alcohol, phytosterols, higher terpenoids, flavonoids, -O- and -C-glycosides, and phenolic acids.

T.S. Krishnamoorthy Durgesh Nandhini (2017) studied on Sugarcane Production in India. He concluded that India is the largest producer and consumer of sugar in the World. About 45 million sugarcane farmers, their dependents and a large agricultural force, constituting 7.5 percent of the rural population, are involved in sugarcane cultivation, harvesting and ancillary activities. This enabled India to become the largest producer of sugarcane and sugar in the world leaving the other major producers Brazil and Cuba. The major sugarcane crop growing states in India are Uttar Pradesh, Bihar, Assam, Haryana, Gujarat, Maharashtra, Karnataka and Tamil Nadu. 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. The major problem of sugarcane in India is based on monsoon and water supply. The cyclical nature in sugar production has caused distortions in the export of sugar in India. This study analyzed the state-wise production and reasons for the changes in production of sugarcane in the time period of 2000-2010.

Dilip A. Pawar et al., (2017) studied on techniques and advances in Jaggery processing. They reviewed that Jaggery is a natural sweetener made by concentrating the sugarcane juice with clarification to remove impurities and uniform heating in open pan. It is a sensitive product, getting affected by number of factors right from cultivation practices of sugarcane to processing and storage. The jaggery industry is still at cottage level because of some technological drawbacks in its export quality processing and storage. A value added jaggery, with enrichment of nutritional ingredients such as aonla, milk powder, wheat flour, whey etc., has a great export potential in turn fetching good market prices. The organic jaggery is becoming popular in the market because of its health benefits and good quality attributes, thus herbal clarificants play a key role in jaggery production.

Zeqing Xiao et al., (2017) conducted study on analysis of Sugarcane Juice Quality Indexes. The analysis of the quality indexes of sugarcane juice plays a vital role in the process of refining sugarcane, breeding, cultivation, and production management. The paper analyzed the dynamic laws of five quality indexes (i.e., brix, purity, polarization, sucrose content, and reducing sugar) combined with graphs over time along the course of crushing season (December–March) in Guangxi province of China.

Priyanka Upreti and Alka Singh (2017) studied the trends in area, production, productivity, costs, returns and profitability of sugarcane and to determine the factors which are contributing toward productivity of sugarcane in major sugar producing states of Uttar Pradesh and Maharashtra. It has been observed that area expansion has significantly contributed towards increased production of sugarcane but productivity has remained stagnant. The study found the positive and significant contribution of human labour, machine, fertilizers, insecticides and size of plot towards productivity of sugarcane and thus efficient management of these inputs can certainly led to increasing the productivity of sugarcane in India.

Yue Luo et al., (2018) reviewed on Sugarcane rind: applications and health benefits. They mentioned that sugarcane rind is usually treated as an industrial waste. However, it contains valuable phytochemicals that can be extracted and utilized. Herein we provide a comprehensive review about application and health benefits of the phytochemicals in sugarcane rind, including polyphenols, flavonoids, especially anthocyanins, phenolic acids, long chain fatty alcohols particularly 1-octacosanol, phytosterols and fiber. Various bioactivities are associated with these phytochemicals, such as antioxidant, anticancer, antivirus, inhibition of inflammatory, and attenuation of the risk of cardiovascular and coronary disease.

Yasir Abbas Shah et al., (2020) conducted study on microbiological quality and safety assessment of sugarcane juice and ice sold by vendors in Faisalabad city, Pakistan. Result of this study revealed that unhygienic conditions and poor qualities of water are the main factors for the contamination of sugarcane juice. The cane may contain high microbial load on its surface as it is transported un-hygienically from field to the point of extraction. Inappropriate washing of sugar cane before extraction adds bacteria into extract leading to contamination Food hygiene standards must be implemented in a proper way on permanent basis for street vendors. Immediate action should be taken by the respective authorities to prevent any type of outbreak. Furthermore, additional treatments must be introduced for street vendors to make sugar cane juice safer for public health.

2.2 Design of sugarcane peeler and cutter

Jiaxiang Lin et al., (2012) developed the large-scale sugarcane stripper with automatic feeding. The large-scale sugarcane stripper with automatic feeding includes the automatic feeding module, cleaning leaves module, collecting module and control module. The machine is an important part of the segmental type sugarcane harvester, using to solve the highest labor intensity problem of cleaning leaves. Collecting the hilly areas sugarcane and cleaning their leaves, can greatly improve the labor productivity and changing the current mode of sugarcane harvest.

M.M. Ahmat et al., developed Sugarcane Bark/Skin Peeling Machine, Due to increasing demand of sugarcane product and development of sugarcane industry a problem was found out that conservative peeling method of sugarcane would take times to cope with the increasing demand. The problem was based on our customer Sugarcane World and Natural Organic Sugarcane. A new design was proposed to solve the peeling method by designing a new blade installed with rollers to push in and out the sugarcane stalk in blade compartment. By following engineering design process the idea was transformed into CAD data and prototype was built. The newly developed prototype was tested and few data obtained gain for improvement.

Mr. Tagare V.S. et al., (2013) designed and manufactured sugarcane peeling machine. They got efficiency of 59.66% using the available raw materials and techniques. The approximately linear sugarcane was loaded and conveyed by hand to the peeling drum. The overall performance of the machine was more efficient compared to already existing ones. The cost of production and maintenance was relatively cheap. The successful fabrication of a sugarcane peeling machine is one of the major, if not the major, challenge in sugarcane processing. This work is intended to help solve some of the problems hindering a successful design and manufacturing of a sugarcane peeling machine.

E. Jayashree and R. Visvanathan (2014) Studied on Development of Concentric Drum, Brush Type Ginger Peeler. To accelerate the process of peeling, nylon bristles of length 25 mm and thickness 0.7 mm were fixed in the inner wooden drum of the developed mechanical ginger peeler. The optimum operating conditions for peeling of ginger was obtained at drum load of 7 kg, for inner drum speed of 45 rpm, outer drum speed of 20 rpm and for the peeling duration of 15 min. The maximum peeling efficiency obtained in the peeler was 61 % and the corresponding material loss was 5.33%.

Ge Xinfeng (2015) worked on design of sugarcane peeling machine. In order to solve the problem that appeared in hand peeling sugarcane, the sugarcane peeling machine is designed, the sugarcane peeling machine includes motor, groove wheel, cutting room, slider crank mechanism, reducer (including belt drive, chain drive) and so on. The designed sugarcane peeling machine is simulated, the results show that the sugarcane peeling machine can peel sugarcane successfully with convenient, fast and uniform.

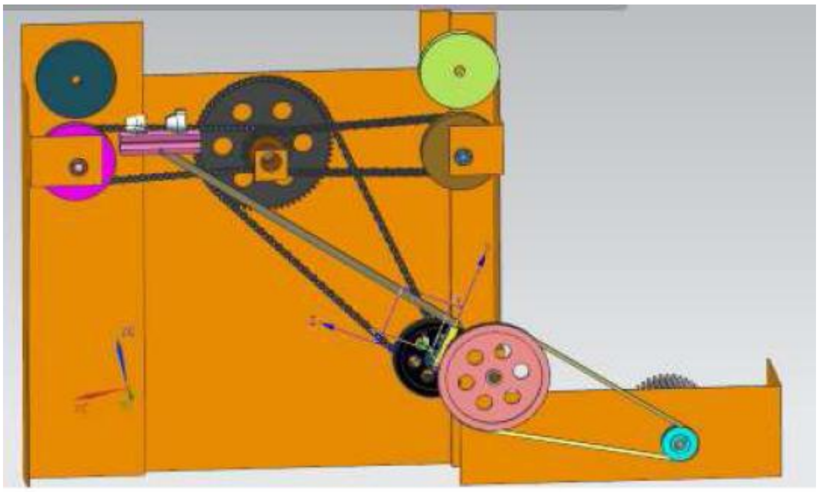
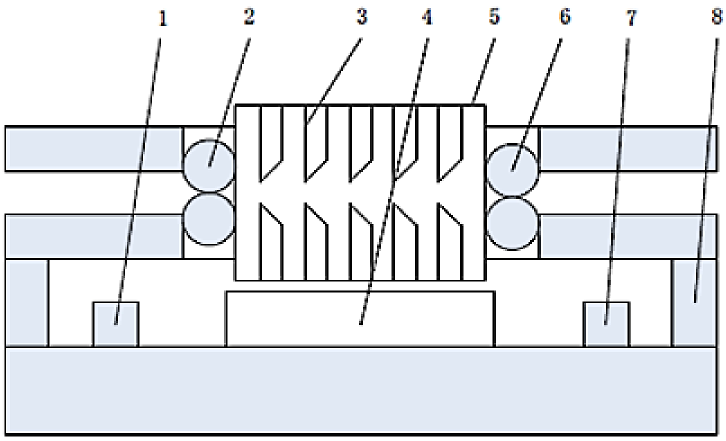


Fig. 2.1 Overall structure of sugarcane peeler

Zhang Dehui (2015) carried out extensive research work on sugarcane peeling based on motion controller. According to him Sugarcane is a common raw material for sugar, but in the process of machining, there will be suspended solids in the cane juice, in order to process better, the sugarcane should be peeled. Traditional way of peeling is by man, production efficiency is low. In this study, a kind of sugarcane peeling machine was designed based on motion controller, it can realize the automation of input, peeling and output. It can make certain contribution for sugarcane processing. The figure below shows the design proposed by him.



1. Feed Motor, 2. Feed rubber wheel, 3. Blades, 4. Storage box,
5. Squirrel cage rest, 6. Discharge rubber wheel 7. Discharge motor 8. Body frame.

Fig. 2.2 Proposed Design

V.P. Talodhikar (2017) made reviews on mechanization & Development of potato peeling machine. Peeling variety of fruits or vegetable is a basic need of present era. Potato peeling processes face a numerous problems of time consuming and became inefficient during weekly breakdown maintenance. It is very important for food process industry as well as domestic point of view. Mechanization of processing operations will no doubt play a pivotal role in removing the negative attributes of the traditional processing techniques and promote timely large scale production with desired quality. This paper shows the chronological development of mechanical peeling and also highlights on new concept of potato peeler which would be the basic requirement under breakdown maintenance.

Prof. S. J. kadam et al., (2018) constructed and tested sugarcane peeler machine. After an intensive literature research, construction and testing, satisfactory sugarcane peeling machine with efficiency of 80% was fabricated using the available raw materials and techniques. The approximately linear sugarcane was loaded and conveyed by hand to the bearing attached with brushes. The overall performance of the machine was more efficient compared to already existing ones. The cost of production and maintenance was relatively cheap. Hence, the machine would be welcomed by industries given its performance, affordability and simplicity.

C. G. Arocha and K. J. Simonyan (2019) studied on development of a motorized ginger rhizomes peeling machine. A 5 kg motorized ginger rhizomes peeling machine was designed and developed. Three moisture contents (70 %, 75 % and 80 %) wb, three feed rates (54 kg/hr, 68 kg/hr and 73 kg/hr) and three peeling speeds (230 rpm, 270 rpm and 300 rpm) were used to evaluate the performance of the developed machine. The study showed that peeling efficiency increased with an increase in moisture content and peeling speed and decreased with an increase in feed rate. Peeling capacity decreased with a decrease in moisture content, and increased with an increase in peeling speed. Percent damage decreased with increasing moisture content, increased with an increase in feed rate and peeling speed.

Prakash Killedar et al., (2019) made reviews on development of sugarcane node cutting Machine. The sugarcane node cutting machine is developed for the cutting the node of sugarcane from sugarcane. Due to increasing demand of sugar in market, many farmers are planting the sugarcane. But by using old method of planting sugarcane, there is more time required for cutting node. Due to this, more waste of time and sugarcane. They produced machine for cutting sugarcane node faster and avoid the wastage of time and effort required to cut the node of sugarcane.

Ritesh Wankhede (2019) conducted study on design and fabrication of automatic fruit slicing machine-Testing and Performance. The major component of machine includes hopper, mainframe, slicing unit, shaft, pulley, bearing, electric motor and outlet. The machine is powered by a three phase, 1440 rpm and 1KW electric motor. The performance of the machine was evaluated in slicing two selected fruits (banana and apple), grouped into three sizes (small, medium and large) at five speeds of 39 rpm, 41 rpm, 43rpm, 46 rpm and 48 rpm respectively. The parameters that were investigated were slicing efficiency and throughput capacity. The medium and large size samples gave a good result for apple with at a speed 41 rpm with capacities and efficiencies of 72 kg/h, 88 kg/h, 97% and 94% respectively. The machine is therefore observed to perform best at the optimum speed of 41rpm for all the fruits. The result of the study shows that the machine can slice different fruits and vegetables satisfactorily with slices ranging from 9-10 mm thickness were obtained.

S. K. Pandey et al., (2020) studied on Advances in Sugarcane Peeling Mechanization. The study presented the features, prospects, performance evaluations and limitations of some sugarcane peeling machines in world like the fixed outer drum peeler, automated cane peeler, knife-edge type self-fed peeler, etc. Their peculiar advantages and operational parameters such as machine speed, output capacity, peeling efficiency and cane losses were evaluated. Aside from the manual ones, the ranges of the peeling efficiency and cane loss were recorded in range of 59.9 – 91.4 % and 2–4% respectively. As machine speed increased, the output capacity and cane loss increased while peeling efficiency decreased. Mechanization of this peeling process has the potential of encouraging growth in cultivation, cane utilization and improving the product quality of value-added products.

Osei Seth (2020) made reviews on review on the performance of some cassava peeling machines developed. The peeling machines reviewed operated within 40-1500 rpm speed range, have 45-100% peeling efficiency, 2.7-2400 kg/hr throughput capacity, and 0-44% flesh losses. Several factors like the tuber physic mechanical and the machine properties affected the performance of the machines, of which some were the parameters of the theoretical models developed. Generally, increased machine speed increased the flesh losses and the throughput capacity, but the peeling efficiency increased in some machines and got decreased in others. The mechanical and the chemical methods combined in some of the works could not yield the desired result, it rather increased food losses. From the study, cassava peeling machine with a 100% peeling efficiency and 0% flesh losses, that is capable of giving the desired result has not been developed yet, hence, an artificial intelligence and bio-sensing technology should be considered in future developments.

2.3 Performance Evaluation of sugarcane peeler and cutter

Larin R. L. and Solis M. R. (2001) studied on design, construction and performance evaluation of a manually operated pineapple peeler and slicer. A manually operated pineapple peeler and slicer was designed, constructed and evaluated whether it is economical for household and commercial uses. The main components of the machine include, power screw with peeler blade assembly base, holder and rotating handle. Results showed that the capacity of the developed pineapple peeler and slicer was significantly higher compared with the traditional method of using kitchen knife. The designed machine has a capacity of 681.33 g/min using the pineapple size which ranged from small, medium and large. The machine could peel and slice pineapple faster than the traditional method. Thus, with large pineapple the machine displayed the highest mean capacity and with the small pineapple the machine displayed the lowest mean time consumed in peeling and slicing.

A significant interaction was observed between the machine and the size of pineapple. Moreover, the efficiency of the machine was twice better than the traditional method of slicing the pineapple.

O.J. Olukunle and B.O. Akinnuli (2012) conducted study on performance evaluation of a single action Cassava peeling machine. This cassava peeling machine is an improvement over existing ones and its performance evaluation is satisfactory at various crop sizes. High broken of cassava was achieved especially at high speed and this is referred to as mechanical damage and not losses .This could be considerably adapted as cassava chips. Low speed is recommended for commercial purpose because of its relatively high quality performance efficiency, low mechanical damage and low peel retention. This makes the machine suitable for small and medium scale cassava processors. The machine was found to perform very well and posed minimal problem with its operation.

M. Manjunatha (2014) studied on development and performance evaluation of a garlic peeler. A power operated garlic peeler having a cylinder-concave mechanism was developed with an intention to reduce cost and time. An experimental garlic peeler having cylinder covered with 10 mm thick rubber was fabricated and evaluated for its performance with crop-machine parameters viz., cylinder speed, cylinder-concave clearance, moisture content and concave mechanisms. Crop-machine parameters were optimized based peeling efficiency and they found to be cylinder speed of 36 rpm, cylinder-concave clearance of 10 mm, mild Steel Square (8×8 screen). Operation cost of the peeler was determined on the basis of fixed and variable cost and found to be INR 22.9/h. The developed garlic peeler saved INR 16.11/kg (94.99 %) and 1.63 (97 %) man hours in comparison to the hand peeling of garlic.

El-Yamani et al., (2016) evaluated the performance of a new small-scale sugarcane peeler machine. The experiments illustrated the effects of the main design and operating parameters, on the machinery performance and finished product quality. The investigated parameters included three different peeling drum brush types namely: zigzag, straight and spiral, four peeling drum speeds of 3.53, 5.30, 7.47 and 9.18m/s, three peeling drum clearances of 1.0, 1.5 and 2.0cm and three feeding rates of 3, 6 and 9 canes/min. The developed machine performance were evaluated in terms of: machine production efficiency, cane stalks peeling efficiency, peel retention on peeled stalks, cane stalks weight losses, machine power consumption and machine unit cost. The gained results revealed in general that using the zigzag peeling drum brush type tends to improve the peeling performance of the developed machine, compared to straight and spiral brush types. In addition, the obtained results indicated that, the maximum machine production efficiency (88.85%) and the minimum electrical power consumption (5.56kW), were achieved at peeling drum speeds of 9.18 and 3.53m/s, peeling drum clearance of 2cm and No. of feeding canes per minute of 3 canes, respectively.

Gourikutty Kunjurayan Rajesh et al., (2016) designed and took performance evaluation of plantain peeler-cum-slicer. Based on the physical and mechanical properties of green mature plantain the peeler cum slicer was developed. The peeling unit of the fabricated machine consists of feeding cylinders, peeling blades, conical throat and splitters. The green plantain fed into the feeding cylinder was pushed down by a pushing mechanism. Slicing unit consists of a cylindrical guide, slicing disc and blade. Slicing was achieved by rotating the disc at 300 min^{-1}. Average peeling efficiency and material loss were obtained at 88.94% and 13.69%, respectively. Diameter of feeding cylinder was significant at 1% ($P<0.01$) level for overall capacity of machine. The overall capacity, slicing efficiency and effective capacity of the plantain slicer was found to be 89.27 kg/h, 89.16 kg/h and 79.59 kg/h, respectively. The capacity of the developed peeler cum slicer was four times higher than manual operation.

Mohammed Temam (2017) studied on design, construction and performance evaluation of power driven potato peeling machine. The potato peeling machine consists of seven parts, main frame, peeling drum, hopper, collection basin, waste remover, water supplying systems, and power transmission. The machine was evaluated using different potato bulb sizes (small, medium & large). A mixed sample of different sizes was also tested.

The evaluation process was conducted between1000 and 1440rpm drum rotational speeds , three different peeling residence times (10,15 and 20seconds) and two different batch loads (1 and 1.5 kg). The optimum peeling efficiency of 52.55%, 87.99% and98% was obtained at 10, 15 and 20 seconds respectively and at recommended drum speed of 1440 rpm. The average value of the mean field capacity of the potato peeler obtained from the trials for small, medium, large and mixed sizes were 0.092kg/sec, 0.093kg/sec ,0.091kg/sec and 0.093kg/sec respectively. Generally the mean field capacity of the potato peeler obtained from the trials for small, medium, large and mixed sizes were 0.092kg/sec (333.7164 kg/hr).

Vijay K. Singh (2017) studied on testing and evaluation of Pedal operated potato peeler in which the performance evaluation of machine was carried out in terms of machine capacity, peeling efficiency, operational cost, benefit cost ratio and payback period. The capacity and peeling efficiency of the machine were 144 kg/h and 83%, respectively. The machine capacity and peeling efficiency were highly affected by weight of potato per batch and operational time of the machine. For maximum capacity (144 kg/h) and peeling efficiency (85.8%), the weight of potato per batch and operational time were 6 kg and 2.5 min, respectively. The operational cost of the machine was Rs.74.77/h. The benefit cost ratio and payback period were 1.72 and 0.33year (4 months), respectively. Finally he concluded that the pedal operated potato peeler would be suitable for farmers as well as small entrepreneurs.

G.V. Prasanna Kumar et al., (2019) developed and evaluated the performance of an electric motor powered ginger washing-cum-peeling machine. It had a washing tank, cylindrical brush rollers, water application system, and an electric motor and power transmission system. Fresh harvested ginger rhizomes were lifted and tumbled on the brush rollers rotating in opposite direction. The abrasive action of the roller brushes along with application of jet of water on the rhizomes completely washed and rough peeled the rhizomes. Performance indices were developed and the best operating parameters of the machine were identified by non-dominated sorting technique. Ginger washing-cum-peeling machine developed had the potential to use in the production line of bleached dry ginger as supplement to manual washing and peeling. The machine can be recommended for use in small processing centres, commercial food centers and restaurants. Output capacity of the machine can be increased by increasing the length of the nylon brush rollers and applying water throughout the length of roller.

Kamran Ikram et al., (2019) studied on design, fabrication and performance evaluation of indigenous sugarcane leaf stripping machine. Main components of stripping machine were intake rollers, cleaning element, out take rollers, power transmission system and an engine as power source. Three combinations for intake rollers were fabricated. Three velocities i.e., CE1 (660 rpm), CE2 (763 rpm) and CE3 (1033 rpm) of cleaning element, two level of sugarcane leaf moisture content, M.C1 (8.2%) and M.C2 (17.60%) and three sugarcane verities, V1 (US-658), V2 (HSF-240) and V3 (CPF-249) were selected for machine performance evaluation. The results indicated that Inlet roller combination C3, cleaning element speed CE3, sugarcane crop variety V1, and moisture content MC1 gave 82.43%, 77.06%, 87.72%, and 82.84% cleaning efficiency, respectively.

Maninder Kaur and Preetinder Kaur (2019) conducted study on economic feasibility of small scale garlic peeler. In this, major focus had been laid on testing economic feasibility of small scale developed garlic peeler the markets are mainly dominated by small scale manufacturing and processing units. The developed small capacity garlic peeler (15kg/h) was found technically efficient and economically viable for peeling garlic cloves. The machine is capable of serving at small scale and small garlic processing and paste making units to enhance the income of self-supported small entrepreneurs.

Ademola Olagoke Afolabi and Muhammad Lawal Attanda (2020) studied on development and performance evaluation of irish potato peeling machine. This was developed for use at small-scale/household level. Machine performance evaluation was carried out using three locally grown Irish potato varieties namely; Nicola, Bartita and Bawondoya respectively. A 22x3 factorial experiment in completely randomized design (CRD) with three replications was used for evaluation where tuber feed rate, shaft speed and variety were the independent variables and peeling efficiency, tuber flesh loss and machine output capacity were the performance indicators.

Adeshina Fadeyibi and Olusola faith Ajao (2020) made technical note on design and performance evaluation of a multi-tuber peeling machine. In research, a batch loading tuber-peeling machine, with a capacity of 10 kg/min, was designed, fabricated and tested for cocoyam, sweet potato, yam and cassava tubers. The machine was designed to operate at a speed range of 350–750 rpm and time range of 5–12 min based on the principle of surface scratching. The performance of the machine was determined with respect to the peeling efficiency, percent weight of peel and flesh loss. The results showed that the peeling efficiency increased with an increase in the shaft speed for all the tubers. Also, the flesh loss and percent weight of peel decreased with an increase in the shaft speed for cassava and cocoyam tubers but increased for sweet potato and yam tubers ($p < 0.05$). Effective peeling of the tubers was achieved for sweet potato and yam at all the shaft speeds and time ranges considered.

Nnaemeka C. Ezeanya (2020) conducted study on effect of speed on efficiency and throughput capacity of cocoyam peeling machine. In this study, the peeling machine was operated at three rotational speeds of 98, 130 and 228 rpm. The speed variation was achieved by a 3 step pulley incorporated into the machine. The output parameters determined in the evaluation of the peeling machine are peeling efficiency and throughput capacity. Results showed that the both the evaluation parameters increased with increasing rotational speeds of the peeling machine.

Trishla Sahu and S.I. Anwar (2020) made a review on performance of Sugarcane Cleaner-Cum-Washer. A sugarcane cleaner-cum-washer (SC-c-W) was developed at ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow for cleaning of sugarcane prior to juice extraction for jaggery making. It was found that the roller set was that in which upper rollers moved with 50.63 and 75.95 rpm and lower rollers moved with 60 and 90 rpm in 1st and 2nd set respectively. It was due to differential speed of rollers which gave best rubbing and scrapping action.

Chapter III

MATERIALS AND METHODS

This chapter deals with materials and methodology used in design and development of sugarcane peeler cum cutter and its performance evaluation. The manually operated sugarcane peeler and cutter require more time and it is not safe and convenient in operation. Hence, there is need to develop such an efficient machine which is practically feasible and accepted by the street vendors and packers. In order to achieve the objectives set for the present study, the sugarcane peeler cum cutter was developed and its performance was tested by following procedure.

The following points were kept in mind while designing and developing the sugarcane peeler cum cutter

1. To use some kind of wire rollers to peel and sharp knife to cut the sugarcane.
2. Power source would be electricity since the operation is stationary.
3. The feeding of material to the cutter would be continuous so that desired output capacity could be achieved.
4. To provide suitable power transmission mechanism for rotating motion of rollers assembly.
5. The sugarcane peeler cum cutter to be developed would be simpler in mechanism, easy to manufacture with higher output and less operating cost.
6. The machine should reduce the drudgery and economical with less maintenance cost.
7. The material used for various components should be of power strength, durability and should perform intended functions with ease.
8. It should cut the sugarcane properly without any damage to its vigor and viability.
9. It should be safe to operate.

3.1 Location of Experimental Site

Sugarcane peeler cum cutter was designed and fabricated at Pakhale Agro Engineering, Dhamangaon Rly, Amravati and evaluated for the performance at Department of Agricultural Process Engineering, Post Graduate Dr. P. D. K. V., Akola. All crop and machine parameters were considered in the design and development of machine.

3.2 Physical and Mechanical properties of sugarcane

The sugarcane (Variety- Co-86032) which is being used widely in Maharashtra state of India for juice extraction was selected for the study. The sugarcane was purchased from the local market in Akola and taken for the determination of various physical properties.

3.2.1 Length

A measuring tape was used to determine the length of sugarcane samples by maintaining tape along the sugarcane. The measuring tape was of 100 feet. Sugarcanes were separated visually into three groups according to their size i.e. small, medium and large. Five sugarcanes were chosen from each group for the determination of length. By keeping measuring tape along the sugarcane, the length of the sugarcane was measured.

3.2.2 Weight

A balance with an accuracy of 1 gram was used to weigh raw sugarcane, peeled sugarcane and the peel of individual sugarcane of ten samples. The readings were recorded in grams.

3.2.3 Diameter and Peel thickness

A digital vernier caliper having least count (L.C.) of 0.01 mm was used to determine the diameter and peel thickness. The diameter of the sugarcane (with peel) and manually peeled sugarcane were recorded at centre of the longitudinal axis of the sugarcane. After manual peeling, the diameter was measured at the same place. By subtracting this diameter from raw sugarcane diameter, the peel thickness was calculated. This procedure was carried out for 10 readings.

3.2.4 Total Soluble Solids (T.S.S.)

Total soluble solid is the sugar content in the substance. The instrument used for the measurement is refractometer. Five samples of different sugarcanes were taken. 1-2 drops of sugarcane juice was put on the refaractometer slide and the sugar level i.e. ^{0}Brix was calculated and averaged for the further use.

3.2.5 Fruit to peel ratio

Fraction of sugarcanes were peeled manually, separated and weighed. The ratio of fruit to peel was estimated for each of the sample and the average value has been reported and was considered as basis of for further calculations.

3.2.6 Moisture Content

For measuring moisture content of raw sugarcane, five samples of different sugarcanes were taken. Initial weight of the raw sugarcane (W_i) was taken. After that, the samples were finely chopped and kept in hot air oven for the 24 hours at 105±5 ^{0}C. The weight of dried samples (W_d) were taken. The moisture content of the raw sugarcane on wet basis was calculated by the following formula,

$$M.C._{(w.b.)} = \frac{W_i - W_d}{W_i} \times 100$$

Where,

$M.C._{(w.b.)}$ – Moisture content on wet basis, %

W_i -- Initial weight of the sample of sugarcane, g

W_d – Weight of dried sample, g

3.2.7 Colour

Colour is the physical property which shows appearance of the substance. Five samples of different sugarcanes were taken for the measurement. Surface colour was determined using chroma Meter (CR-400) which includes lightness and chroma saturation. In this colour space, the colour points are characterized by three colour coordinates. ‘L’ is the lightness coordinate ranging from no reflection for black (L=0) to perfect diffuse reflection for white (L=100). ‘a’ is the 'redness' coordinate ranging from negative values for green to positive values for red. ‘b’ is the yellowness coordinate ranging from negative values for blue to positive values for yellow.

3.3 Design consideration of sugarcane peeler cum cutter

Peeling is the process of removal outer, unwanted cover from the edible portion. For designing peeler, the principle of rubbing was taken into consideration. When more than one rubbing rollers rub the commodity while passing through a clearance between them, it got peeled. Another operation is cutting. For cutting purpose, a sharp knife mechanism was used. After the overall study of these principles and facts, the components for the machine were decided.

Following were some design considerations for the selection of components of the machine i.e. force and the torsional moment is important consideration for peeling unit and the belt length is important for the proper transmission of power from motor to the shaft.

3.3.1 Determination of Torsional Moment:

Torsional moment is expressed by the Equation

$$T = \frac{P \times 60}{2\pi N}$$

Where,

T = torsional moment (Nm)

P = power of prime mover (Watts)

N = rotational speed of driven pulley (rpm)

3.3.2 Force required to peel the Sugarcane:

The force required to peel the cocoyam is expressed by the equation

$$F = \frac{T}{r}$$

Where,

F = Force (N)

T = Torque (Nm)

r = Radius of disk having peeling rollers (m)

3.3.3 Determination of length of Belt:

The length of belt was determined by the equation

$$L = 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4C}$$

Where,

L= Length of belt (m)

C= Centre distance between the two pulleys (m)

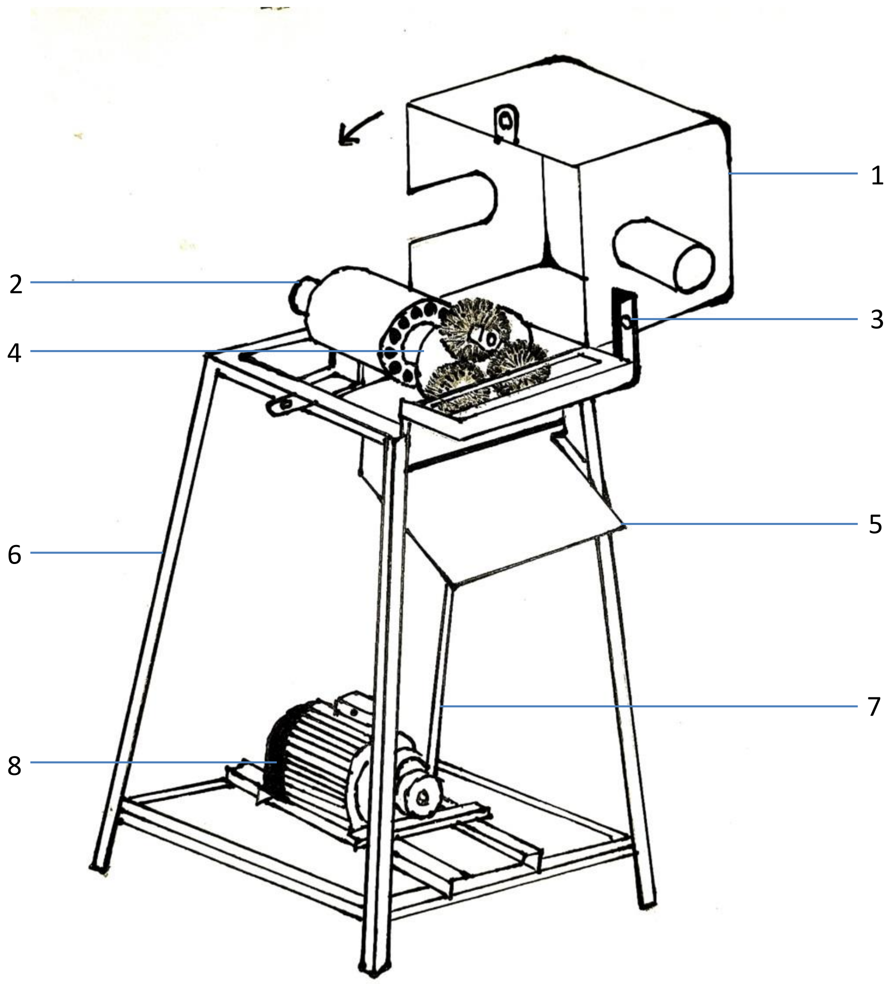
D= Diameter of peeling disk shaft pulley (m)

d= diameter of prime mover pulley (m)

3.4 Description of the Machine

The sugarcane peeling cum cutting machine was designed and developed for the purpose of removal of hard surface of the sugarcane and to cut them into pieces. The sugarcane peeler cum cutter was installed on angle iron frame. It mainly consists of six rollers (three pairs). These rollers were connected to the rotating disk which has the adjustable slots by the roller pins. It has an arrangement of cutting for which a knife is attached to the machine. One motor is provided to operate the machine through belt drive. Details and dimensions of various components of the sugarcane peeler cum cutter are described.

Plate 3.1 Sugarcane Peeler cum Cutter Machine



1. Cover
2. Hollow Shaft
3. Peeling Assembly
4. Cutting Assembly
5. Discharge unit
6. Main Frame
7. V-belt
8. DC Motor

Fig. 3.1 Isometric View of Sugarcane Peeler cum Cutter Machine

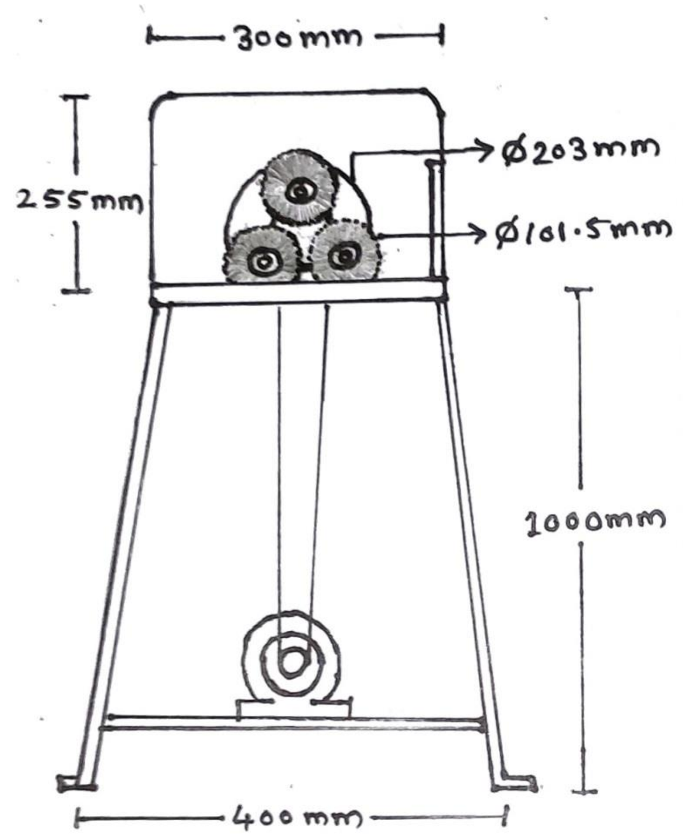


Fig. 3.2 Front View of Sugarcane Peeler cum Cutter Machine

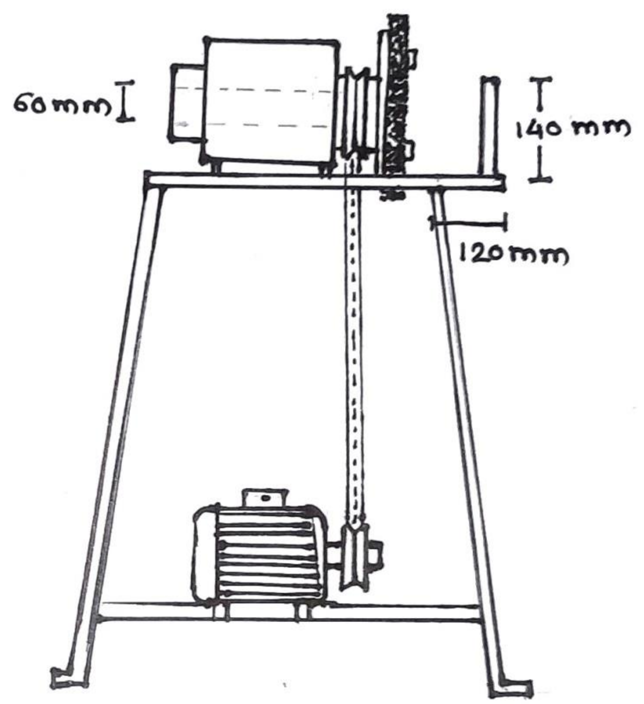


Fig. 3.3 Side View of Sugarcane Peeler cum Cutter Machine

3.4.1 Frame Assembly

Main Frame was required to support other parts of the designed machine and withstand against the vibration during the operation. The main frame was fabricated from mild steel iron angle having dimensions of 25×25×5 mm for mounting peeling assembly, cutting assembly and power transmission unit. The length, width and height of main frame were 440 mm, 310 mm, 1115 mm respectively. Shaft housing was welded on the main frame and cutting assembly and power transmission unit was attached to the main frame with the help of nuts and bolts.

3.4.2 Peeling Assembly

Peeling assembly was consists of hollow shaft, roller disc, roller pins and brush rollers.

3.4.2.1 Hollow Shaft

The hollow shaft was made using mild steel pipe with the dimensions of hollow shaft i.e. length, inner diameter and outer diameter were 229 mm, 50 mm and 60 mm, respectively. This was attached in the circular housing using bearings (60×95×18 mm). A pulley of diameter 100 mm made up of cast iron was attached to the shaft to take drive from the motor with the help of belt. A roller disc was directly welded to the one end of the shaft and other end was kept open from which the feeding of sugarcane was carried out.

3.4.2.2 Roller Disc

Roller disc was made up of mild steel sheet of thickness 12.56 mm and diameter 24.84 cm. This roller disc was directly welded to the hollow shaft and it had circular hole of diameter equal to inner diameter of the shaft. The disc has three slots as shown in plate 3.2 for holding the brush rollers by means of roller pins. The slots were at the angle of 120^0 from the centre with each other and having adjustment of 24 mm.

1

2

3

4

1. Rotating Disc
2. Roller brush and pin
3. Main Frame and DC Motor
4. Cutting Assembly

Plate 3.2 Main Components of Sugarcane Peeler cum Cutter Machine

3.4.2.3 Roller Pins and brush rollers

Roller pins were made up of mild steel iron bar of length 86.8 mm. It had threads to both the sides. There were two sections in which one was to attach pin to the roller disc and another was to hold the brush rollers. The roller pins were responsible for the various adjustments of the roller clearance for the sugarcane peeling. The roller brush had the dimensions of 104 mm in diameter and 17 mm in thickness. Wire head of the roller were responsible for the peeling of sugarcane. The roller pin and brush roller are shown in plate 3.2.

3.4.3 Cutting Assembly

The cutting mechanism was manually operated. The cutting assembly of the machine was a simple stainless steel cutting knife of edge length of 160 mm and thickness of 1.5 mm. This knife had a wooden grief for the safety purpose. This cutting knife was attached to the spring which holds the knife in same position.

3.4.4 Power Transmission Unit

The input power was given through a 0.5 Hp, 230 V DC electric motor having maximum rpm of 1500. A pulley was attached to the motor shaft of diameter 51 mm. This power was transferred to the shaft by V-belt. A driven pulley was attached to the shaft with bolt. The driven pulley was of 100 mm diameter.

3.5 Laboratory Equipment for Testing of Sugarcane Peeler cum cutter Machine

The laboratory test set up consists of the following accessories, equipment's and instruments for conducting laboratory tests of sugarcane peeler come cutter machine.

1. Speed measuring instrument (tachometer)
2. Time measuring instrument (digital stop watch)
3. Weight measurement instrument (weighing balance)
4. Power measuring instruments (ammeter, wattmeter)

5. Dimensions measuring instruments (Tape, Vernier Caliper)
6. Heart Rate monitor

3.5.1 Speed measuring instrument

A tachometer (revolution-counter, tach, rev-counter, RPM gauge) is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common. In this machine, there used a hollow shaft so, the shaft rotations were calculated by the speed reduction formula by measuring the rotations of the motor of the machine.

3.5.2 Time measuring instrument

Digital stop watch was used to measure the time required in peeling of sugarcanes at different speed range of machine, for evaluating the actual capacity of the machine.

3.5.3 Weight measurement instrument

Electronic weighing balance (Manufactured by-Goldtech Gta 30k) with maximum - 50 kg. weighing capacity was used for weighing sugarcanes during testing of sugarcane peeler cum cutter machine. The least count of machine was 1g. The electronic weighing balance with sugarcane is shown in plate 3.4.

3.5.4 Power measuring instruments

Input power of sugarcane peeler cum cutter machine was calculated by measuring input power of electric motor. A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. An ammeter is a measuring device used to measure the electric current in a circuit. A voltmeter is connected in parallel with a device to measure its voltage, while an ammeter is connected in series with a device to measure its current. At the heart of most analog meters is a galvanometer, an instrument that measures current flow using the movement, or deflection of a

Plate 3.3 Electronic Weighing Balance

Plate 3.4 Measuring Tape

Plate 3.5 Digital Vernier Calliper

Plate 3.6 Digital Tachometer

Plate 3.7 Heart Rate Monitor

needle. The needle deflection is produced by magnetic force acting on a current-carrying wire.

3.5.5 Dimensions measuring instruments

Length of the sugarcane was measured by using measuring tape which was 100 feet long and having metric scale. Thickness of sugarcane was measured by using a digital vernier caliper (Mityutoyo) with least count 0.01 mm. These instruments also used in the fabrication of the sugarcane peeler cum cutter machine.

3.5.6 Heart Rate Monitor

Heart rate measurement was carried out with the help of heart rate monitor (fitbit versa, Lite Edition) which is a wrist monitor which constantly measure the heart rate and store it in the mobile application. It has display which shows heart rate and other mobile notifications to which it is connected. It is a charging instrument.

3.6 Performance Evaluation for Peeling of Sugarcane

Sugarcanes were procured from local market of Akola and were used for peeling and cutting. Before start of actual experiments, preliminary trials were conducted and sugarcane peeler cum cutter machine was cleaned thoroughly. The sample of one sugarcane was used for each experiment. The sugarcanes were fed manually. After completion of peeling operation, the machine was stopped and different dimensions of peeled sample like weight, thickness were measured carefully.

The performance of the sugarcane peeler was evaluated for its suitability for peeling of sugarcanes was tested with following parameters.

Independent Variables

Following parameters were decided after conducting some filler trials.

1. Peeling Roller Speed, rpm - 200, 300, 400
2. Peeling Roller Clearance, mm - 20, 25, 30

Dependent Variables

1. Peeling Efficiency
2. Machine Output capacity
3. Damage percentage

The peeling efficiency was assumed to be affected by peeling roller speed and peeling roller clearance. The levels of independent variables for peeling of sugarcanes are shown in Table 3.1. This table shows the coded and uncoded variables and their levels.

Table 3.1 Levels of independent variables for evaluation

Independent variables	**Symbols**		**Levels**	
	Coded	**Un-coded**	**Coded**	**Un-coded**
Peeling Roller Speed, rpm	X_1	X_1	1 0 -1	400 300 200
Peeling Roller Clearance, mm	X_2	X_2	1 0 -1	30 25 20

Table 3.2 Experimental layout for two variables and three level response surface analysis

		Factor 1	**Factor 2**
Std.	**Run**	**Roller speed, rpm**	**Roller clearence, mm**
1	10	200	20
2	3	400	20
3	9	200	30
4	13	400	30
5	6	158.579	25
6	1	441.421	25
7	12	300	17.9289
8	4	300	32.0711
9	7	300	25

1. Raw unpeeled Sugarcanes

2. Sugarcanes Peeled by machine

3. Peeled husk

4. Cut Sugarcanes

Plate 3.8 Mass fraction of various end products

10	2	300	25
11	11	300	25
12	8	300	25
13	5	300	25

All these trials were conducted with 1 sugarcane sample size and data for peeling efficiency and machine output capacity was reported. To avoid bias, 13 runs were performed in a random order. The decision for the range and centre points of the variables was taken through preliminary trials.

3.6.1 Calculation of Machine Output Capacity

Machine output capacity was calculated by following expression,

Machine Output Capacity,

$$M.O.C. = \frac{M}{t}$$

Where,

M - Mass of sugarcane input, Kg

T - Time for peeling and cutting of sugarcane, h

3.6.2 Calculation of peeling efficiency

Peeling efficiency was calculated by following expression,

Peeling Efficiency (η_p),

$$\eta_p = \frac{T_d}{T_i} \times 100$$

Where,

T_d -Thickness of sugarcane peeled by Machine, mm

T_i - ideal thickness to be peeled by machine, mm

3.6.3 Calculation of Damage Percentage

Damage percentage was calculated by following expression,

Damage percentage,

$$Damage\ Percentage = \frac{W_{Dp}}{W_i} \times 100$$

Where,

W_{Dp} – Weight of the damage sugarcane during peeling, g

W_i – Initial weight of the sugarcane, g

3.7 Performance Evaluation for Cutting of Sugarcane

In sugarcane peeling cum cutter machine, cutting mechanism was manual. So, for evaluating the machine for cutting, five samples were drawn through the machine at optimized values of peeling of sugarcane. The cutting efficiency was calculated for evaluation by the following formula,

Cutting Efficiency (η_c),

$$\eta_c = \frac{W - W_{Dc}}{W} \times 100$$

Where,

W – Initial weight of sugarcane used for cutting, g

W_{Dc} – Weight of damaged sugarcane in cutting, g

3.8 Ergonomic Evaluation

In this evaluation, Physiological cost i.e. heart rate and oxygen consumption rate were measured. For measuring Heart rate, the instrument used was heart rate monitor. Increase in heart rate i.e. ΔHR is calculated by subtracting resting heart rate from working heart rate. Resting heart rate was calculated by taking heart rate reading after 15 min rest. On working for 15 min, working heart rate was measured.

Oxygen Consumption rate was calculated by the expression,

$$Y = 0.0114X - 0.68$$

Where,

Y- Oxygen Consumption Rate, Lit/min

X- Heart Rate, Beats/min

From this data, categorization of the work was carried out according to table 3.3.

Table 3.3 Categorization of the work

Sr. No.	Work Category	Physiological Response	
		Oxygen Consumption Rate, Lit/min	Heart Rate, Beats/min
1	Light work	<0.5	upto 90
2	Moderate work	0.5-1.0	90-110
3	Heavy work	1.0-1.5	110-130
4	Very Heavy work	1.5-2.0	130-150
5	Extremely heavy work	>2.0	150-170

3.9 Cost Analysis

Cost analysis for peeling by sugarcane peeler cum cutter was estimated. The rates of raw material, personnel, utility, products were as prevailing in the market. The project was proposed for functioning about 12 months with capacity of 0.7 tonnes per day custom hiring. The benefit cost ratio, break-even point, payback period and cost of processing were calculated in the cost analysis. The benefit cost ratio and the break-even point were calculated by the formulae,

Benefit Cost Ratio,

$$BCR = \frac{Benefit}{Cost\ of\ Production}$$

Break Even Point,

$$BEP = \frac{Fixed\ Cost}{Fixed\ Cost + Net\ Profit/year} \times 100$$

Chapter IV

RESULT AND DISCUSSION

Preliminary trials were conducted to fix the roller speed and brush clearance for which sugarcanes peeled to be remained in brush rollers. The gap of 25 mm was identified to which have good results.

The results are presented with the help of graphs and tables. Their interpretation is also discussed in the following sections.

4.1 Physical properties

The physical properties such as length and weight of sugarcane were measured (Table 4.1). The sugarcanes were separated visually and categorised as small, medium and large. The observations were replicated and average was calculated which are given in Appendix A-1.

The average length of sugarcanes in small, medium and large size group were 224.44, 252.52 and 271.76cm, respectively. The average weight of sugarcanes in small, medium and large size group was 1546.8, 1810.4 and 1907.8g, respectively, which is given in table 4.1.

The diameter of unpeeled sugarcane, manually peeled sugarcane and thickness of peeled sugarcane were measured. The observations and their average values of three replications are given in Appendix A-2. The average values of these physical properties of sugarcane were found to be 28.2, 23.93 and 4.27mm, respectively.

The TSS of the sugarcanes were tabulated in Appendix A-3. The average TSS was found to be 17.8 ^{0}Brix. The fruit to peel ratio of the sugarcane was measured and the observations are given in Appendix A-4. The average value for fruit to peel ratio was found 9.03. (Table 4.1) The observations for moisture content of raw sugarcanes are given in Appendix A-5. The average moisture content of sugarcane was found to be 66.85%. The moisture content was less because of the rapid decrease in moisture content of sugarcane after harvesting.

The colour values for sugarcanes were tabulated in Appendix A-6. The colour values showed that the colour of sugarcane was slight towards whiteness and there was also more greenness and yellowness found in sugarcanes.

Table 4.1 physical properties of sugarcanes

Sr. No.	Particular		Range	Average
1	Length, mm	Small	210.2 - 231	224.44
		Medium	248.4 – 256.4	252.52
		Large	248.4 – 256.4	252.52
2	Weight, g	Small	1392 - 1668	1546.8
		Medium	1632 - 1943	1810.4
		Large	1840 - 2076	1907.8
3	Diameter of unpeeled sugarcane, mm		26.91 – 34.19	28.2
4	Diameter of peeled sugarcane, mm		22.31 – 30.4	23.93
5	Peel thickness, mm		4.95 – 3.58	4.27
6	Total Soluble Salts (^{0}Brix)		16 - 20	17.8
7	Fruit To Peel Ratio		7.21 – 10.25	9.03
8	Moisture Content, %		63.3 – 70.8	66.85

4.2 Design of sugarcane peeler cum cutter machine

The sugarcane peeler cum cutter machine was designed, developed and fabricated. The design work of sugarcane peeler cum cutter machine was done according to the procedure mentioned in 3.3. The sugarcanes on feeding into machine firstly got peeled with the help of wire brush and then cut into pieces with the help of cutting mechanism. The peeled waste was collected from discharge unit. Various components and their technical specifications of the designed machine are mentioned in table 4.2.

Table 4.2 Technical Specifications of various components

Sr. No.	Component	sub-component	Technical Specification	
1	Main Frame		Length (mm)	440
			Breadth (mm)	310
			Height (mm)	1115
2	Peeling Asembly	Hollow Shaft	Length (mm)	229
			Diameter (mm)	60
		Roller Disk	Diameter (mm)	248.4
			Thickness (mm)	12.56
		Roller Pin	Length (mm)	86.4
		Roller Brush	Diameter (mm)	104
			Thickness (mm)	17
3	Cutting Assembly	Cutting Knife	Length (mm)	160
			Thickness (mm)	1.5
4	Power Transmission Unit	DC Electric Motor	Power (Hp)	0.5
			Max. RPM	1500
		V-belt	Length (inches)	57
		Driving Pulley	Diameter (mm)	51
		Driven Pulley	Diameter (mm)	100

4.3 Performance Evaluation

4.3.1 Peeling Efficiency (%)

The experiments were conducted with various treatment combinations as given in Table 3.2. Table 4.3 shows effect of various levels of peeling parameters on peeling efficiency. The peeling efficiency was observed to be ranging between to 21.71 to 58.8%. The maximum peeling efficiency of 58.8% was observed at 441 rpm roller speed and 25 mm roller clearance but the damage percentage was also high. This happened due to the increase in roller speed which increases the contact time of wire brush with the sugarcane. But at the same roller speed, there is high percentage of damaged sugarcanes. The minimum peeling efficiency of 21.71% was observed 300 rpm roller speed and 32.07 mm roller clearance. Due to the high clearance in rollers, the sugarcane did not get uniform contact with the wire brush. Earlier researchers also got same results but they had used hard material such as knifes or abrasive rollers which increases damage percentage and there was juice extraction during the peeling process.

Table 4.3 Effect of various levels of peeling parameters on peeling efficiency

Sr. No.	Run	Roller Speed, rpm	Roller Clearance, mm	Peeling efficiency, %
		x_1	x_2	
1	10	200	20	42.64
2	3	400	20	49.87
3	9	200	30	38
4	13	400	30	39.66
5	6	158.579	25	36.78
6	1	441.421	25	58.8
7	12	300	17.9289	45.96
8	4	300	32.0711	21.71
9	7	300	25	50.93
10	2	300	25	57.35
11	11	300	25	56.06
12	8	300	25	51.98
13	5	300	25	57.4

The analysis of variance (ANOVA) was carried out for the experimental data and the significance of roller speed and roller clearance as well as their interactions on peeling efficiency was analyzed. The response surface quadratic model was fitted to the experimental data and statistical significance of linear, interaction and quadratic effects were analyzed for peeling efficiency response (Table 4.4). It revealed that the model was highly significant at 5 % level of significance and lack of fit was non significant indicating that the model was quite adequate for predicting the response.

Table 4.4 ANOVA for effect of peeling variables on peeling efficiency

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1427.13	5	285.43	21.37	0.0004	significant
A-Roller speed	264.86	1	264.86	19.83	0.003	
B-Clearence	380.12	1	380.12	28.47	0.0011	
AB	0.0462	1	0.0462	0.0035	0.9547	
A^2	81.34	1	81.34	6.09	0.043	
B^2	751.98	1	751.98	56.31	0.0001	
Residual	93.48	7	13.35			
Lack of Fit	55.71	3	18.57	1.97	0.261	not significant
Pure Error	37.76	4	9.44			
Cor Total	1520.61	12				

Std. Dev.	3.65	R^2	0.9385
Mean	46.24	Adjusted R^2	0.8946
C.V. %	7.90	Predicted R^2	0.7007
		Adeq. Precision	12.8255

The results showed that among linear effects roller clearance had significant effect on peeling efficiency (P<0.01) at 1 % level of significance followed by roller speed. The existence of quadratic terms indicates the curvy linear nature of response. It indicates that increasing the value of roller clearance initially increases the response up to certain level of variable however further increase in the level of variable decreases the value of response. On the other hand, as the increase in the value of roller speed, the peeling efficiency increases but the breakages also increases.

The quadratic response surface model data indicated the results as significant. The lack of fit was found to be non-significant which indicates that the developed model was adequate for predicting the response. The coefficient of determination (R^2) was 0.9385 for peeling treatment which indicated that the model could fit the data for peeling activity very well for both the variables, i.e. roller speed and roller clearance.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

Final Equation in Terms of Coded Factors:

$$Peeling\ Efficiency = +54.74 + 5.75X_1 - 6.89X_2 + 0.1075X_1X_2 - 3.42{X_1}^2 - 10.40{X_2}^2 \quad ....4.1$$

Where,

X_1= roller speed, rpm

X_2= roller clearance, mm

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients. The response surface equation was obtained for the model of second degree in terms of actual factors as under.

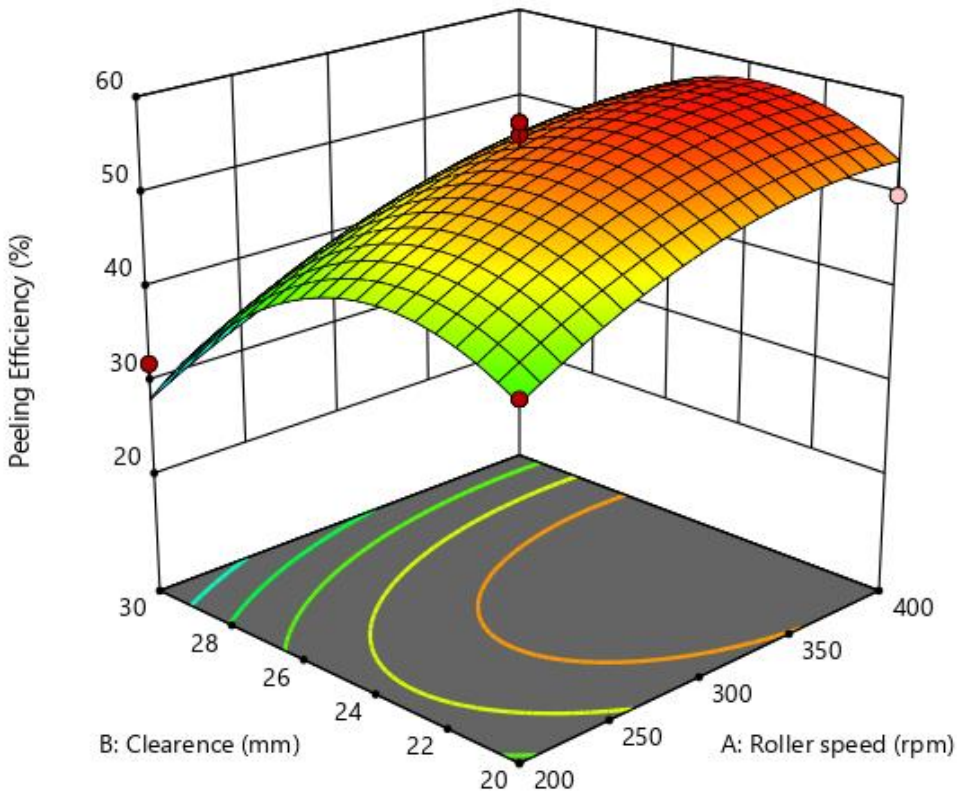


Fig. 4.1 Effect of roller speed and roller clearance on peeling efficiency

$$Peeling\ Efficiency = -217.14019 + 0.257334X_1 + 19.34088X_2 + 0.000215\ X_1X_2 - 0.000342{X_1}^2 - 0.415880{X_2}^2$$

.........4.2

Where,

X_1= roller speed, rpm

X_2= roller clearance, mm

4.3.2 Machine output capacity, Kg/h

The experiment was conducted with various treatment combinations as given in Table 3.2. The results of machine output capacity by using various variables are given in Table 4.5.

Table 4.5 Effect of various levels of variables on machine output capacity

Sr. No.	Run	Roller Speed, rpm	Roller Clearance, mm	Machine output capacity, Kg/h
		x_1	x_2	
1	10	200	20	62.39
2	3	400	20	87.54
3	9	200	30	77.98
4	13	400	30	90.1
5	6	158.579	25	64.37
6	1	441.421	25	94.03
7	12	300	17.9289	62.96
8	4	300	32.0711	87.16
9	7	300	25	85
10	2	300	25	87.47
11	11	300	25	82.68
12	8	300	25	79.42
13	5	300	25	84.94

From Table 4.5, it revealed that the machine output capacity was observed to be ranging from 62.39 Kg/h to 94.03 Kg/h depending upon the treatments. The maximum machine output capacity was observed in case of treatment having the combination of roller speed 441 rpm and 25 mm roller clearance. This was happened because, high roller speed increases the speed of operation and less time required for peeling. The minimum machine output capacity was found for treatment having the combination of roller speed 200 rpm and roller clearance 20 mm. At this roller speed and roller clearance the time required was greater because, less clearance choke the process and less roller speed was responsible for the difficulties in forward movement of the sugarcane. According to earlier researchers, this machine output capacity was very effective for the small and portable machines.

Table 4.6 ANOVA for effect of treatment variables on machine output capacity

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1282.85	5	256.57	21.67	0.0004	significant
A-Roller speed	784.39	1	784.39	66.25	< 0.0001	
B-Clearence	342.88	1	342.88	28.96	0.001	
AB	42.45	1	42.45	3.58	0.1002	
A^2	21.5	1	21.5	1.82	0.2198	
B^2	101.93	1	101.93	8.61	0.0219	
Residual	82.88	7	11.84			
Lack of Fit	46.29	3	15.43	1.69	0.3062	not significant
Pure Error	36.6	4	9.15			
Cor Total	1365.74	12				

Std. Dev.	3.44	R^2	0.9393
Mean	80.46	Adjusted R^2	0.8960
C.V. %	4.28	Predicted R^2	0.7171
		Adeq Precision	15.3056

The ANOVA in Table 4.6 revealed that the model was highly significant at 1% level of significance. The results showed that among linear effects, roller clearance was more effective on machine output capacity followed by roller speed. All the interaction and quadratic effects were found significant for machine output capacity.

The lack of fit was non-significant and hence the model can be considered as quite adequate for predicting the response. The coefficient of determination (R^2) was 0.9393 for machine output capacity which indicated that the model could fit the data for activity very well for both the variables, i.e. roller speed and roller clearance.

The response surface equation was obtained for the model of second degree in terms of coded factors as under.

$$\text{Machine output capacity} = +83.9 + 9.90X_1 + 6.55X_2 - 3.26X_1X_2 - 1.76{X_1}^2 - 3.83{X_2}^2 \quad \text{......4.3}$$

Where,

X_1 = roller speed

X_2 = roller clearance

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients. The response surface equation was obtained for the model of second degree in terms of actual factors as under.

$$Machine\ output\ capacity = -138.91782 + 0.367367X_1 + 10.91960X_2 - 0.006515X_1X_2 - 0.000176{X_1}^2 - 0.153115{X_2}^2 \quad \text{......4.4}$$

Where,

X_1 = roller speed

X_2 = roller clearance

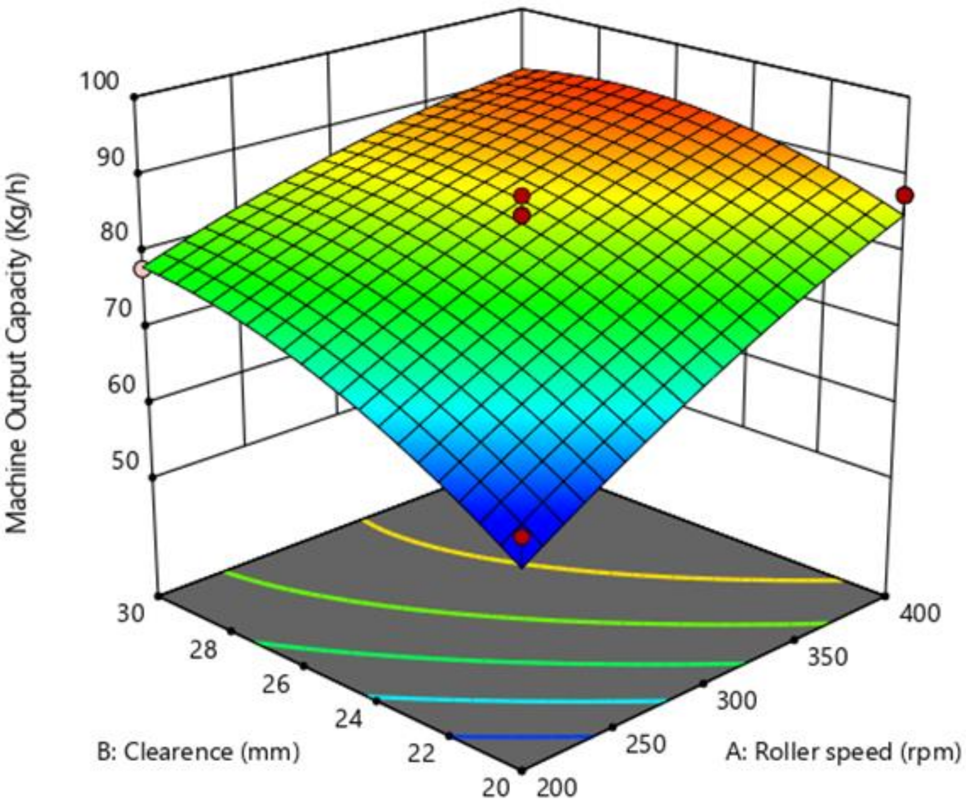


Fig. 4.2 Effect of roller speed and roller clearance on machine output capacity

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the centre of the design space.

4.4 Optimization of peeling efficiency and machine output capacity

4.4.1 Numerical optimization

In order to optimize the input parameters for sugarcanes by numerical optimization this finds a point that maximizes the desirability function. The main criteria for optimization were maximum peeling efficiency, maximum machine output capacity and all the input parameters in range. The optimization criteria for different input parameters and responses constraints are as shown in Table 4.7.

Table 4.7. Optimization criteria for input parameters and responses

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A:Roller speed	is in range	200	400	1	1	3
B:Clearence	is in range	20	30	1	1	3
Peeling Efficiency	Maximize	21.71	58.8	1	1	3
Machine Output Capacity	None	62.39	94.03	1	1	3

Software generated optimum conditions of independent variables with the predicted values of responses is as below (Table 4.8). Software Design Expert version 11 was used for the optimization of responses. A stationary point at which the slope of the response surface was zero in all the direction was calculated by partially differentiating the model with respect to each variable, equating these derivatives to zero and simultaneously solving the resulting equations. The optimum values for different variables and their predicted responses thus obtained are given in Table 4.8.

Table 4.8 Optimized variables and their predicted responses for peeling of sugarcanes

Variable	Optimized values	Responses	Predicted values
Roller Speed, rpm	399.994	Peeling efficiency, %	58.059
Roller clearance, mm	23.926	Machine output capacity, Kg/h	91.155
Desirability	0.94		

The optimum values of different variables for peeling were found within the range considered in the study.

4.4.2 Graphical optimization

The superimposed contours for response and their intersection for maximum peeling efficiency Fig. 4.3 indicated the range of optimum values of process variables.

The superimposed contours of both the responses for both variables along with their intersection zones for maximum peeling efficiency (%), maximum machine output capacity, indicated the range of optimum values of process variables.

4.5 Validation of the model for peeling of sugarcanes

The performance of this model was also verified by conducting an experiment for the validation. In order to validate the optimum conditions of peeling treatment variables, the experiments were conducted at optimum input parameters derived conditions. The average values of three experiments are given in Table 4.9. The experimental values of peeling efficiency and machine output capacity were found to be 56.68 % and 89.01 Kg/h. It could reveal that the experimental values were very close to the predicted values which confirmed that the model was quite adequate to predict response. (Table 4.9).

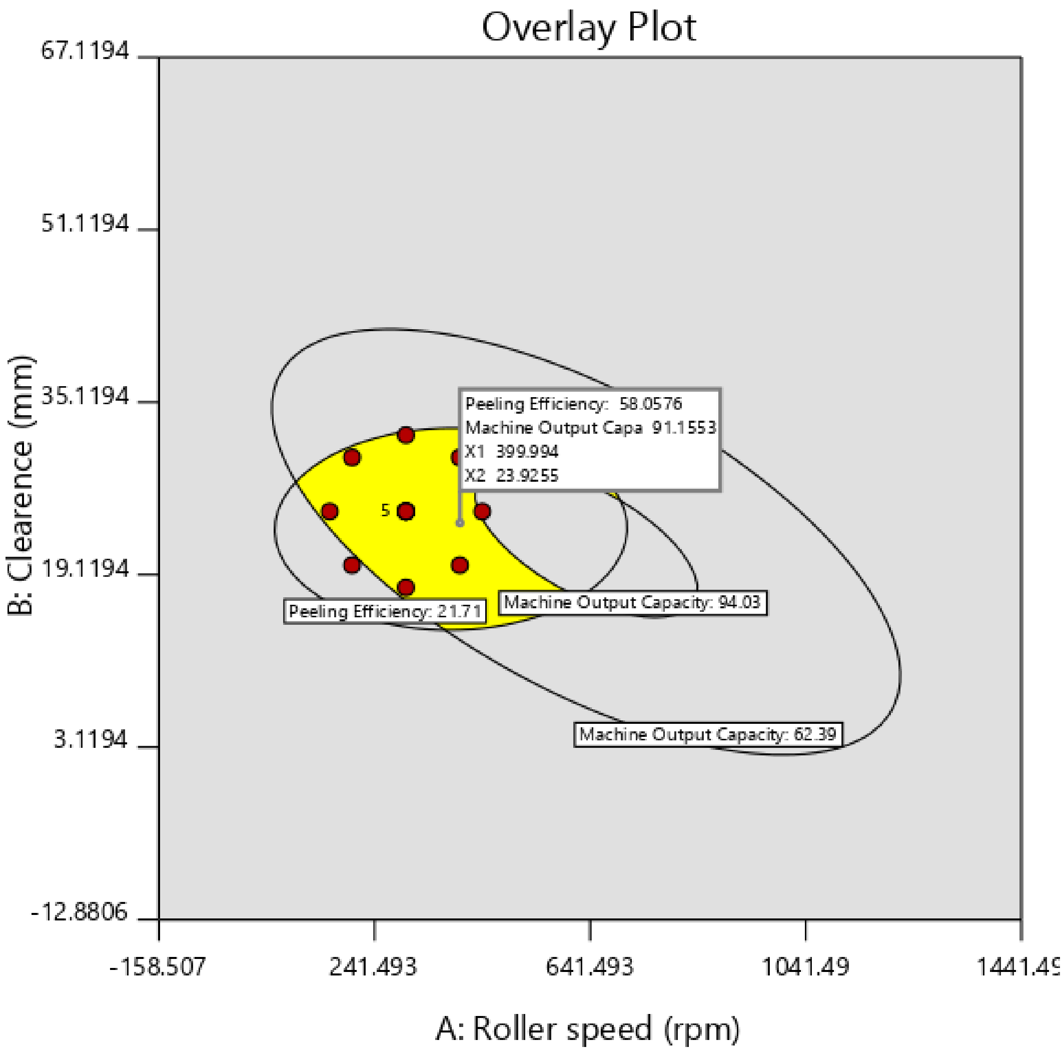


Fig. 4.3 Superimposed contours for peeling efficiency and Machine output capacity

Table 4.9 Predicted and experimental values of responses at optimum level of different variables

Sr. No.	Responses	Predicted values	Experimental values (± SD)	C.V.
1	Peeling efficiency, %	58.058	56.68 (± 0.69)	1.21
2	Machine output capacity, Kg/h	91.155	89.01 (± 2.54)	2.85

4.5 Damage Percentage (%)

The results of damage percentage by using various peeling parameters are given in Table 4.10.

Table 4.10 Effect of various levels of peeling parameters on damage percentage

Sr. No.	Run	Roller Speed, rpm	Roller Clearance, mm	Damage percentage (%)
		x_1	x_2	
1	10	200	20	0.5
2	3	400	20	1.83
3	9	200	30	0
4	13	400	30	0
5	6	158.58	25	0
6	1	441.42	25	2.72
7	12	300	17.93	2
8	4	300	32.07	0
9	7	300	25	0
10	2	300	25	0.4
11	11	300	25	0
12	8	300	25	0.79
13	5	300	25	0

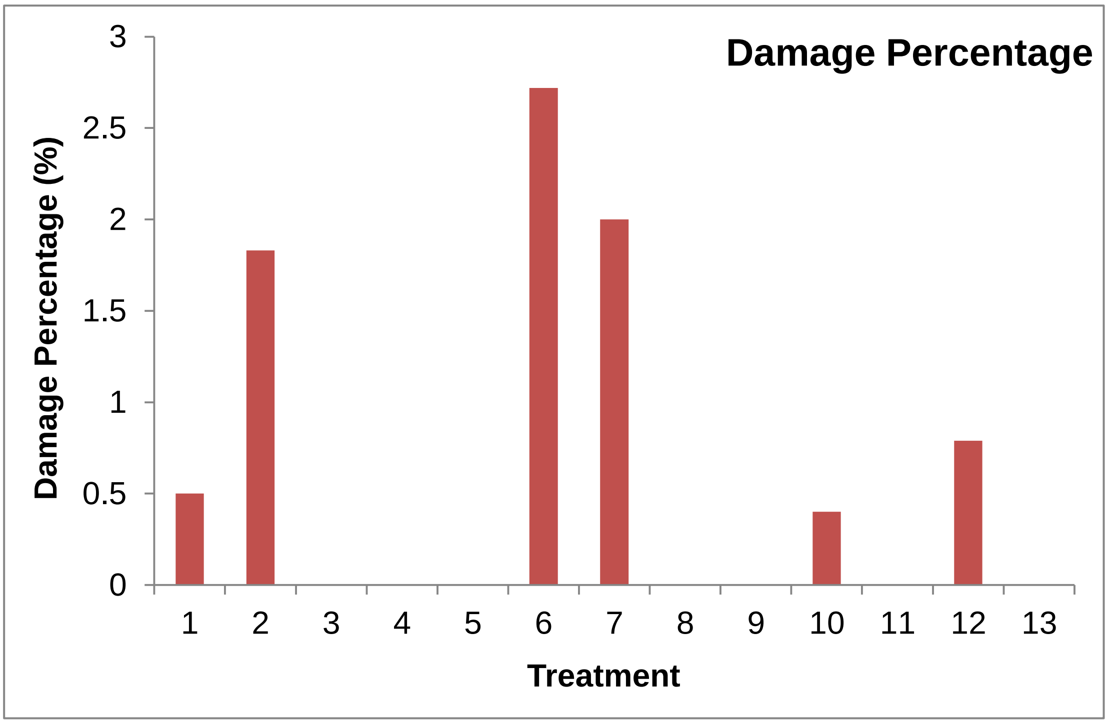


Fig. 4.4 Effect of roller speed and roller clearance on damage percentage

From Table 4.10, it revealed that the damage percentage was observed to be ranging between 0.4 to 2.72 % depending upon the peeling treatments. The maximum damage percentage was observed in case of treatment having the combination of roller speed 441 rpm and roller clearance of 25 mm. Some trials did not have any damage.

4.6 Cutting Efficiency

After peeling, sugarcanes were evaluated for the cutting efficiency at 400 rpm roller speed, 24 mm roller clearance and the data is given in Appendix C-2. The average cutting efficiency was found to be 85.44%. The fig. 4.5 shows that there was not too much variation in cutting efficiency and its range was 83-88%. A graph showing variation in cutting efficiency is given in fig. 4.5.

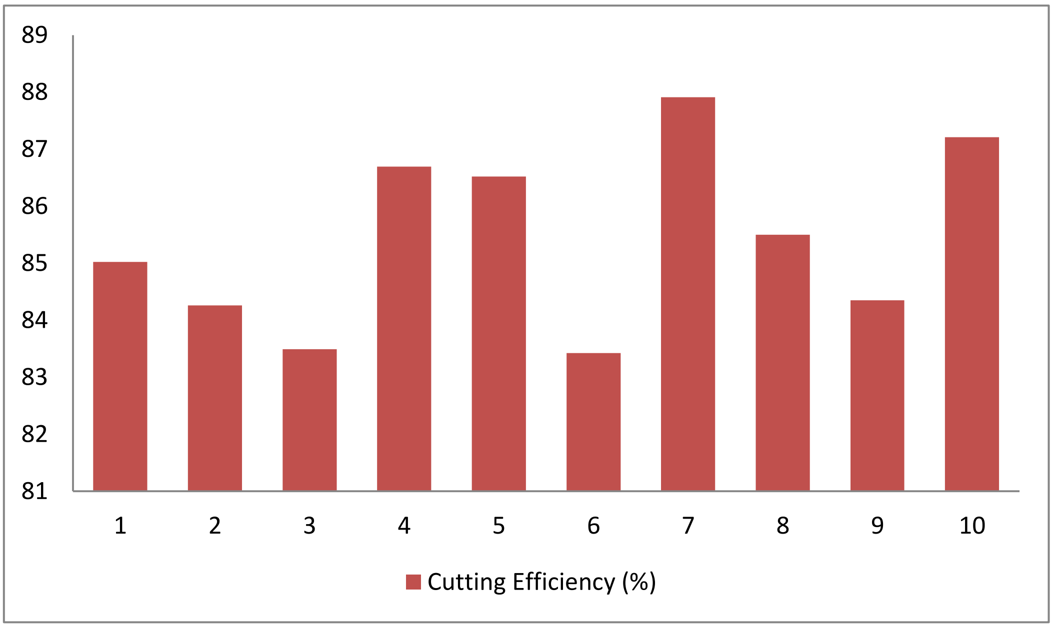


Fig. 4.5 Variation in Cutting Efficiency

4.7 Ergonomic Evaluation

Ergonomic evaluation was carried out while performing trials. Physiological cost i.e. heart rate and oxygen consumption rate were recorded and averaged and mentioned in appendix D. average increase in heart rate and oxygen consumption rate were found to be 24.8 beats/min and 0.49 lit/min. as the oxygen consumption rate was below 0.5 lit/min, the machine was in light work category.

4.8 Cost Analysis of machine

The cost of the machine was estimated to Rs 18,000/-. The business of sugarcane peeling with the machine was found technically feasible and economically viable with annual net profit of Rs 1,04,988/-, break even point of 43.86%, cost benefit ratio of 1.95 payback period of 2 months. Benefit cost ratio greater than 1.0 and lower breakeven point indicate the profitability of peeling by the machine. (Table 4.11)

Table 4.11 Cost Economics

Sr. No.	Particulars	Rate	Total Cost
1	**Rent of shade (5mx10m)**		
	For 12 months	500/month	6,000
	Total		**6,000**
2	**Cost of machinery/equipment**		
	Sugarcane Peeler cum cutter machine		18,000
	Balance and weight		5,000
	Total		**23,000**
3	**Labour requirment /year**		
	one unskilled labour (for 300 days)	200/day	60,000
	Total		**60,000**
4	**Raw material**		**Nil**
5	**Utility per year**		
	Power(Kwh) =0.5 x 8 x 0.746 x 300 = 896 units	9/unit	8,064
	Total		**8,064**
6	**Working capital per year**		
	Raw material		Nil

`	Utility		8,064
	Salary and wages		60,000
	Total		**68,064**
7	**Capital Investment**		
	Cost of machinery /equipment		23,000
	Working capital		68,064
	Rent of shade		6,000
	Total		**97,064**
8	**Cost of production/annum (300 days)**		
	Depreciation of machine	10%	2,300
	capital investment + interest	12%	1,08,712
	Total		**1,11,012**
9	**Sale Revenue/annum**		
	Peeling of 216 tonnes of sugarcanes	1000/t	**2,16,000**
10	**Net profit (9)-(8)**		
	2,16,000 – 1,11,012		**1,04,988**
11	**Fixed cost**		
	Depreciation on machine	10%	2,300
	Interest on capital investment		11,648
	Salary and wages/Labour cost		60,000
	Utility		8,064
	Total		**82,012**
12	**Benefit Cost Ratio (B/C Ratio)**		
	2,16,000/1,11,012		**1.95**
13	**Break Even Point (BEP)**		
	[82,012/(1,04,988+82,012)]x100		**43.86%**
14	**Payback period for equipment**		
	18,000/(1,04,988+18,000)		**2 months**
15	**Return on investment**		
	(1,04,988/97,064)X100		**1.08**
16	**Employment generation**		
	Man days/year		**300**
17	**Cost of processing**		
	1,11,012/82,012		**Rs 1.35/kg**

Chapter V

SUMMERY AND CONCLUSION

Sugarcane (*Saccharum officinarum*) is one of the important cash crop for farmers. It is a perennial grass that thrives in hot, humid locations like Brazil and India. Sugar production is the primary product obtained from sugarcane but some countries take sugarcane for ethanol production. Sugarcane also used for the juice extraction on a large extent. Sugarcane juice is a type of drink commonly found in Southeast Asia, South Asia and Latin America, and also in other countries where sugarcane is grown commercially. Sugarcane juice is very popular delicious drink and it is rarely available commercially in packaged form. It is extracted by crushing sugarcane between roller crusher and consumed with (or) without ice.

It also has the highest number of calories per unit area of any plant. It is served in many eateries from roadside stalls to five-star hotel dining halls. Additionally, sugarcane juice is used for the medication in some countries. For instance, the Indian systems of medicine have utilized it to cure jaundice and liver-related disorders. Flavonoids that can be found in sugarcane juice have the abilities to protect cells from degenerative processes and to reduce the development of health problems such as cancer and cardiovascular diseases. There is also demand for the peeled sugarcane consumption which helps in teeth exercise.

There are lots of impurities sticking to sugarcane stalk like trash, dust, roots, wax, gum, dry leaves, soil particles, chlorophyll and other colour compounds etc. In jaggery making, mostly sugarcane is crushed directly and all these unwanted materials go into the sugarcane juice. So, it is advisable to peel the sugarcane before crushing.

At present, the peeling of sugarcane is done manually which requires sharp knife and considerable physical strength. There is very limited information is available regarding sugarcane peeling machine. Therefore, sugarcane peeler cum cutter machine was designed and fabricated at Pakhale Agro Engineering, Dhamangaon Rly. The machine consists of peeling unit, cutting unit and power transmission unit. Rubbing action of three pairs wire roller brush removed the upper cover of the sugarcane.

Three pairs of wire roller brush of diameter 104 mm and thickness 17 mm were attached to a rotating disk with the help of roller pins. Rotating disk was attached to the hollow shaft through which sugarcane passes from one end. Three pairs of roller brush made a clearance at the other end of the hollow shaft where the rotating disk was attached. The shaft got power through v-belt. When the sugarcane passes through the clearance, it got peeled and the waste was collected from discharge unit. The clearance can be adjusted according to the diameter of the sugarcane.

The sugarcanes were procured from the local market of Akola. By conducting filler trials, the roller speed and the roller clearance were decided. The trials were conducted at three roller speed (200, 300, 400 rpm) and three roller clearance (20, 25, 30 mm). The effect of these variables on peeling efficiency and machine output capacity was studied. At optimized conditions, cutting efficiency was also studied.

The following important conclusions were obtained from this study.

1) The capacity of sugarcane peeler cum cutter was found to be 90 kg/h.
2) The maximum peeling efficiency i.e. 58.8% was found at roller speed 441 rpm and roller clearance 25 mm.
3) Maximum Cutting efficiency of the machine was found 87.9 %.
4) The cost benefit ratio and break-even point were found 1.95 and 43.86%, respectively.

SUGGESTIONS FOR FUTURE WORK

1. Manual feeding should be replaced by automatic feeding unit.
2. This mechanism should be use along with the sugarcane crushing machines of roadside juice vendors.
3. Manual cutting should be replaced by automatic cutting with single power source.
4. Effect of size variety, physical properties of sugarcane can be evaluated for further optimization.
5. Work on storage of peeled sugarcane should be carried out.

CHAPTER VI

LITERATURE CITED

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Appendix A-1

PHYSICAL AND MECHANICAL PROPERTIES OF SUGARCANE

Length and Weight of the Sugarcane

Size	Sr. No.	Length (cm)	Weight (g)
Small	1	210.2	1473
	2	222.8	1392
	3	228.2	1668
	4	230.0	1580
	5	231.0	1621
	Average	**224.44**	**1546.8**
Medium	6	248.4	1632
	7	249.8	1849
	8	254.0	1830
	9	254.0	1943
	10	256.4	1798
	Average	**252.52**	**1810.4**
Large	11	268.2	1906
	12	269.0	1870
	13	269.6	1847
	14	272.0	2076
	15	280.0	1840
	Average	**271.76**	**1907.8**

Appendix A-2

Diameter and Peel Thickness

Sr. No.	Diameter of Unpeeled Sugarcane (mm)	Diameter of manually Peeled Sugarcane (mm)	Peel Thickness (mm)
1	27.07	22.52	4.55
2	26.98	23.03	3.95
3	34.19	30.4	3.79
4	28	24.42	3.58
5	27.94	24.21	3.73
6	28.68	23.85	4.85
7	27.27	22.31	4.96
8	26.91	22.81	4.1
9	27.02	22.72	4.3
10	27.92	23.02	4.9
Average	**28.2**	**23.93**	**4.27**

Appendix A-3

Total Soluble Solids of sugarcane

Sr. No.	Total Soluble Solids (^{0}Brix)
1	16.5
2	18
3	17
4	17.5
5	16.7
6	16
7	18.6
8	18.9
9	18.6
10	20
Average	**17.8**

Appendix A-4

Fruit to peel Ratio

Sr. No.	Weight of Sugarcane piece (g)	Weight of sugarcane after peeling (g)	Peel Weight (g)	Fruit to peel ratio
1	540	492	48	10.25
2	396	357	39	9.15
3	329	299	30	9.97
4	413	370	43	8.60
5	398	362	36	10.06
6	378	337	41	8.22
7	496	445	51	8.73
8	600	545	55	9.91
9	320	281	39	7.21
10	230	205	25	8.20
Average				**9.03**

Appendix A-5

Moisture Content of sugarcane

Sr. No.	Moisture Content (%)
1	67.6
2	70.8
3	63.8
4	68.1
5	65.9
6	63.3
7	65.6
8	68.9
9	70.2
10	64.3
Average	**66.85**

Appendix A-6

Colour values of sugarcane

Sr. No.	L	a	b
1	59.65	-3.32	19.22
2	64.29	-1.99	20.21
3	54.02	-3.93	18.54
4	63.77	-2.47	21.65
5	61.56	-1.69	21.01

Appendix B

DESIGN CONSIDERATION OF SUGARCANE PEELER CUM CUTTER

Torsional Moment and Force:

Rotational Speed (RPM)	Torsional Moment (Nm)	Force (N)
200	17.82	143.48
300	11.88	95.65
400	8.91	71.74

Length of belt:

$$L = 2C + \frac{\pi(D + d)}{2} + \frac{(D - d)^2}{4C}$$

Where, L= Length of belt (m)

C= Centre distance between the two pulleys= 0.6 m

D= Diameter of peeling disk shaft pulley= 0.1 m

d= diameter of prime mover pulley= 0.051 m

Length of the belt was found to be 1.438 m = 56.61 inches. So, belt of 57 inches was selected.

Appendix C-1

EFFECT OF ROLLER SPEED AND ROLLER CLEARANCE ON DEPENDENT PARAMETERS

Tr. No.	Roller speed, rpm	Clearance, mm	Peeling Efficiency, %	Machine Output Capacity, Kg/h	Damage Percentage, %
1	200	20	42.64	62.39	0.5
2	400	20	49.87	87.54	1.83
3	200	30	32	77.98	0
4	400	30	39.66	90.1	0
5	158.579	25	36.78	64.37	0
6	441.421	25	58.8	94.03	2.72
7	300	17.9289	45.96	62.96	2
8	300	32.0711	21.71	87.16	0
9	300	25	50.93	85	0
10	300	25	57.35	87.47	0.4
11	300	25	56.06	82.68	0
12	300	25	51.98	79.42	0.79
13	300	25	57.4	84.94	0

Appendix C-2

CUTTING EFFICIENCY OF SUGARCANE

Sr. No.	Cutting Efficiency (%)
1	85.02
2	84.26
3	83.49
4	86.69
5	86.52
6	83.42
7	87.91
8	85.5
9	84.35
10	87.21
Average	**85.44**

Appendix D

ERGONOMIC EVALUATION

Heart Rate and Oxygen Consumption Rate

Sr. No.	Resting HR, Beats/min	Working HR, Beats/min	Increase in HR(ΔHR), Beats/min	Oxygen Consumption Rate(OCR), Lit/min
1	78.8	97.8	19	0.43
2	78.5	105.1	26.6	0.52
3	82.3	106.8	24.5	0.54
4	77	103.9	26.9	0.50
5	75.4	102.4	27	0.49
Average			**24.8**	**0.49**

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