DEVELOPMENT OF A POWER OPERATED RUBBER TAPPING MACHINE

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PROJECT REPORT

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Department of Food and Agricultural Processing Engineering
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Tavanur P.O.-679573Kerala, India
2016

DECLARATION

We hereby declare that this project entitled "DEVELOPMENT OF A POWER OPERATED RUBBER TAPPING MACHINE" is a bona fied record of project work done by us during the course of study and that the report has not any previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

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CERTIFICATE

Certified that this project entitled “DEVELOPMENT OF A POWER OPERATED RUBBER TAPPING MACHINE” is a bona fide record of project work jointly done by Aswathy .M.S, Soumya Krishnan V, Sruthi N.U under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them

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DEDICATED TO RUBBER TAPPING SOCIETY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

Symbol	**Abbreviations**
ha	hectare
%	percentage
m^3	cubic meter
CFT	cubic feet
RRIM	Rubber Research Institute of Malaysia
RRII	Rubber Research Institute of India
/	per
cm	centi meter
et. al	and all others
-	minus
mm	milli meter
°	degree
N	north
S	south
g	gram
i.e.	that is
:	is to
&	and

KAU	Kerala Agricultural University
KCAET	Kelappaji College of Agricultural Engineering And Technology
Dept.	department
Fig.	figure
MS	mild steel
DC	direct current
hp	horse power
rpm	revolutions per minute
V	volt
kg	kilo gram
sec	seconds
HV	Vickers

Introduction

Chapter 1

INTRODUCTION

The natural rubber tree (*Hevea brasiliensis*), native of Brazil, is the most important commercial source of natural rubber. According to Rubber Research Institute, India, rubber is grown in about 9 million hectares in the tropical regions of Asia, Africa and America. Malaysia is a leading producer of rubber. With over 5, 30,000 ha under rubber, India is now the third largest producer of natural rubber in the world. In India, rubber is predominantly a small holders' crop and over 87% of the rubber is from this sector.

Natural rubber consists of polymers of the organic compound isoprene, with minor impurities of other organic compounds plus water. Rubber exhibits unique physical and chemical properties. Rubber's stress-strain behavior exhibits the Mullins effect and the Payne effect, and is often modeled as hyper elastic. Due to the presence of a double bond in each repeat unit, natural rubber is susceptible to vulcanization and sensitive to ozone cracking.

Forms of poly isoprene that are used as natural rubbers are classified as elastomers. Natural rubber is used by many manufacturing companies for the production of rubber products. Currently, rubber is harvested mainly in the form of the latex from certain trees. The latex is a sticky, milky colloid drawn off by making incisions into the bark and collecting the fluid in vessels. This latex rubber is harvested from trees through a method called rubber tapping. The latex then is refined into rubber ready for commercial processing. Natural rubber is used extensively in many applications and products, either alone or in combination with other materials. In most of its useful forms, it has a large stretch ratio and high resilience, and is extremely waterproof. In India there is a huge demand for rubber as it is used in the manufacturing many products.

When a cut is made on the trunk, several layers are seen. On the outside is the bark. In the centre is the wood and between the wood and the bark there is a layer which cannot be seen with the naked eye, because it is very thin. This is the cambium layer.

The cambium makes the tree grow, by producing wood and bark. So it must not be damaged for the tree to grow normally. The cambium contains little channels called lactiferous vessels because they contain latex. This layer is next to the cambium. The lactiferous vessels are little tubes that produce latex. In tapping, you cut these little tubes containing latex. But you must take care not to cut the cambium.

1.1 TAPPING SYSTEMS

Response to different tapping systems varies from clone to clone. In general budded trees are tapped on half spiral alternate daily system and seedlings on half spiral third daily system. Alternate daily tapping is the recommended frequency for medium yielding clones (RRIM 600, GT 1, PB 28/59 etc.). For high yielding clones like RRII 105, PB 260, PB 217 etc., low frequency tapping systems with stimulation may be practiced. However, low frequency tapping can be adopted for medium yielding clones also.

Survival of natural rubber industry is being threatened by low and fluctuating prices, escalating cost of production and scarcity of skilled tappers. Tapper wages constitute a major component of cost of production. In view of the situation, Low Frequency Tapping systems, which judiciously combine stimulation, are favored in most countries. Trees under low frequency tapping have to be stimulated from opening onwards for achieving maximum sustainable yield. Number of stimulations to be given varies with clone, age of the tree and frequency. In high yielding clones like RRII 105 and PB 217, 15 to 30% sustainable yield increase can be achieved by three annual stimulations (April/May, September and November). In the case of medium yielding clones like RRIM 600 and GT1, four annual stimulations (April/May, August, October and December) are recommended.

Controlled upward tapping (CUT) can be practiced for longer exploitation of the virgin bark above the basal panel. In CUT instead of using ladder, a long handled modified gouge knife is used for upward tapping from the ground. Bark consumption is minimized as far as possible. Higher yield can be obtained for many years as there is neither any bark-island effect nor any injury to cambium. In CUT, monthly bark consumption should be restricted to 3cm. If necessary, the support cut may be cleaned at times to prevent spill over. Since it is difficult to rain guard the CUT panel, it is advised to rest the panel during rainy season. The best system is periodic panel change i.e. no tapping on upper panel during rainy season (approximately 5-6 months) during which the base panels can be tapped with rain guard. Thus with tapping rest on high panel during rainy season, one high panel can be tapped for 24 months (3-4 years), leading to increased duration of crop harvesting on high panel. On completion of one panel, next panel may be opened on the right side of the existing panel (while facing the tree).

Intensive tapping is generally done on old rubber trees for a few years prior to their removal. The methods of intensive tapping depend on the condition of the trees, previous tapping systems, availability of the bark and the period available for crop harvesting before felling. The methods employed are increased tapping frequency, extension of tapping cut, opening of double cuts and use of yield stimulants. While opening two cuts at the same time, the cut should be sufficiently apart at least by 45 cm to avoid the interference of drainage area between the cuts.

High Level Tapping is practiced when tapping of renewed bark on basal panels becomes uneconomic. New cuts are opened at higher levels, 180 cm from bud union or even higher. The tapper uses a small ladder to reach the cut. Since ladder tapping is more strenuous and time-consuming, usually reduced tapping tasks are given (135 trees).

1.2 TAPPING PROCESS

Every day a worker goes to hundreds of trees in the early morning and scrapes away the caked latex and a thin layer of bark. If done carefully and with skill, this tapping panel will yield latex for up to five years. Then the opposite side will be tapped, allowing this side to heal over. A helical cut is made in the tree, approximately four feet from the ground and circling about half the tree. The latex flows down the spiral into a cup for two hours before the sap hardens and closes the cut in the tree. The work is done at night or in the early morning before the day's temperature rises so the latex will drip longer before coagulating and sealing the cut. Depending on the final product, additional chemicals can be added to the latex cup to preserve the latex longer. Ammonia solution helps prevent natural coagulation and allows the latex to remain in its liquid state. Plastic bags containing a coagulant have replaced cups in many plantations in Malaysia. This form of latex is used as the raw material for latex concentrate, which is used for dipped rubber products or for the manufacture of ribbed smoke sheet grades.

Presently this is done with a gouge, a tool that is used by pushing it so as to remove bark. Push the gouge several times along the cut and the channel, taking away a very little bark at a time so as to cut the bark as close as possible to the cambium, but without damaging it. As the bark is about 6 millimeters thick, the cut must be 4.5 mille meters deep. The vertical channel is 25 centimeters long. At the lower end of this channel, a gutter is made. Below that a latex cup is tied to the tree. The latex flows along the cut, into the channel, and at last, through the gutter, it drops into the cup.

Currently the largest problem with tapping rubber trees is due to the care that must be taken to avoid damaging the tree. Workers are trained for six months before learning the proper technique and a poor tapper can kill many valuable trees. The process of carefully cutting hundreds of trees is also physically taxing. Improving this process would allow excess market demand to be met by tapping more trees. Considering this, EMP (Environmental Management Plan) Malaysia has tied up with a Taiwanese manufacturer in 2006 to produce a machine- made replaceable Gebung Type Rubber Tapping knives for smallholders and plantation users.

The Gebung knife is operated satisfying some conditions. The knife must lean beside the tree trunk. The skin is peeled off through the existing road. The peel-off skin should not exceed 1 mm. the thinner the peeling off, the longer the tree life.

A labour has to apply force many times on each tree to get the desired path for the harvesting of rubber. So, this makes the labour tired and they to do this job for nearly 300 trees in a short duration at early morning on every day. This leads shortage in labour for rubber tapping in India. Hence a battery operated concept of tapping knife is needed to reduce their effort. Our proposed machine is intended to satisfy and full fill the above problem. We also expect it could make a great revolutionary change in the field of tapping.

Thus the objectives of the study are:

- To study the existing tapping devices
- To study the ergonomic factors associated with tapping
- To develop a power operated rubber tapping machine
- To conduct performance evaluation of the developed rubber tapping machine
- To conduct the economic analysis of the developed rubber tapping machine

Review of Literature

Chapter 2

REVIEW OF LITERATURE

Rubber tapping is the process of extraction of latex from the rubber trees. Latex is a white or slightly yellowish liquid composed of rubber, protein, sugar, water etc. This latex is concentrated, compounded and then used in different forms for the manufacture of various goods.

For the manufacturing of these above given products we have all necessary mechanisms, from the manually operated machines to the highly sophisticate automated machines which can produce large tones in few seconds. But the primary level procedure, i.e. the tapping operation is still carried out manually and requires skilled labour. It is done with the help of specially made knives. Malaysian knives and Indian knives are mainly used. In the coming future the world is going to face a great shortage in availability in labours. Taking these problems into consideration engineers all around the world is trying to develop alternative ways for the tapping process. But till date no good design has been brought up.

There are different studies about the various situations of tapping and about the factors that are to be considered while harvesting the latex and such works are reviewed in this section.

2.1 STUDIES ON RUBBER VARIETIES

Li Z (2011) conducted rubber tree distribution mapping along with identification of ages of the trees. This study was able to reduce the effect of overestimation of rubber trees, to use technologies to help differentiate between the trees and other plants, and to match the imagery data with the regional statistics.

Dongling et al. (2014) conducted investigation on different rubber varieties in South China and there were about 28 rubber plantations with different tapping years of 8 varieties. The results showed that there were six kinds of existing plant types of rubber tree after planting of rubber plantations, which were available tapping trees, wind damaged trees, cold damaged trees, tapping panel dryness trees, absent trees and weak trees, respectively.

2.2 STUDY ON YIELD FROM RUBBER

Chaiear et al. (2001) conducted research to determine if exposure to natural rubber latex by rubber tappers and glove manufacturers triggers an increase of sensitization to latex. Workers are classified based on amount of exposure they receive and tests such as skin prick tests are conducted. The study suggests that in Thai latex industries, sensitization to latex is extremely rare despite the amount high amounts of concentrated airborne exposure to latex.

Schroth et al. (2004) studied different methods to increase productivity of rubber trees, which includes the application of a chemical ethephon which increased rubber production by up to 38% per week. The study also conducted tests on the two different knives used in the region as well as the different methods of tapping, the Amazonian method as opposed to the Asian method of rubber tapping.

Silva et al. (2005) demonstrated for the first time that intensive intercropping of young rubber with banana may result not only in a sustained increase in growth and yield of rubber trees but also a reduction in the length of the unproductive immature phase. Intercropping with short-term crops also provides a significant additional income during the long immature period of rubber tree growth when no latex is produced.

Chantuma et al. (2011) carried out a study conducted to test a new taping system which is called the Double Cut Alternative tapping system (DCA) as opposed to the currently used single cutting system. The object is to give the trees the ability to produce more latex with the DCA due to a more favorable metabolic activity during the first 10 years of tapping. DCA however, also resulted in a higher rate of tapping panel dryness.

Sdoodee et al. (2012) tested the Double Cut Alternative method under different conditions which attempted to increase the lifespan of the tree, thereby increasing the latex yields. The method of DCA involves two separate, alternating cuts instead of just one. The high tapping frequency remains the same. This was tested in the Songkhla province and so would require further work to confirm the better outcomes that were produced.

Sainoi et al. (2012) studied the impact of ethylene gas application on young-tapping rubber Trees. Ethylene stimulant tapping system enhanced latex production in gram per tapping of young-tapping of rubber trees but there was no significant difference in cumulative latex production compared with the conventional tapping system. In addition, Dry Rubber Content (% DRC) and girth increment of ethylene stimulation tapping system tended to decrease from regular. Bark consumption was significantly reduced under the stimulant application treatments. Latex physiology tended to be affected under the stimulate treatments; this may lead to negative impact in the long term.

Fenghua et al. (2013) investigated an innovative rubber yield stimulation technology, using ultrasound as a pre-treatment on the tapping cut surface of the rubber trees. The field trial results demonstrate that ultrasound treatment of 4 min can increase latex and dry rubber yields by 23% and 14%, respectively, on an average of 50 replications. However, a decrease in thiols content in ultrasound treatment is notable.

Feng et al. (2014) investigated variation in PTP (Phloem Turgor Pressure) with rubber tree clone, age, yield potential and commonly used Ethrel (an. ethylene releaser) stimulation, these relations and examine whether PTP can be used as an index for rubber tree clone assessment and tapping system optimization. The results showed that: (1) the daily change of PTP in the foliation season suggests that a high PTP can ensure a high latex yield (2) PTP is positively related to the yield potential of rubber tree clones; (3) although Ethrel stimulation could not significantly increase the initial PTP of a rubber tree, it delays the recovery of PTP after tapping. Therefore,

PTP is an indicator of rubber tree latex yield and can be used for tapping system optimization.

2.3 STUDY ON DIFFERENT TAPPING SYSTEMS

Rodrigo et al. (2006) conducted a study which was aimed to assess the existing tapping systems and associated effects on the productivity and other related issues in both plantation and smallholder sectors in Sri Lanka. Also, focus was given to identify the factors hindering for the adoption of LFT (Low Frequency Tapping). Information was initially gathered using questionnaire based surveys and then verified through participatory workshops. The study revealed that the poor productivity in the plantation sector was highly associated with the shortage of skilled tappers. Productivity of the smallholdings tapped with family labour was less than that of smallholdings tapped with hired labour and this had been associated with the quality of tapping.

Samuel et al. (2009) conducted an experiment in southeast of Cote d’Ivoire on the combined effect of tapping systems and height of opening on clone PB 235 agronomic parameters and susceptibility to tapping panel dryness was led in order to determine the best exploitation system.

Giroh et al. (2009) conducted a study to analyze the technical inefficiency of rubber tapping in Rubber Research Institute of Nigeria Benin City, Edo State. Time series data of 129 tappers were analyzed using stochastic frontier analysis. The tappers were sampled using simple random sampling technique. The result of the stochastic frontier production function revealed that the variance of parameters (gamma and sigma squared) of the frontier production function were both significant at $p<0.01$.

2.4 STUDY ON CLIMATIC AND CULTURAL REQUIREMENTS

Rao and Vijayakumar (1992) found out that in traditional rubber growing areas, the total rainfall ranges between 2000-4000 mm, distributed over 140-220 days, without more than one to four dry months. Rubber can successfully be cultivated under these kinds of humid lowland tropical conditions, roughly between 15°N and 10°S.

Grist et al. (1998) reported that moisture stress has resulted in decreasing latex yields as well as decreasing total production of dry matter. The growth and latex yield of a tree are affected in different ways by soil moisture. Moisture stress has more dramatic effects on the latex yield than on tree growth, as turgor pressure in latex vessels inside the trunk of the tree is required to facilitate the latex flow.

Brown et al. (2000) examined the effects of extractive reserves on the political and economic empowerment of local communities. It presents a theoretically informed analysis of the interactions between rubber tappers and environmental organizations in the establishment and implementation of extractive reserves in Brazil. The analysis suggests that the alliances have been more successful in enabling political empowerment rather than economic empowerment, though they have not resulted in improvements in livelihood conditions of poor forest dwellers.

Stephen et al. (2012) conducted a study on the changing cultural identity of rubber tappers using a survey data of who self-identifies as a rubber tapper which includes socio-economic background, household assets etc. Shifts in livelihoods such as cattle ranching among rubber tappers are also studied as there is a disagreement concerning the acceptability of this practice.

Ali H and Davis D R (2013) conducted a survey to study the effects of age, sex and tenure on the job performance of rubber tappers. Experience is a greater indicator than age in determining job performance. Female tappers were found to have greater latex output, potentially due to greater generalized hand dexterity.

Mudd et al. (2015) studied the characteristics of biosphere-atmosphere exchange in rubber plantations, which are rapidly expanding throughout mainland

Southeast Asia. This is important to understand the impacts of the land-use change on environmental processes. In attempt to shed new light on the impacts of conversion to rubber, eddy flux measurements over a 3-year period was conducted in two rubber plantation sites.

2.6. EXISTING TAPPING DEVICES

Huang et al (2011) experimented on several measures to improve the mechanical properties of hand-pushing tapping knife. The knife was metallographically investigated through hardness tests and chemical treatments.

Mannayi Rahu, a para-rubber gardener in Wang district of Narathiwas Province developed the Hornbill knife to maximize the product outcome and prolong the age of the rubber tree. It is an application between Gebung knife, razer blade, and traditional spoke shave.

Malaysian Rubber Board invented the Automatic tapping machine or ARTS which is an automatic latex harvester attached to the tree with the concept of bark incision. The machine is capable to perform the tapping task automatically according to the programmed time. This system utilizes the solar energy to charge the power supply unit to ensure continuous supply of power for the system to operate thus promoting a greener and more sustainable concept and technology. This development will be a paradigm shift to the rubber industry especially in the upstream sector.

A group of students from College of Engineering, Punnapra, created a rubber tapping machine which costs less than 1500 INR which works simply on a motor powered blade. It weighs 750 g and its user friendly module suits to the mind of different rubber tappers.

P V Joseph created a tree grooving machine capable of moving over the tree surface to remove interior and exterior growth from the trees while leaving a canopy of tree cuts over the specified area. It includes a wheeled mobile platform supporting cutting units positioned at the front, each having circular saw blades rotatable carried by bearing members so the planes of all saw blades are parallel and held laterally

beyond the sides of the platform. Sideways are fixed on both right and left sides of the platform, at an angle relative to its mounting surface, along which the cutting means move between upper and lower limits of the tree barks that are driven and powered by an internal combustion motor mounted at the rear, which also drives the vehicle glider wheels. The device and the cutting means are protected by the guard rollers and dust guards. A belt or the handle is provided at both sides of the device chassis for the easy handling of the machine.

Rajesh et al developed a semi automated twin blade rubber tapping machine consisting of an electric motor, rotary cutter and protecting shield. The machine consists of 12 V & 1 amps-Electric motor, MS-Shield, CI-Cutter and 12 V & 7 amps-Rechargeable battery.

Arunachalam et al developed an automated rubber tapping machine consisting of a rail and a sliding block is attached to the rail which is connected to an A.C. powered motor through a gear arrangement.

Manoj et al (2012) from P. A. Asees College of Engineering and Technology developed an automatic rubber tapping machine consisting of a guide rail and two motors, one on the top is connected to a bottom plate and the one side connected to the rail.

Malarmannan et al (2013) developed a semi automatic rubber tapping machine which is able to tap up-to 300-400 trees within 3 hours and keeps the labor tired free performance.

Zakariahs (2010) developed a motorized rubber tapping machine comprising a hollow body, a shaft, a motor, a pair of cams and a plurality of bearings.

Materials and Methods

Chapter 3

MATERIALS AND METHODS

This chapter describes the various requirements and ergonomic considerations to develop a power operated rubber tapping machine. It also includes the methodology for fabrication of the machine. The evaluation procedure for the power operated rubber tapping machine.

3.1 STUDY ON RUBBER TAPPING PROCESS

A detailed study was conducted on how the tapping process is carried out to understand the design requirements that should be considered during the development of a power operated rubber tapping machine.

3.1.1. Traditional gouge knife

The blade of the knife shall be manufactured from carbon steel or alloy steel or tool steel. The chemical composition of the carbon steel shall be as follows:

a) Carbon 0.7 to 0.9 %;

b) Silicon 0.1 to O-4 %;

c) Manganese O-5 to 1-O %;

d) Sulphur 0.05 %;

e) Phosphorus 0.05 %.

Handle is made of Timber and Ferrule of Mild steel or brass. The blade of the knife shall be heat-treated to give hardness within the range of 450 HV to 500 HV.

Plate 3.1 Traditional gouge knife

Dimensions

The width of the cutting edge shall be 25.0 ± 0.5 mm

The length of the blade shall be 100 ± 3 mm

The length of the tang shall be 110 ± 3 mm

The length of the handle shall be 140 ± 3 mm

The minimum thickness of the blade shall be 6.0 mm

The angle of cutting edge shall be 105 ± 3˚

3.1.2. Gebung Knife

The composition of the knife is same as that of the traditional gouge knife. Handle can be of timber or steel. Effort applied by the labour is less as to and fro cutting action is used unlike that of the pushing action in the traditional knife. But the life of the blade is less. To overcome this knives with replaceable blades are also developed

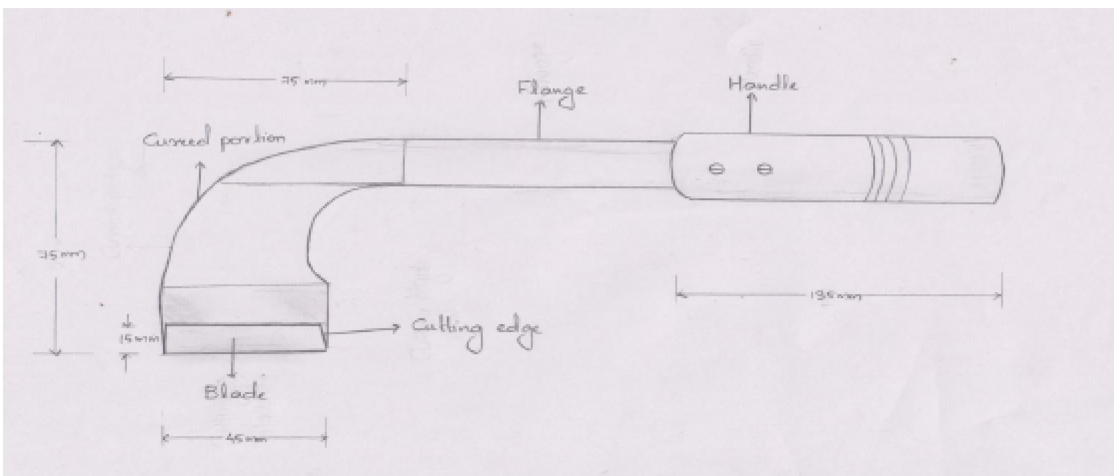


Plate 3.2 Gebung knife

Dimensions

The width of the cutting edge shall be 15 ±3 mm

The length of the blade shall be 45 ± 3 mm

The length of the flange shall be 190± 5 mm

The length of the handle shall be 135 ± 3 mm

The minimum thickness of the blade shall be 1±0.5 mm

3.1.3. Hornbill knife

It is an application between the traditional gebung knife, razor blade and traditional spoke shave. This knife only takes out a thin layer which prolongs the age of the tree. The manner of tapping can be both upward and downward. Also the knife is replaceable.

Plate 3.3 Hornbill knife

3.3. STUDY ON ERGONOMIC CONSIDERATIONS

Any machine or device should be designed considering the anthropometry i.e. human body dimensions, limits of body movements and strength. Tapping is associated with following problems:

- Vision of cutting
- Problems in different positions while tapping
- Body pains by continuous work
- The comfort level of holding the device
- Chance of an accident
- Weight of device

Plate 3.4 Ergonomic study

3.4. DEVELOPMENT OF POWER OPERATED RUBBER TAPPING MACHINE

Power operated rubber tapping machine was developed and fabricated in the Pioneer Automobiles, Karimugal, Ernakulam. The machine consists of replaceable blade, shaft, power transmission system, gear assembly, motor, casing and a battery.

3.4.1. Replaceable blade

It is the main component of the machine. It helps to cut the bark of rubber tree during tapping. The blade is made of 0.5 mm thick MS and it is threaded to the shaft. It has a cutting width of 1cm and a supporting edge of 4 cm.

Plate 3.5 Replaceable blade

3.4.2. Shaft

The shaft or push rod is made of MS having 295 mm length and 20 mm diameter. A hole of diameter 0.8 cm is provided at one end for connecting blade. On the other end, an extension of 15 mm length is given and a 6 mm diameter hole is drilled to it to connect the shaft with the power transmission system.

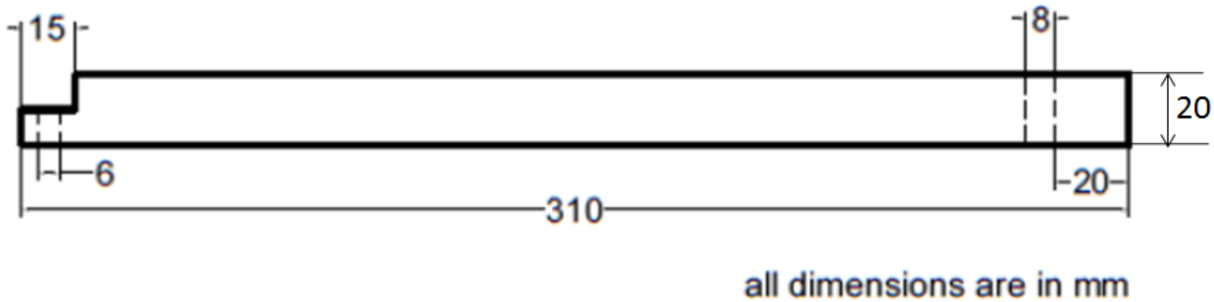


Fig 3.1 Shaft

3.4.3. Power transmission system

It is made by two bearings which are kept 40 mm apart. The bearings thus form the big end and the small end. The big end is connected to the gear assembly and small end is connected to the shaft.

Plate 3.6 Power transmission system

3.4.4. Gear assembly

The gear assembly in any device is used to reduce the speed. Two gears of 14 and 44 teeth are used which rests on the bearing seat. Gear having 14 teeth is connected to the motor shaft and that having 44 teeth is connected to the power transmission system via flywheel.

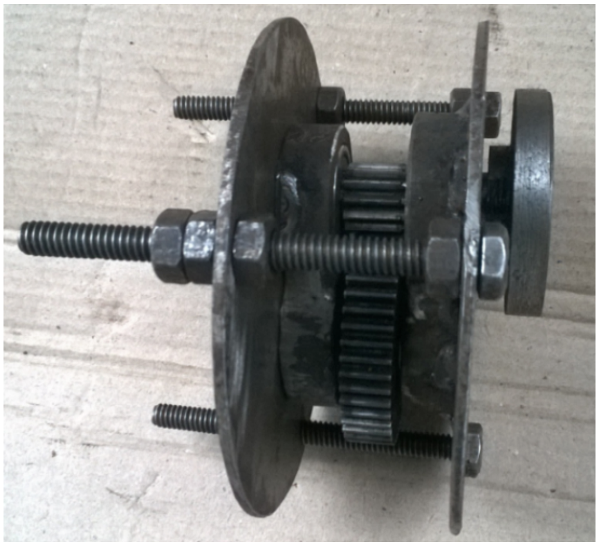


Plate 3.7 Gear assembly

3.4.5. Motor

The primary function of motor is to convert electrical energy to mechanical energy. A DC shunt wound motor which is usually used as wiper motor in cars is used. It is of 0.25 hp and it gives a speed output of 2250 rpm to the gears. The speed of the machine is 716 rpm

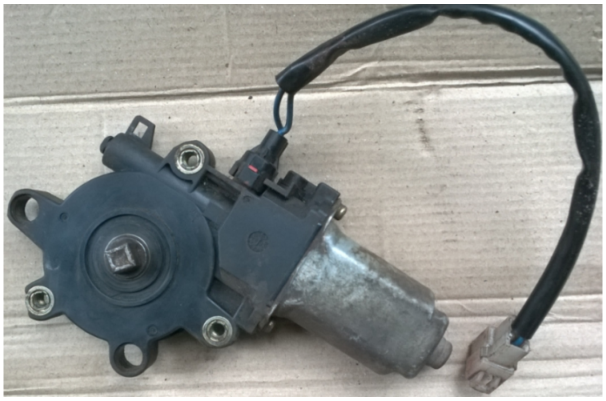


Plate 3.8 Motor

3.4.6. Flywheel

The flywheel stores the rotational energy. It is made of MS and is attached to the gear shaft. It is 280 g in weight thus balancing the weight on the other side. This minimizes vibrations. An eccentricity of 16 mm is provided to connect the power transmission system.

Plate 3.9 Flywheel

3.4.7. Casing

Outer casing made of cast iron is provided for encompassing the components like shaft, power transmission system and gear assembly. It protects the user from moving parts.

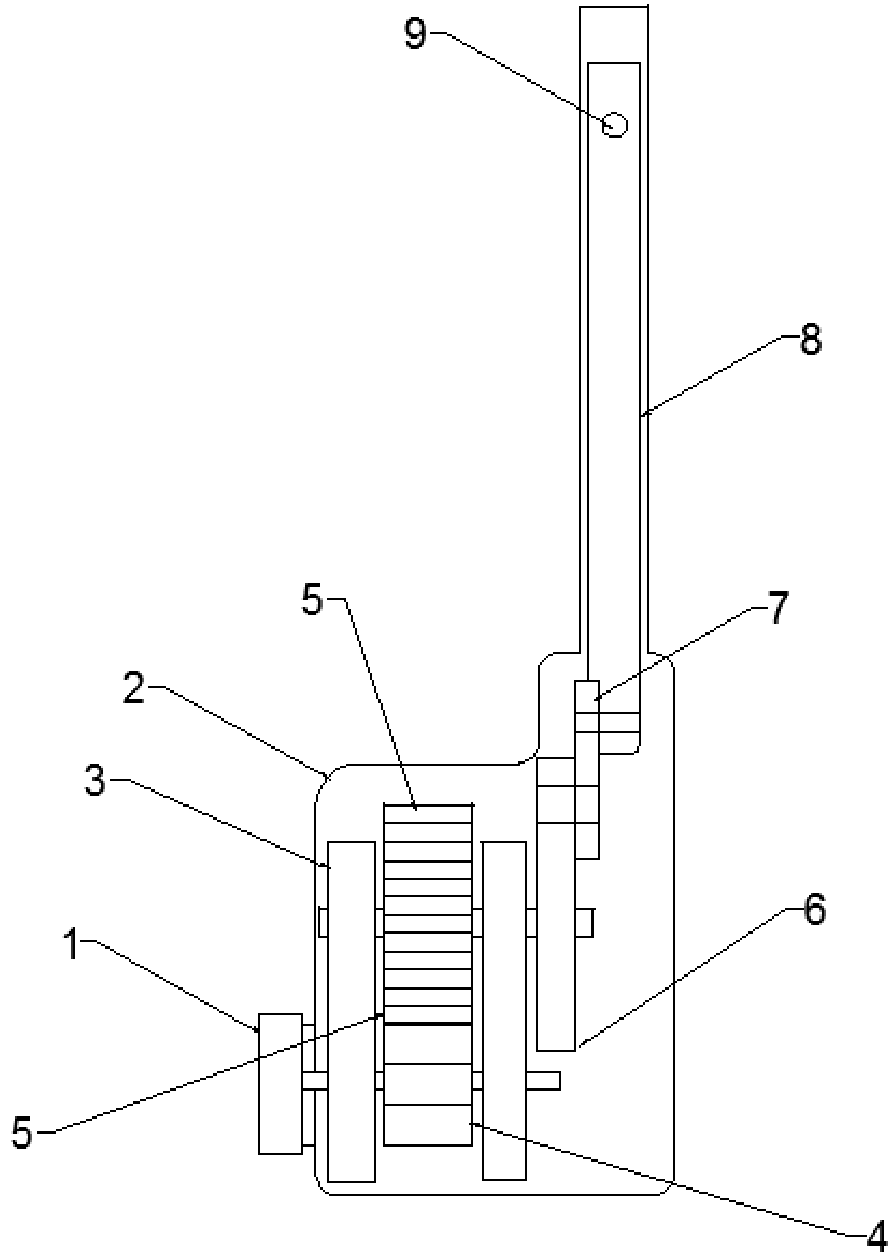
3.4.8. Battery

Battery act as the electrical power source for the motor. It converts stored chemical energy into electrical energy. It is made up of a combination of materials like zinc, manganese and potassium. A 12 V, 17 Ah battery is used. A knapsack battery is most suitable.

3.5. OPERATION OF RUBBER TAPPING MACHINE

The machine is connected to a 12 V battery. The battery induces rotary motion in the motor. The motor used is of 0.25 hp and delivers a speed of 2250 rpm. The rotary motion of the motor is transmitted to the gear assembly using a shaft. The speed reduction to 716 rpm is achieved by a pair of gears. A power transmission system linking the shaft and the gear assembly converts this rotary motion into reciprocating motion of the shaft. The blade is reciprocated along with the shaft. The required stroke is achieved by an eccentricity of 16 mm in the flywheel.

Plate 3.10 Power operated tapping machine



1. Motor **4. Gear with 14 teeth** **7. Power transmission system**

2. Casing **5. Gear with 44 teeth** **8. Shaft**

3. Bearing seat **6. Flywheel** **9. Thread for blade**

Fig 3.2 Interior view of the machine

3.6. PERFORMANCE EVALUATION OF THE MACHINE

Rubber plantation of Friends Agro Processing Centre, Naduvattam was selected for testing the machine. 8 year old trees were used for testing. Operations were carried out on 3 trees and the observations were noted. The performance of the machine was evaluated in terms of capacity, depth of cut, thickness of cut, time and weight.

3.6.1 Capacity

Capacity can be defined as the number of trees tapped per hour.

3.6.2. Depth of cut

It is the depth at which the blade will penetrate through the bark. It was measured using a scale.

3.6.3. Thickness of cut

It is the thickness of the cut bark. It was measured using vernier calipers.

3.6.4. Time

It is the time taken to perform all the tapping processes in a single tree. A stopwatch was used to record the time.

3.6.5. Weight

The weight of the machine is measured using a digital weighing balance.

3.7. ECONOMIC ANALYSIS OF THE MACHINE

The cost of operation of any machine is found out under two heads known as Fixed cost and Operating cost. Fixed cost includes depreciation, interest on the capital and taxes and insurance. Repair and maintenance, wages and lubricants come under the operating cost.

3.7.1 Fixed cost

Depreciation per hour=

$$\frac{Capital\,Investment\,(C) - Salvage\,Value\,(S)}{Life\,Of\;Machine \in Years\,(L)\,X\;No:Of\;Working\;Hours\,Per\;Year\,(H)}$$

Interest per hour= $\frac{C+S}{2}$ x i/H

Insurance and tax= 10 % of initial cost

3.7.2. Operating cost

Repair, maintenance and lubricant= 1.1 % of initial cost

Labour = Based on actual wages of workers

Results and Discussion

Chapter 4

RESULTS AND DISCUSSION

4.1. STUDY ON TAPPING PROCESS

When a tree is 50 cm in circumference at a height, of 1 meter from the ground, that is, 5 years after it has been put in the plantation, you can begin to tap the tree. To start the tapping, take a metal ribbon attached to a wooden lath 1.10 m long. This metal ribbon is at an angle of 30 degrees to the horizontal Roll the metal ribbon round the tree. With an awl (an iron point), make a **cut** along the ribbon. The cut ends when you have gone right round the tree. The beginning of the cut and the end of the cut are on the same vertical line. With the awl make a vertical channel from the lower edge of the cut. The cut and the channel must be deepened.

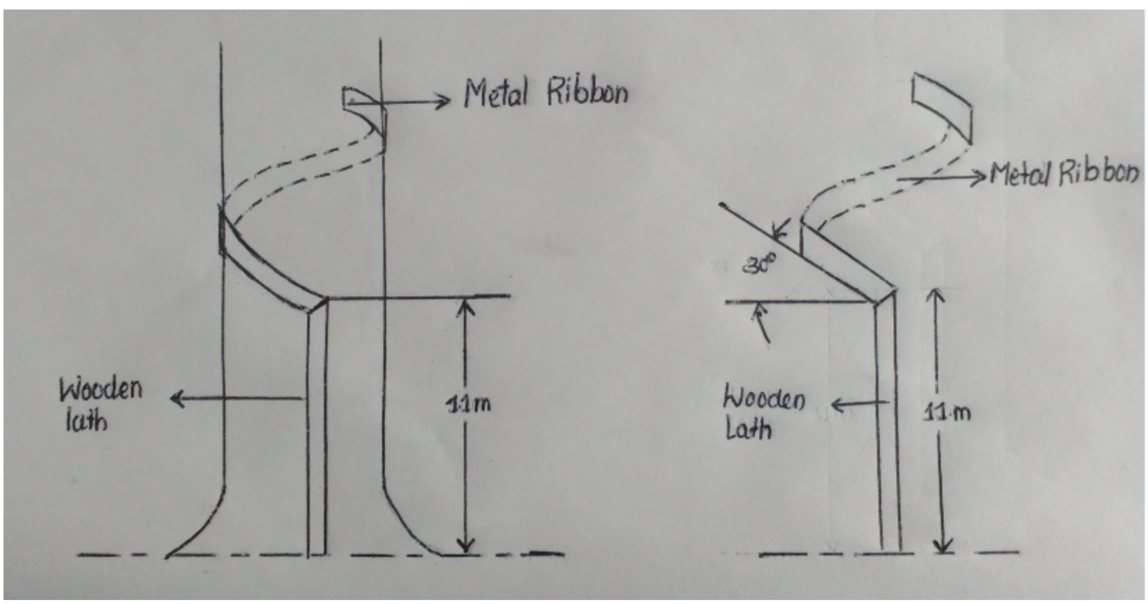


Fig 4.1 Rubber tapping process

4.2. STUDY ON ERGONOMIC CONSIDERATIONS

The casing connecting the blade and the shaft blocks the vision of tapper while tapping from bottom to top, which can be solved by attaching the blade in-line with the shaft. As the casing used was of cast iron, the weight of the device was considerably high. This makes tapping difficult on top. Chances of fatigue are also inevitable. By replacing the cast iron casing with fiber and the shaft with nylon pipe shaft, it is possible to reduce the weight to a greater extend. As the jerking is within the limits, a smooth tapping is assured.

4.3. PERFORMANCE EVALUATION OF THE DEVICE

Equipment's performance is the basic criteria to evaluate its ability. The performance of the developed power operated mechanical rubber tapping device was evaluated in terms of capacity, depth of cut, thickness of cut, time and weight. The observations recorded is tabulated in the tables 4.1, 4.2 and 4.3.

Plate 4.1 Testing of the machine

31

Table 4.1 Depth of cut

	Depth of cut, mm	
	Mechanically	Manually
Tree 1	8	6
Tree 2	7	6
Tree 3	9	6.5

Table 4.1 Thickness of cut

	Thickness of cut, mm	
	Mechanically	Manually
Tree 1	2	1.5
Tree 2	1.5	1
Tree 3	2.5	1.5

32

Table 4.1 Times

	Time, sec	
	Mechanically	Manually
Tree 1	21	15
Tree 2	19	15
Tree 3	23	15

From the above tables, on an average, the time taken for performing all the tapping operations in a single tree was 40 seconds, the tapping alone taking 21 seconds.

Thus the capacity of the device was found to be 90 trees per hour.

The average depth of cut was 8 mm as it depends upon the thickness of bark.

The average thickness of cut was 2 mm.

The weight of the machine was 3.025 kg.

Table 4.2 Results of performance evaluation

Item	Mechanically	Manually
Capacity	90 trees per hour	100 trees per hour
Depth of cut	8 mm	6.1 mm
Thickness of cut	2 mm	1.3
Time	40 sec	50
Weight	3.025 kg	300 g

4.4. ECONOMIC ANALYSIS OF THE MACHINE

The economic analysis of the machine was obtained as follows:

4.4.1. Fixed cost

Initial cost of the machine was Rs 13,000. Taking the salvage value to be 10 % of the initial cost, service life as 10 years and annual operating hours as 600 hours, depreciation was found to be 1.95. Taking % rate of interest per year as 9 %, interest is 1.07. Taxes and insurance will account to 0.325. Thus the fixed cost per hour was found to be Rs 3.345.

4.4.2 Operating cost

The repair, maintenance and lubricant cost were taken as 1.1 % of initial cost. The labour charge comes to about Rs 1 per tree. Thus the operating cost becomes Rs 90.24 per hour.

Table 4.3 Results of economic analysis

Fixed Cost per hour			Operating cost per hour	
Depreciation	**Interest**	**Taxes and insurance**	**Repair, maintenance, lubricant**	**Labour**
1.95	1.07	0.325	0.238	90
Total cost per hour Rs 93.58				

4.5. FUTURE IMPLEMENTATION

- Weight of the machine can be reduced by replacing the cast iron casing with fiber.
- Length of the shaft can be reduced and can be replaced by a nylon pipe shaft.
- The cutting tool could be placed in line with the shaft thus allowing a clear vision of cut.
- A switch may be provided in the casing for switching on and off the machine.

Summary and Conclusions

Chapter 5

SUMMARY AND CONCLUSIONS

Natural rubber is a solid product obtained through coagulating the latex produced by certain plants, particularly the Brazilian rubber-tree (*Hevea Brasiliensis*). Rubber is the largest cultivation in Kerala, especially in rural areas. It is an economic crop, which is the producer of isoprene (natural rubber). Isoprene is the major raw material of different industries like tire manufactures, footwear manufactures etc. and it is extensively used for furnishing roads as a substitute of Tar.

Rubber is grown in about 9 million hectares in the tropical regions of Asia, Africa and America with Malaysia being the leading producer. With over 5, 30,000 ha under rubber, India is now the third largest producer of natural rubber in the world. In India, rubber is predominantly a small holders’ crop and over 87% of the rubber is from this sector. A rubber tree from small holdings will have about 0.57 m^3 (20 CFT) of timber and the per ha yield is about 150 m^3 (5295 CFT). The stem wood has timber value of only 60%. Present total availability of rubber wood is estimated as 0.94 million m^3/year and it is estimated to be 1.5 m^3/year times by the end of the decade.

Currently the largest problem with tapping rubber trees is due to the care that must be taken to avoid damaging the tree. Workers are trained for six months before learning the proper technique and a poor tapper can kill many valuable trees. The process of carefully cutting hundreds of trees is also physically taxing. Improving this process would allow for excess market demand to be met by tapping more trees.

Before the fabrication of the machine, a detailed study was conducted on the tapping process, to know about the design requirements that should be considered during the development of a power operated rubber tapping machine. Also a study was conducted on the existing rubber tapping knives and found out that gouge knife,

gebung knife and hornbill knife was dominant in the market. As per the ergonomic study conducted, the problems associated with tapping were understood.

The developed power operated rubber tapping machine consists of a replaceable blade, a shaft, power transmission system, a gear assembly, a motor, casing and a battery. In simple terms, the operation of the machine is that, tapping is achieved by the reciprocating motion of the blade.

The performance of the developed power operated rubber tapping machine was evaluated in terms of capacity, depth of cut, thickness of cut and time. As per the rubber board, an expert tapper can tap 100 trees in 1 hour taking 36 seconds for a single tree. The developed machine could tap about 90 trees in 1 hour taking 40 seconds for a single tree. When tapping manually using a knife the tapper can control the depth and thickness of the cut while the machine developed obtain a depth of 8 mm and a thickness of 2 mm. A traditional gouge knife weighs 200- 300 g. The developed machine weighs 3.025 kg due to the heavy cast iron casing and the shaft. This can be replaced by fiber and nylon respectively to reduce the weight to a larger extend.

The economic analysis of the machine was carried out and it shows that the total cost per hour while using the machine for tapping 90 trees an hour is Rs 93.58. Manually tapping can cover 100 trees an hour and the total operating cost alone comes to about Rs 150/ hr giving a labor charge of Rs 1.5 per tree.

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Chapter 6

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DEVELOPMENT OF A POWER OPERATED RUBBER TAPPING MACHINE

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ABSTRACT

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ABSRACT

Rubber tapping is the process by which the sap (latex) is removed from a lubber tree without damaging the cambium of the tree. Tapping is the most costly activity in natural rubber production and the shortage of tappers is a serious problem in rubber plantations.

Rubber tree tapping is usually done using a manual type tapping knife. By using this knife, bark consumption and cutting depth cannot be controlled. To solve this problem, it is important to develop a mechanized tapping which can control bark consumption and cutting depth. The objective of this project is to fabricate and test the working of a mechanical rubber tapping machine.

Before the fabrication of the machine, a detailed study was conducted on the tapping process and the existing rubber tapping knives. As per the ergonomic study conducted, the problems associated with tapping were understood. The developed power operated rubber tapping machine consists of a replaceable blade, a shaft, power transmission system, a gear assembly, a motor, casing and a battery. The performance of the developed power operated rubber tapping machine was evaluated in terms of capacity, depth of cut, thickness of cut and time.