DESIGN OF MODIFIED 2-DIMESIONAL MECHANISM FOR VARIOUS OPERATIONS IN PEPPERMINT PLANT FOR RURAL INDIA

A Thesis

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In Partial Fulfillment of the Requirements

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In

"Production and Industrial Engineering"

Submitted by

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CERTIFICATE

This is to certify that **Mr. Anurag Sharma** (Enroll. No. 1400100299) has carried out the research work presented in the thesis titled **"Design of modified 2-dimesional mechanism for various operations in peppermint plant for rural India"** submitted for partial fulfillment for the award of the **Degree of Master of Technology in Production and Industrial Engineering** from **Integral University, Lucknow** under my supervision.

It is also certified that:

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Signature of Supervisor
Dr. Mohd. Anas
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Department of Mechanical Engineering
Integral University, Lucknow
Date: 08/09/2021
Place: Lucknow

DECLARATION

I hereby declare that the thesis titled "**Design of modified 2-dimesional mechanism for various operations in peppermint plant for rural India**" is an authentic record of the research work carried out by me under the supervision of Dr. Mohd. Anas, Associate Professor, Department of Mechanical Engineering, Integral University, Lucknow. No part of this thesis has been presented elsewhere for any other degree or diploma earlier.

I declare that I have faithfully acknowledged and referred to the works of other researchers wherever their published works have been cited in the thesis. I further certify that I have not willfully taken other's work, para, text, data, results, tables, figures etc. reported in the journals, books, magazines, reports, dissertations, theses, etc., or available at web-sites without their permission, and have not included those in this M. Tech. thesis citing as my own work.

Date: 08/09/2021

Signature

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I will be failing in my duties if I miss to express my profound and deepest sense of gratitude to my beloved parents and other members of family and friends for their keen interest in my studies, immense support and encouragement, without which it was impossible to complete this dissertation.

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Anurag Sharma

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ABSTRACT

Peppermint leaves have wide range of applications in medicines, toothpastes, soaps, mouth fresheners, chewing gums etc. However, in India, the traditional way of processing peppermint leaves for extraction of peppermint oil is slow, tedious, labour intensive, hazardous, and causes skin problem as well.

This thesis proposes a method of mechanizing the post harvesting process, with least modification in the current apparatus being used by the farmers in the Indian villages. It proposes a Non-electric Two dimensional Mechanized system for movement and compaction of the compact/ hay. The mechanism will help to reduce the number of labourers per unit hay volume and the risk associated with the contact of in-process hay with their skin. Also a lot of time is wasted in putting the leaves/ hay in the boiler vessel, preparing the hay in a compact form and in removing the processed leaves.

This thesis is an attempt to get rid of most of the problems aforementioned and make the process safe, efficient, less labour intensive and more economical for farmers and workers. The mechanism proposed is sustainable and farmer friendly as it does not require any special training for its operation. It will increase the profit of small scale industries with small capital investment for the setup.

CHAPTER 1

INTRODUCTION

1.1 GENERAL THEORY ABOUT PEPPERMINT OIL PRODUCTION

Figure 1: Peppermint plant

Peppermint oil is extracted from Mentha piperita and has contents of menthol (45% approx.) and menthone (22%). Peppermint (i.e. Mentha Piperita) belongs to mint family (Lamiaceae), which is widely considered as a medical and aromatic plant and are produced extensively for the medicinal and as food product. Peppermint is thought to have originated in Northern Africa and the Mediterranean. In the Ebers Papyrus, an ancient Egyptian medical text dating to 1550 BC, mint is listed as calming to stomach pains. Its leaves bear essential oils containing a large number of aromatic chemicals like menthol, menthone, isomenthone and menthofuran which are used in pharmaceutical, food, flavour, cosmetics and beverages industries. Tobacco industry consumes about 40% of the total mint essential oil followed by pharmaceutical and confectionary industries. Menthol, being the major substance, give the mints major characteristic aromas and flavours. It is used as a raw material in toothpaste, toothpowder, chewing tobacco, confectionary, mouth fresheners, analgesic balms, cough drops, perfumes, chewing gums, candies and tobacco industry. This is due to its fresh minty taste and fragrance and cooling effects due to presence of menthol.[1,2]

The peppermint oil is reported to have anti-oxidant properties, antibacterial activity and is one of the most important constituents of some over the-counter remedies in Europe for irritable bowel syndrome.[3]

Different types of peppermint plants cultivated in India are Peppermint, Spearmint, Bergamot mint and Japanese mint. At present, Japanese mint is cultivated in India on about 60,000 hectare of land with estimated production of 12,000 tonnes of mint oil which accounts for about 75% of total menthol mint production in the world. India grows Japanese mint in around 60,000 ha in tarai districts like Rudrapur, Bilaspur etc. of Uttaranchal and Central U.P. like Barabanki, Moradabad, Bareily, Badaun and Lucknow, besides smaller area in parts of Punjab (Ludhiana and Jallandhar). Along with Japanese mint, India produces Peppermint on an area of about 2,500 ha, Bergamont mint on 1,200 ha and Spearmint on 3,000 ha land which produces 200 tones, 150 tones and 300 tones of oils respectively. Other countries that grow these species and produce oil are China, Brazil, USA, former USSR and Thailand[4].

Presently, India is one of the largest producer of Mentha oil in the world. As per , The HINDU Business Line report, dated February 21, 2019, India produces 80% of the world's mint supply and exports 75% of its output.[5]

It is widely grown in temperature region of the world. In India it is grown between February to September (cultivated twice and hence extracted twice from single field). The crop gives high yield with regular irrigation and takes about 3.5 months to grow. Peppermint plant grows to about 30-90cm height and has smooth stems that are square in cross section. Its leaves can be 4–9 cm long and 1.5–4 cm broad and are dark green with reddish veins, and they have an acute apex and coarsely toothed margins.

Peppermint can be cultivated both in tropical and sub-tropical areas. The mean temperature between 20-40 C during major part of the growing period and rainfall between 100-110 cm (light showers at planting stage and ample sunshine at the time of harvesting) is ideal for its cultivation. Well drained loam or sandy loam soils rich in organic matter having pH between 6 and 8.2 are ideally suited for its cultivation. It can also be cultivated on both red and black soil. In case of acidic soil having pH less than 5.5 is recommended.

Table-1: Estimated area and production of mint in India and abroad.

Source: Essential Oils Association of India (2001), Vision 2005

Species	Area (ha.)	Production (tonnes of Oil)	Total world production (tonnes of Oil)	Major Producing Countries
Japanese Mint	60,000	12,000	16,000	India,China, Brazil
Peppermint	2,500	200	4,000	USA, France, former USSR, Brazil, India
Bergamote mint	1,200	150	200	USA ,Brazil, Thailand
Spearmint	3,000	300	2,000	USA,China,former USSR, India

The problems are collected by surveying these areas of UP (Uttar Pradesh, India).

1.2 PROBLEM ARISING IN THE PRODUCTION OF PEPPERMINT OILAND UNFAIR GOVERNMENT POLICIES

Mint Growers Association of India (MGAI)[6] is a NGO registered with government of India. Five peppermint farmers belonging to Baragaon, Barabanki region in Uttar Pradesh came together in 2001 to raise the concern and problems faced in peppermint farming at the state and national platform. It also aims to increase the organic peppermint productivity and enhance the standard of living of farmers.

Presently MGAI is working actively in different peppermint growing areas in UP namely Barabanki, Ambedkarnagar, Behraich, Hardoi, Amethi, Sitapur etc. The total number of members has now grown to more than 1000.

Farmers grow mint leaves, harvest and process at the distillery unit to produce peppermint (menthepiperita) oil. Later they sell menthapiperita oil to factories across UP and in few states like Jammu. These factories further process menthapiperita oil into different products (menthol, peppermint oil) and by-products which are then sold in domestic market and exported in International market.Usually rate of peppermint oil is 1200/kg.

Figure 2: Cultivation of peppermint plant

1.3 MINT GROWERS ASSOCIATION OF INDIA[6]

MGAI is vigorous in bringing the change at the ground level with respect to production of mint oil and have succeeded reasonably well but what concerns the association most is that the future of mint oil sales in domestic and international market is under threat. Sharing the details Mr. Sharma highlights, “German based BASF Company has introduced synthetic menthol in International market. It is the by-product of chemicals produced by the company. If this synthetic menthol gets imported in India then surely Indian mentha industry will be ruined completely as BASF produced synthetic menthol is an alternative to Indian produced menthol from mentha oil.” Industry insiders reveals Colgate has entered into the agreement with BASF for annual supply of 1000 tonne synthetic menthol.

Synthetic mentha produced by BASF in the international market shall definitely affect exports of mentha oil based Indian products. Quoting the figures Mr. Sharma adds, “Approximately 50 thousand tone mentha is produced in India annually. With decline in export orders we will have 20-25% loss. If the mint is sold at Rs. 1000/kg then 20% loss implies the price will fall by Rs.200/kg leaving farmer only with Rs. 800/kg which is almost close to his production cost. It shall be difficult for the farmer to grow mint at this price.” This change might lead to a complete shutdown of mentha oil industry in the country. MGAI is interacting with all government dignitaries to bring their attention to this crucial problem and trying to identify some concrete solution, so far the future is uncertain.

Another grave matter faced by mint farmer is that mint is not registered as agricultural crop instead is marked as horticulture crop by UP government. With this bifurcation if the mint harvest is lost due to any reason then there is no compensation given to the farmers for the loss incurred. In addition, farmer pays 5%VAT plus 1.5% Mandi Tax when selling mint or mint oil. These add on taxes on mint is only applicable in UP.

In addition state government has declared mentha as sensitive crop. Hence traders are also losing interest in mentha trade because they are required to deposit security of Rs. 5-10 lakhs and fulfill many formalities before trading mentha.

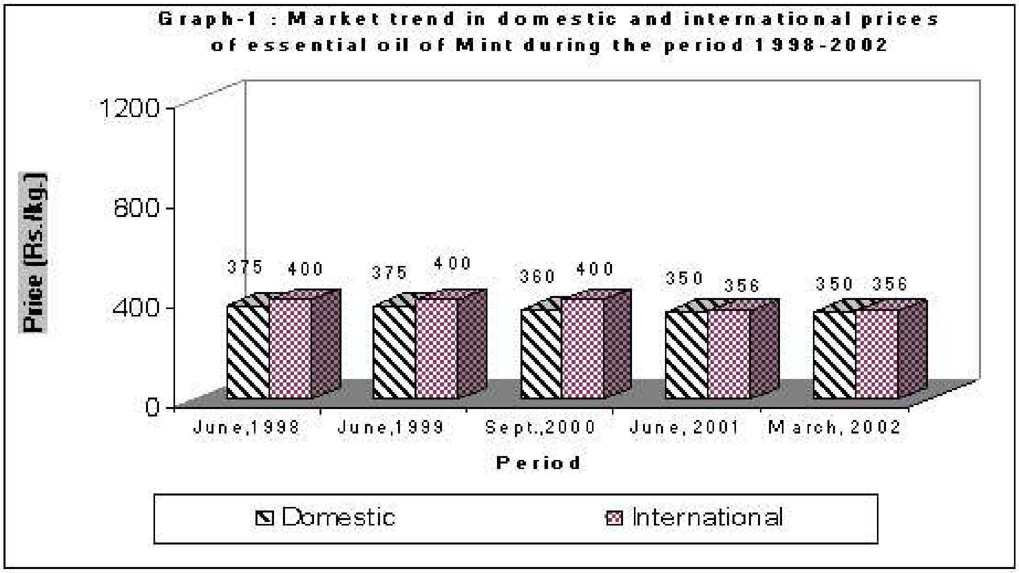
Mint is a cash crop and life line for the farmers. It is ideal for annual crop circle. After almost all the crops be it vegetables or cereals, mint is planted as it revives the soil with rich nutrients. Usually the fields are left empty from May-July and these months are good time to grow mint. It helps in continuing the cash inflow for the farmers."20 new latest technology updated distillation tanks have been installed in Barabanki by Ashri Menthol in support from Government of India. These tanks will use less water and used water shall be recharged as well. The tanks facilitate production of mint oil," he adds. Farmers sell peppermint in mandi and to exporters only after analyzing the rates on internet.

1.4 MARKET ANALYSIS AND STRATEGY

1.4.1 Demand and Supply Patterns

The Mint oils obtained from Menthaarvensis, Menthapiperita, Menthacitrata and Menthaspicata have put India on the world map. Of these, mint oil and menthol are primarily exported whereas others meet the home requirement of the industry. Despite our quantity of peppermint and spearmint being at par with World Standards, we have not made any headway in export trade because of fierce competition by USA. The latter is also the largest consumer of these oils.

The trend in domestic & international prices of oil during the five year period i.e. 1998-2002 is depicted in the graph below.



Graph 1 : Market trend in domestic and international prices of essential oil of mint

1.4.2 Import / Export Trends

A large part of the country's oil production is exported. It meets fierce competition in trade with China. The crop has of late involved a large sector in processing and trade activity in several small towns of U.P. (Rampur, Sambhal, Chandausi, Badaun, and Barabanki). A large number of farmers, traders, distillers and exporters are associated with this activity. The investment in the

Fluctuations in price are common. Currently it varies between Rs.350-400 for oil and Rs.600-800 for menthol (July-August and October) but the price is also governed by demand and price prevailing in importing countries and speculations on volumes and crop condition within India.

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Table-2: Export of mint oils, menthol and other derivatives from India (1998-99 to 2002-03).

Item	1998-99		1999-2000		2000-2001		2001-2002		2002-2003	
	Q	V	Q	V	Q	V	Q	V	Q	V
Mint oil	926.0	21.2	457.0	25.5	1095.4	39.3	1151.5	48.9	1280.8	52.0
Menthol	6198.4	175.3	7967.5	414.8	8809.0	393.4	7494.7	371.8	8851.0	388.4
DMO	734.0	70.5	648.6	15.3	636.3	18.0	452.1	12.9	505.2	16.2
Total Value	-	267.0	-	455.6	-	450.7	-	433.6	-	456.6

Source: Monthly Statistics of Foreign Trade of India, Vol I Export)

Q = Quantity (tonnes) ; V = Value (Rs. crores)

1.5 PRODUCTION TECHNOLOGY

1.5.1 Agro-Climatic Requirements

Japanese mint can be cultivated both in tropical and sub-tropical areas. The mean temperature between 20-40^0 C during major part of the growing period and rainfall between 100-110 cm. (light showers at planting stage and ample sunshine at the time of harvesting) is ideal for its cultivation.

Well drained loam or sandy loam soils rich in organic matter having pH between 6 and 8.2 are ideally suited for its cultivation. It can also be cultivated on both red and black soil. In case of acidic soil having pH less than 5.5, liming is recommended.

1.5.2 Growing and Potential Belts

India grows Japanese mint in around 60,000 ha in tarai districts (Rudrapur, Bilaspur etc.) of Uttaranchal and central U.P. (Barabanki, Moradabad, Bareily, Badaun and Lucknow) besides smaller area in parts of Punjab (Ludhiana and Jallandhar).

1.5.3 Varieties

The new varieties developed on Japanese mint in the country together with their traits as given in release note or extension literature are presented below:

Table 3: Variety of Japanese mint

Sr. No.	Variety	Characteristics given in literature
1.	MAS-1	It is a dwarf variety 30-45 cm. in height and early maturing variety. Less prone to insects due to short height. Menthol content-70-80%. Yield: About 200 q/ha. of herbage & 125-150 kg. of oil /ha.
2.	Hybrid-77	Early maturing variety. It is 50-60 cm. in height. Less prone to diseases viz. leaf spot & rust diseases. Menthol content-80-85%. Yield: About 250 q/ha. of herbage & 120-150 kg. of oil /ha. It is especially well adapted to sandy loam soils and drier climate than that of the tarai region.
3.	Shivalik (selection from Chinese cultivar)	The recovery of oil from the herb is 0.4 -0.5 %. Menthol content: 65-70%. This variety is highly suitable for obtaining second cut through ratooning. It is particularly grown in tarai region of U.P. & Uttaranchal. The herbage yield is 300q/ha while the essential oil yield amounts to about 180 kg/ha. Highly sensitive to the fungal diseases and pests prevailing in the tarai area.

It is a matter of investigation that inspite of claims of high herb yield, oil yield and menthol content in the oil, the farmers have reaped on an average 1200kg of oil per ha. for more than last two decades showing a marginal increase over these years.

1.5.4 Propagation

Mint can be propagated vegetatively through stolons and runners. By and large, most area under the crop is propagated by planting live juicy 8 to 10 cm. long stolons (underground stems) during early spring season. The seed rate used is 400-450 kg. of stolons per ha. and the spacing varies from 40 to 60 cm., depending upon soil fertility and the kind of the intercultural implements used. In northern India, planting of Japanese mint is suitable from first week of February to second week of March.

1.5.5 Production of Stolons

The plot should preferably be the best piece of land. It should be given high level of FYM during land preparation. Around 200 sq. m. plots are required to produce stolons for 1 hectare. Mature plants of chosen variety brought from a reliable nursery should be planted at 30 X 30cm. The nursery for the stolons is planted in August. The nursery is given frequent irrigation avoiding stagnation of water. Stolons are produced in autumn and are ready for use during the months of January to March. To obtain the stolons , the soil is opened manually or mechanically. These stolons can be used immediately or within a fortnight or so.

1.5.6 Planting from Stolon's

The field should be ploughed and harrowed thoroughly and divided into beds of suitable size to facilitate irrigation and make it free from weeds and stubbles. In each bed, lines are opened at a distance of 40 to 60 cm depending upon the variety and inter-culture implement used. The furrows are opened about 5 to 6 cm deep manually or through tractor driven harrow. Within a furrow, stolons are placed in rows at 10 cm. distance and furrows are closed with top soil. The bed is irrigated immediately after placing the stolons. On an average, 4 quintals of stolons are required for planting in one hectare of land. The stolons sprout in about 2 to 3 weeks when planted in February. Generally the planting should be done early depending upon ground temperature.

1.5.7 Irrigation

Ten irrigations are given during summer season at intervals of 10-12 days whereas another 4-6 for autumn crop harvested in late October. In order to obtain luxuriant growth, sufficient fertilizers and water must be applied to mint crop. A minimum water of about 100 mm is required to obtain good crop yield. Water logging during rainy season should be avoided by providing adequate drainage. In case of heavy soils and the soils prone to water logging, it is preferable to cultivate mint on ridges. The frequency of irrigation can also be reduced by 25% through the application of leaf mulches @ 5 t/ha.

1.5.8 Nutrition

The recommended dose for chemical fertilizers is Nitrogen 120 kg, phosphorus 60 kg and potassium 40 kg per ha. The entire quantity of P and K along with one-fifth of N is mixed with the soil at the time of planting; the remaining four-fifth of N is given as top-dressing twice for each harvest in available split doses. About 20 tons of well-rotten FYM, 150 kg DAP and 100 kg MOP per hectare are applied at the time of planting. Subsequently, half of N in the form of calcium ammonium nitrate or urea is applied in 2 split doses at 30 and 60 days after planting and similar quantities for ratoon crop at 25 days and 45 days of the harvest.

1.5.9 Intercultural Operations

By and large, 4 to 14 weeks after planting is crucial period for weed control. The crop requires intensive weeding and this is the most expensive cultural operation which contributes to a higher yield of the crop. Weeding with hand or mechanical hoes within the first six weeks of planting does control weeds. This process can be repeated once and rarely twice at an interval of about two to three weeks, after the first weeding. Since weeding and hoeing accounts for 30% of the cost of cultivation, use of wheel hoes either driven by hand or bullock drawn helps in reducing cost on intercultural. Several pre-and post-application of weedicides are recommended but these weedicides cannot control monocot weeds after the rainy season. Therefore best method is to combine manual, mechanical and chemical methods. Some of the effective herbicides includes Oxyflurofen (0.5 kg a.i. / ha), Pendimethalin (0.75 a.i. / ha), Simazine and Atrazine (1 kg a.i. / ha). The best procedure is to first apply a weedicide followed by manual or mechanical weeding at 8 to 10 weeks when mulching should also be applied.

1.5.10 Crop Rotation

The rotation of mint crop with other food crops is found to be a good way of controlling weeds. Continuous cropping of any of the mints is not advisable. The best rotation is Mint: Rice and Mint: Potatoes and Mint: Vegetables: Peas etc. depending upon cropping system followed in the region.

1.5.11 Harvesting and Yield

The crop planted through stolons in January and February is harvested twice i.e. in June and October months. The first crop is harvested after 100-120 days of growth and the second harvest in about 80-90 days following the first harvest. The fresh herbage at harvesting stage contains 0.5 to 0.68% of oil and is ready for distillation after wilting for 6-10 hrs. The wilted crop is cut 10cm. above the ground by means of a sickle on bright sunny days, since harvesting on cloudy or rainy days decrease the menthol content in the oil.

The average yield is 20 tons of fresh herbage per ha. In two harvests, this, in turn, yields around 250 kg of oil in a year.

1.6 POST HARVEST MANAGEMENT

1.6.1 Storage of Herbage

Mint herbage should be shade dried for about a day before it is distilled. Care should be taken so that decomposition of the herbage does not initiate during the drying process. There would be some reduction in oil yield if wilted herbage crop is stored for a longer period of 2-3 days. As such, storage of herbage for a longer period is not recommended.

1.7 HYDRODISTILLATION PROCESS

In order to isolate essential oils by hydro distillation, the aromatic plant material is packed in a still and a sufficient quantity of water is added and brought to a boil; alternatively, live steam is injected into the plant charge. Due to the influence of hot water and steam, the essential oil is freed from the oil glands in the plant tissue. The vapor mixture of water and oil is condensed by indirect cooling with water. From the condenser, distillate flows into a separator, where oil separates automatically from the distillate water.

The recovery of oil from the herb is 0.5-0.8%. Oil is obtained through steam distillation. The oil is of golden yellow colour, containing not less than 75% menthol. The duration of steam distillation is 2-2.5 hours for complete recovery of the oil. About 80% of the oil is received in the receiver in about one hour's time. The oil that is received later is richer in menthol.

The fresh or semi dried herbage is placed in a tank and treated with passing steam under pressure. The steam that comes out of the tank is then passed through a condenser. The condenser receiving the steam, carrying the oil extracted from the herbage in the tank is kept constantly cool by circulating cold-water over/around it. The condensed oil and water mixture is collected in a receiver. Since the water and oil have different densities, oil floats on the surface of the water in the receiver. The oil is skimmed off and collected.

1.7.1 Mechanism of Distillation

Hydro distillation of plant material involves the following main physicochemical processes:

- Hydro diffusion
- Decomposition by heat

1.7.1.1 Hydro diffusion

Diffusion of essential oils and hot water through plant membranes is known as hydro diffusion. In steam distillation, the steam does not actually penetrate the dry cell membranes. The hydro diffusion is depending upon the permeability of plant material while It is in swollen condition. Membranes of plant cells are almost impermeable to volatile oils. Therefore, in the actual process, at the temperature of boiling water, by osmosis a part of volatile oil dissolves in the water present within the glands, the swollen membranes and finally reaches the outer surface, where the oil is vaporized by passing steam

1.7.1.2 Effect of Heat

Almost all constituents of essential oils are unstable at high temperature. To obtain the best quality oil, distillation must be done at low temperatures. The temperature in steam distillation is determined entirely by the operating pressure, whereas in water distillation and in water and steam distillation the operating pressure is usually atmospheric. All the previously described three effects, i.e. hydro diffusion, hydrolysis and thermal decomposition, occur simultaneously and affect one another. The rate of diffusion usually increases with temperatures as does the solubility of essential oils in water. The same is true for the rate and extent of hydrolysis. However, it is possible to obtain better yield and quality of oils by: (1) maintaining the temperature as low as possible, (2) using as little water as possible, in the case of steam distillation, and (3) thoroughly comminuting the plant material and packing it uniformly before distillation.

1.7.2 Types of Hydro distillation process

There are three types of hydro distillation for isolating essential oils from plant materials:

- Water distillation
- Water and steam distillation
- Direct steam distillation

1.7.2.1 Water Distillation

In this method the working material is set with water and heated at the bottom of drum with fuel usually dry used waste i.e. boiling in the drum is occur boiled by applying heat by direct fire , steam jacket, closed steam jacket, closed steam coiler open steam coil. The main characteristic of this process is that there is direct contact between boiling water and plant material.

When the still is heated by direct fire, adequate precautions are necessary to prevent the charge from overheating. When a steam jacket or closed steam coil is used, there is less danger of overheating; with open steam coils this danger is avoided. But with open steam, care must be taken to prevent accumulation of condensed water with in the still. Therefore, the still should be well insulated. The plant material in the still must be agitated as the water boils, otherwise agglomerations of dense material will settle on the bottom and become thermally degraded. Certain plant material slice cinnamon bark, which is rich in mucilage, must be powdered so that the charge can readily disperse in the water; as the temperature of the water increases, the mucilage will be leached from the ground cinnamon. This greatly increases the viscosity of the water-charge mixture, thereby allowing it to char. Consequently, before any field distillation is done, a small-scale water distillation in glassware should be performed to observe whether any changes take place during the distillation process. From this laboratory trial, the yield of oil from a known weight of the plant material can be determined. The laboratory apparatus recommended for trial distillations is the Clevenger system.

Water distillation requires a greater number of stills, more space and more fuel. It demands considerable experience and familiarity with the method. The high-boiling and somewhat water-soluble oil constituents cannot be completely vaporized or they require large quantities of steam. Thus, the process becomes uneconomical.

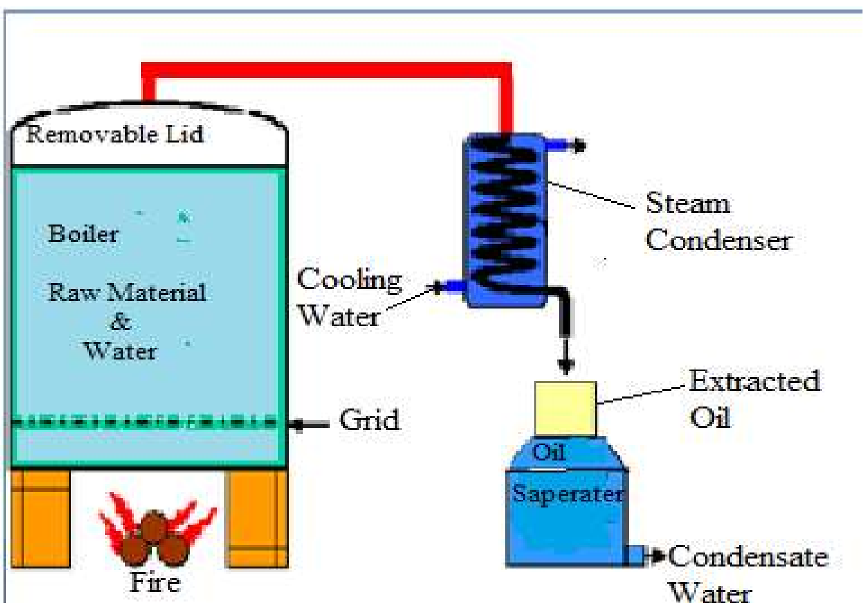


Figure 3: Water distillation (Peppermint Oil)

Disadvantage of Water Distillation

- Oil component slike esters are sensitive to hydrolysis while other slike a cyclic on oterpene hydrocarbons and aldehydes are susceptible to polymerization (since the pH of water is often reduced during distillation, hydrolytic actions are facilitated).

- Oxygenated components such as phenol shave a tendency to dissolve in the still water, so their complete removal by distillation is not possible.
- As water distillation tends to be a small operation (operated by one or two persons), it takes a long time to accumulate much oil, so good quality oil soften mixed with bad quality oil.
- The distillation process is treated an art by local distillers, who rarely try to optimize both oil yield and quality.
- Water distillation is a slower process than either water and steam distillation or direct steam distillation.

1.7.2.2 Water and Steam Distillation

In water and steam distillation, the steam can be generated either in a satellite boiler or within the still, although separated from the plant material. Like water distillation, water and steam distillation is widely used in rural areas. Moreover, it does not require a great deal more capital expenditure than water distillation. Also, the equipment used is generally similar to that used in water distillation, but the plant material is supported above the boiling water on a perforated grid. In fact, it is common that persons performing water distillation eventually progress to water and steam distillation.

It follows that once rural distillers have produced a few batches of oil by water distillation, they realize that the quality of oil is not very good because of its still notes (subdued aroma). As a result, some modifications are made.

Using the same still, a perforated grid or plate is fashioned so that the plant material is raised above the water. This reduces the capacity of the still but affords a better quality of oil. If the amount of water is not sufficient to allow the completion of distillation, a cohobation tube is attached and condensate water is added back to the still manually, thereby ensuring that the water, which is being used as the steam source, will never run out. It is also believed that this will, to some extent, control the loss of dissolved oxygenated constituents in the condensate water because there-used condensate water will allow it to become saturated with dissolved constituents, after which more oil will dissolve in it.

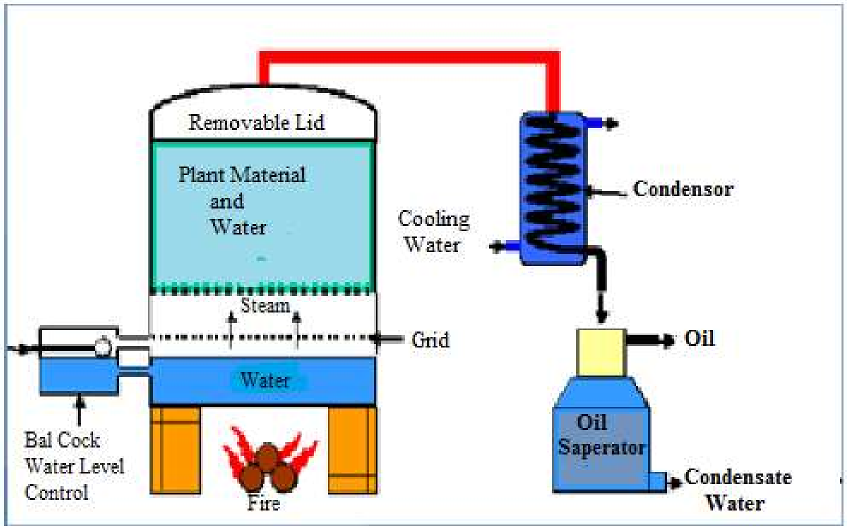


Figure 4: Water and Steam Distillation

ADVANTAGES OF WATER AND STEAM DISTILLATION OVER WATER DISTILLATION

- Higher oil yield.
- Components of the volatile oil are less susceptible to hydrolysis and polymerization (the control of wetness on the bottom of the still affects hydrolysis, where as the thermal conductivity of the still walls affects polymerization).
- If refluxing is controlled, then the loss of polar compounds is minimized.
- Oil quality produced by steam and water distillation is more reproducible.
- Steam and water distillation is faster than water distillation, so it is more energy efficient. Many oils are currently produced by steam and

water distillation, for example lemon grass is produced in Bhutan with a rural steam and water distillation system.

DISADVANTAGES OF WATER AND STEAM DISTILLATION

- Due to the low pressure of rising steam, oil so high-boiling range require a greater quantity of steam for vaporization-hence longer hours of distillation.
- The plant material becomes wet, which slows down distillation as the steam has to vaporize the water to allow it to condense further up the still.
- To avoid that the lower plant material resting on the grid becomes water logged, a baffle is used to prevent the water from boiling too vigorously and coming in direct contact with the plant material.

1.7.2.3 Direct Steam Distillation

As the name suggests, direct steam distillation is the process of distilling plant material with steam generated outside the still in a satellite steam generator generally referred to as a boiler. As in water and steam distillation, the plant material is supported on a perforated grid above the steam inlet. A real advantage of satellite steam generation is that the amount of steam can be readily controlled. Because steam is generated in a satellite boiler, the plant material is heated no higher than 100° C and, consequently, it should not undergo thermal degradation. Steam distillation is the most widely accepted process for the production of essential oils on large scale. Throughout the flavor and fragrance supply business, it is a standard practice. An obvious drawback to steam distillation is the much higher capital expenditure needed to build such a facility. In some situations, such as the large-scale production of low-cost oils (e.g. rosemary, Chinese cedar wood, lemongrass, litseacubeba, spike lavender, eucalyptus, citronella, corn mint), the world market prices of the oils are barely high enough to justify their production by steam distillation without amortizing the capital expenditure required to build the facility over a period of 10 years or more.

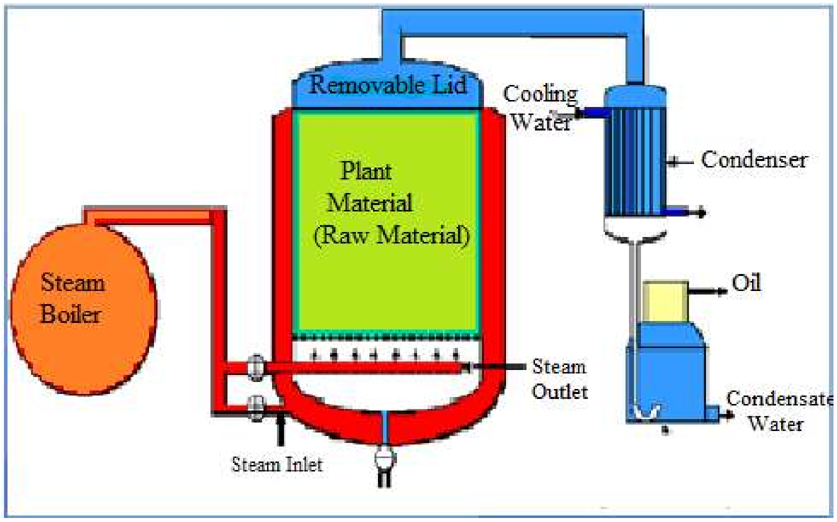


Figure 5: Direct Steam Distillation

ADVANTAGES OF DIRECT STEAM DISTILLATION

- Amount of steam can be readily controlled.
- No thermal decomposition of oil constituents.
- Most widely accepted process for large-scale oil production, superior to the other two processes.

DISADVANTAGE OF DIRECT STEAM DISTILLATION

- Much higher capital expenditure needed to establish this activity than for the other two processes.

1.8 NON CONVENTIONAL METHOD FOR EXTRACTING ESSENTIAL OIL (PEPPERMINT OIL)

Since economy, competitiveness, eco-friendly, sustainability, high efficiency and good quality become keywords of the modern industrial production, the development of EOs' extraction techniques has never been interrupted. Strictly speaking, conventional techniques are not the only way for the extraction of EOs. Novel techniques abided by green extraction concept and principles have constantly emerged in recent years for obtaining natural extracts with a similar or better quality to that of official methods while reducing operation units, energy consumption, CO2 emission and harmful co-extracts in specific cases. The principles of green extraction can be generalized as the discovery and the design of extraction processes which could reduce the energy consumption, allow the use of alternative solvents and renewable/ innovatory plant resources so as to eliminate petroleum-based solvents and ensure safe and high quality extracts or products [7]

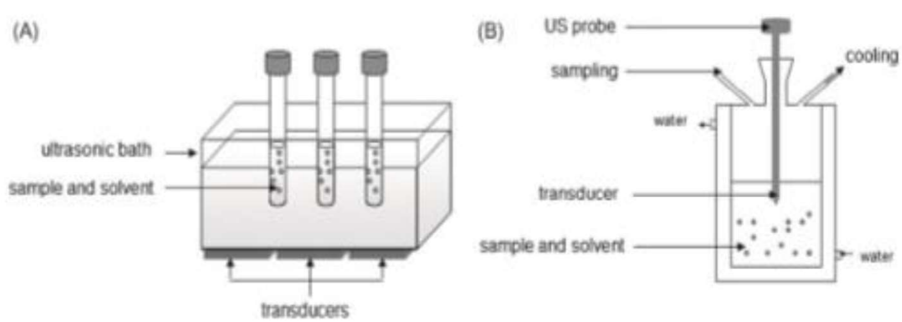
1.8.1 Turbo Distillation

This technique is developed to reduce energy and water consumption during boiling and cooling in hydro-distillation. The turbo extraction allows a considerable agitation and mixing with a shearing and destructive effect on plant materials so as to shorten distillation time by a factor of 2 or 3. Furthermore, it is an alternative for extraction of EOs from spices or woods, which are relatively difficult to distill. Besides, an eco-evaporator prototype could be added with aspect of the recovery and the reuse of the transferred energy during condensation for heating water into steam[8]

1.8.2 Ultrasound-Assisted Extraction

With the aim of higher extraction yields and lower energy consumption, ultrasound assisted extraction has developed to improve the efficiency and reduce the extraction time in the meanwhile. The collapse of cavitations bubbles generated during ultra-sonication gives rise to micro-jets to destroy

EOs' glands so as to facilitate the mass transfer and the release of plant EOs. This cavitation effect is strongly dependent to the operating parameters (e.g. ultrasonic frequency and intensity, temperature, treatment time, etc.) which are crucial in an efficient design and operation of sono-reactors. In addition to the yield improvement, the EOs obtained by Ultrasound-Assisted Extraction (UAE) showed less thermal degradation with a high quality and a good flavor [9]However, the choice of sonotrode should be careful as the result of the metallic contamination which may accelerate oxidation and subsequently reduce EOs' stability . This technique has already proved its potency to scale up, which shows 44 % of increment on extraction yield of EOs from Japanese citrus compared to the traditional methods (Mason et al. 2011).



Laboratory ultrasound apparatus: (a) ultrasonic bath and (b) ultrasonic probe.

Figure 6: Laboratory ultrasound apparatus (a) Ultrasonic bath (b) Ultrasonic probe.

The most common equipment's used for extraction purposes are ultrasonic baths (Fig. 5(a)) and ultrasound probe fig 5(b) Ultrasonic baths are mainly used forcleaning, degassing or solid dispersion in a solvent. It can be used for extraction; however, the low reproducibility and low power of ultrasound delivered directly to the product to be treated are major drawbacks in this case. The ultrasonic probe appears to be more efficient for extraction. The probe system is more powerful due to an ultrasonic intensity delivered from a smaller surface, when comparing to the ultrasonic bath. Moreover, the probe is immerged in the reactor resulting in a direct delivery of ultrasound in the reaction media. The intensity of ultrasound obtained by the probe system leads to a quick increase of temperature in the reactor. The cooling of the reactor by a double-jacket is then necessary to conduct extraction. At a laboratory scale and at an industrial scale, ultrasound extraction can be performed in a batch or in a continuous mode. It can also be mentioned that ultrasound can be coupled with other extraction techniques (e.g. supercritical extraction, Soxhlet42)

1.8.3 Microwave-Assisted Extraction

Microwave is a non-contact heat source which can achieve a more effective and selective heating. With the help of microwave, distillation can now be completed in minutes instead of hours with various advantages that are in line with the green chemistry and extraction principles. In this method, plant materials are extracted in a microwave reactor with or without organic solvents or water under different conditions depending on the experimental protocol. The first Microwave-Assisted Extraction (MAE) of EOs was proposed as compressed air microwave distillation (CAMD) [10]. Based on the principle of steam distillation, the compressed air is continuously injected into the extractor where vegetable matrices are immersed in water and heated by microwave. The water and EOs are condensed and separated outside the microwave reactor. The CAMD can be completed in just 5 min and there is no difference in quantitative and qualitative results between extracts of CAMD and 90 min conventional extraction using steam distillation. In order to obtain high quality EOs, vacuum microwave hydro-distillation (VMHD) was designed to avoid hydrolysis (Mengal et al. 1993). Fresh plant materials have been exposed to microwave irradiation so as to release the extracts; reducing the pressure to 100–200 mbar enables evaporation of the isotropic water-oil mixture at a temperature lower than 100 °C. This operation can be repeated in a stepwise way with a constant microwave power, which is contingent on the desired yield.

The VMHD, which is 5–10 times faster than classic HD, showed comparable yield and composition to HD extracts. Beyond that, in fact, there exist a couple of modern techniques assisted by microwave such as microwave turbo hydro distillation and simultaneous microwave distillation, which are impressive for short treatment time and less solvent used[11] On account of growing concern for the impact of petroleum-based solvents on the environment and the human body, several greener processes without solvent have sprung up in the last decade. Solvent-free microwave extraction (SFME) was developed with considerable success in consistent with the same principles as MAE. Apart from the benefits mentioned before, the SFME simplifies the manipulation and cleaning procedures so as to reduce labor, pollution and handling costs. A cooling system outside the microwave oven allows the continuous condensation of the evaporated water-oil mixture at atmospheric pressure. The excessive water is refluxed to the reactor in order to maintain the appropriate humidity of plant materials. It is interesting to note that the easy-controlled operating parameters need to be optimized for maximization of the yield and final quality. The potential of using SFME at laboratory and industrial scale has been proved on familiar plant materials with a considerable efficiency compared to conventional techniques (Filly et al. 2014). Inspired by SFME, a number of its derivatives have emerged, which offer significant advantages like shorter extraction time, higher efficiency, cleaner feature, similar or better sensory property under optimized conditions. It is worth mentioning that the MHG is neither a modified MAE that uses organic solvents, nor an improved HD that are high energy and water consumption, nor a SFME which evaporates the EOs with the in situ water only. In addition, MHG derivants such as vacuum MHG and microwave dry-diffusion and gravity (MDG) has developed later with the consideration of energy saving, purity of end-products and post-treatment of wastewater (Farhat et al. 2010; Zill-e-Huma et al. 2011). Extraction of natural products by microwave processes has been applied to numerous vegetable matrices as shown in Table 4. Moreover, microwaves can extract a wide range of compounds: EO, vegetable oils, dyes, aromas, and polyphenols. Hydro distillation (HD), hydro diffusion, or distillation-extraction is traditionally used to extract EO. Due to their chemical composition (volatile molecules), EO are thermo-sensitive and vulnerable to chemical reactions. SFME has been applied to extract EO on lavadin,69 oregano,70 citrus peels,71 and basil and thyme.72 Compared to conventional extraction processes, SFME has shorter extraction duration to achieve the same extraction yield (30 min, compared to 4 h by HD), no solvent consumption and show good reproducibility. Furthermore, the EO composition exhibit composition differences compared to HD. Périno-Issartier et al.,73 by comparing five extraction processes, showed that lava din EO extracted by SFME and MHG exhibits better locative profile than EO extracted by HD.

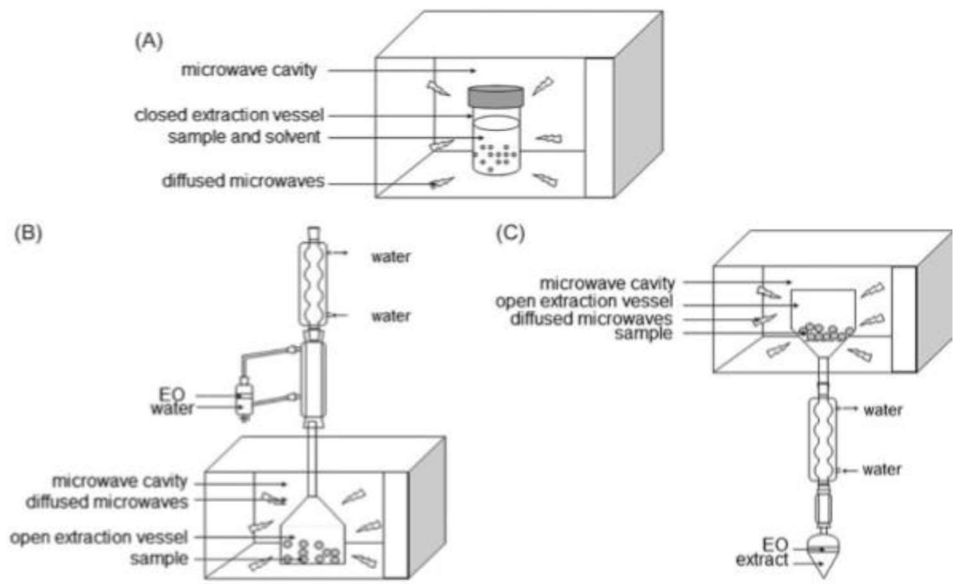


Figure 7: Microwave-Assisted Extraction

CHAPTER 2

LITERATURE REVIEW

Literature survey is done to get the foundation data on the issues to be recognized in the present work and to centre the significance of the present study. The aim is to develop efficient design of peppermint oil (Small scale industries of India). It additionally stresses on Response Surface Methodology technology to optimise the efficient design of peppermint plant.

2.1 MECHANISM OF EXTRACTION OF ESSENTIAL OIL

Gavahian et al., [2014] In this study, SD resulted in a similar extraction time to the conventional HD technique. SD and HD indicated that both extraction method resulted in significant changes in gland and the amount of changes in HD were slightly greater than SD. Essential oil obtained by HD and SD were almost similar in their physical properties and chemical compositions. These similarities can suggest SD as an alternative reference method for qualitative extraction of essential oil. [12]

Ammann et. al. [1999] compared Superheated water extraction, steam distillation and supercritical fluid extraction (SFE) are compared for extraction of *l*-menthol, menthone, eucalyptol and other components of peppermint *(mentha piperita)* leaves. It was comcluded that Under the chosen conditions steam extraction is the most efficient way to extract peppermint oil from leaves. Extraction with superheated water is less efficient, and supercritical carbon dioxide extraction is the least suitable method. CO2 is too slow to extract natural compounds from peppermint leaves in a reasonable time. Sabinene hydrate cannot be found in superheated water extracts. The loop flush was necessary to collect all extracted compounds.

Stashenko et al., [2004], Gavahian et al., [2011]; Gavahian et al., [2012] were carried out “ Hydro distillation (HD), Steam distillation (SD) suffer from some disadvantages including losses of volatile compound, long extraction times and energy intensive. However, these are simplest methods of extraction and their equipment's are often more available then novel methods of extraction like microwave-assisted hydro distillation (MAHD) and ohmic-assisted hydro distillation (OAHD).[13]

Li, Ying, et al., From Conventional to Green Extraction, Essential Oils as Reagents in Green Chemistry Which are influenced by the distillation duration, the temperature, the operating pressure, and most importantly, the type and quality of raw plant materials.

Hydro distillation plant for extracting essential oil is a conventional process but there is a various modification has done in last few decades but still there is various modification need.Water distillation, water and steam distillation, steam distillation, cohobation, maceration and effleurage are the most traditional and commonly used methods. Maceration is adaptable when oil yield from distillation is poor.[10]

Li Ying, et al., Essential Oils: From Conventional to Green Extraction, By Essential Oils as Reagents in Green Chemistry the analytical composition of essential oil extracted from the same plant organ may be quite different with respect to the techniques used. These conventional extraction techniques could typically extract Peppermint oil from plants ranging from 0.005 to 10 %, which are influenced by the distillation duration, the temperature, the operating pressure, and most importantly, the type and quality of raw plant materials.

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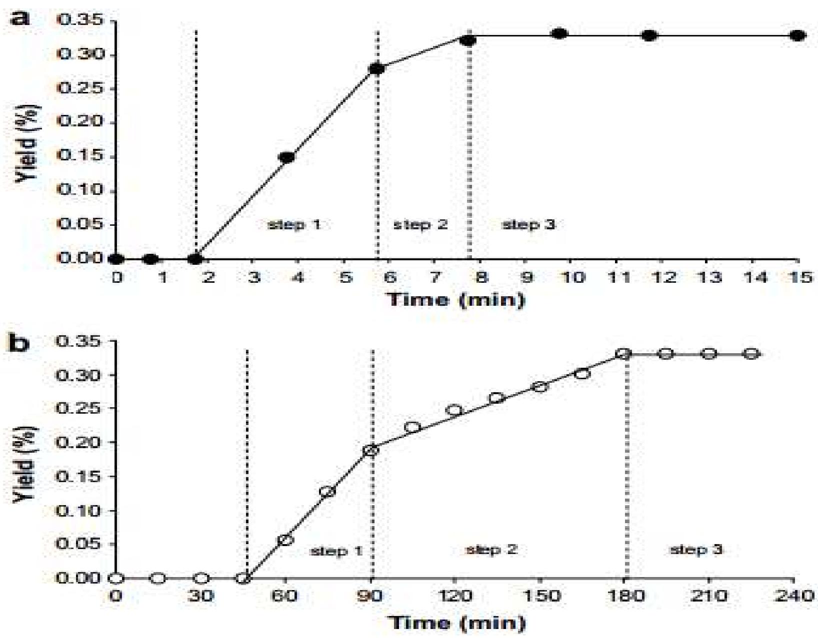
Braimah, S. R.,Andoh, P.Y et al. [2016] have designed a mechanical system to extract and separate lemon grass oil, used in medicine, perfumery industry, vitamin A manufacturing and pharmaceuticals. This paper has directed to design a mechanical system that will be used to extract and separate lemon grass oil. It was done using direct steam distillation process. Three concepts were developed based on the orientation of the condensers, source of power, and method of oil production. The three concepts were evaluated and the best concept was selected as the final design. Design analysis was performed on each part to determine their specification, the material to be used and manufacturing processes for the fabrication. Tests were performed to find machine performance and quality of the oil produced. It was concluded that the prototype machine .Developed can be used to extract lemon grass oil from the leaves.[15]

SeidYimer et al. [2014] had research project in which Eucalyptus leaves are extracted for essential oil by steam distillation process using sox let apparatus. The extracted oil has antimicrobial, antibacterial and anti-fungal properties. The extracted oil is applied on cotton fabrics by pad-dry-cure method using padding mangle and value adding to the ordinary cotton fabric as Medical fabric. Such process was complex.[16]

Nabil Bousbia et al.[2008] The yields of essential oil extracted from rosemary (R. officinal is) with the different isolation methods are respectively 0.35 ± 0.07% and 0.33 ± 0.09% for the HD and MHG. As is shown in Graph 2: a and b, an isolation time of 15 min with MHG provides yields similar to those obtained after 180 min by means of HD, which is one of the reference methods in essential oil isolation. Graph 2: a and b shows the variation of the extraction yield according to the extraction time. Three phases are observed in the process of the microwave extraction (Graph 2a). Step 0 represents the heating phase from room temperature to 100 C. The first step (Step 1) is represented by an increasing line which characterizes the first quantities extracted, located at the surface of vegetable particles representing approximately 82% of the yield obtained into 5.5 min. This phase is followed by an second increasing line (Step 2) representing the intern diffusion of the essential oil from the midst of the particles towards the external medium involved by the intern warming of the water located in the plant cells. In this stage (realized into 8 min), the oil amount extracted represents nearly 18% of the global yield.[17]

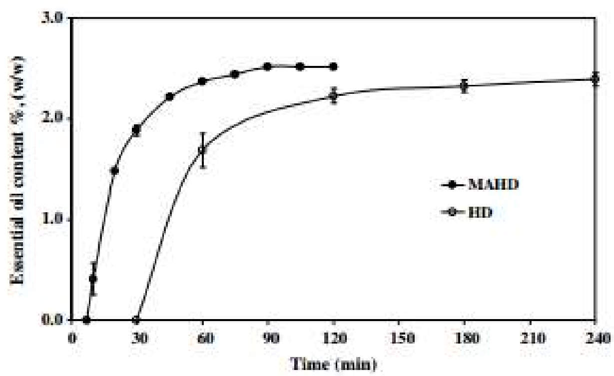


Graph 2: Yield profiles as a function of time for the MHG (a) and HD (b) isolations of essential oil from rosemary leave

Mohammad-Taghi Golmakani et al. [2008] Kinetics of essential oil extraction from thyme using MAHD has been compared with that of HD on Fig. 2. Extraction with MAHD started at much earlier time than that with HD (7 min vs. 30 min, respectively). This is due to the more efficient heat flow involved with microwaves. Unlike the classical conductive heating methods, micro- waves can heat the entire sample almost simultaneously and at a higher rate (Kaufmann & Christen, 2002). Full recovery of essential oils was achieved within the first 2 h of operation with MAHD. In the case of HD, a time period of at least 4 h was necessary for such purpose.

For both HD and MAHD, the extraction starts at the boiling point of water (100 C, if the operation is per- formed at atmospheric pressure). With

MAHD, the boiling point was reached in 7 min, while in the case of HD this was at 30 min. By the time the extraction of essential oils started with HD, more than 75% of total essential oils (1.89%, w/w) had extracted with MAHD. After 75 min of extraction, MAHD resulted in similar oil recovery to that obtained by 4 h of HD (2.44% vs. 2.39%, respectively).[18]



Graph 3: Comparison of extraction kinetics and extraction yield

Virendra P. S. et al. [2006] has said that the way in which oils are extracted from plants is important because some processes use solvents that can destroy the therapeutic properties. There are wide number of ways to extract the Essential oil but the quality never remains the same. "Steam Distillation" method for extraction is the cheapest way for the extraction of Oils from the different parts of the plants.[19]

Presti et al., 2005.1 were carried out "A number of methods have been adopted for essential oils extraction and isolation, e.g. hydro distillation (HD), steam distillation (SD), microwave-assisted hydro distillation extraction, ultrasound assisted extraction and organic solvent extraction .Traditional methods for the extraction of essential oils from medicinal plants are known to be SD and HD. It is known that these methods suffer from some disadvantages such as long extraction times, tiring and laborious work and complex and disastrous method of removal of burned leaves.[20]

K. Satish Kumar et al. [2010] has suggested that method of extraction dependent the extraction method employed. Distillation based recovery processes such as steam vacuum distillation is preferred for the extraction of essential oils from plant materials.[21]

Marie E. Lucchesi et. al. [2004] compared SFME compared with a conventional technique, hydro-distillation (HD), for the extraction of essential oil from three aromatic herbs: basil (Ocimum basilicum L.), garden mint (Mentha crispa L.), and thyme (Thymus vulgaris L.). The essential oils extracted by SFME for 30 min were quantitatively (yield) and qualitatively (aromatic profile) similar to those obtained by conventional hydro-distillation for 4.5 h. The SFME method yields an essential oil with higher amounts of more valuable oxygenated compounds, and allows substantial savings of costs, in terms of time, energy and plant material. SFME is a green technology and appears as a good alternative for the extraction of essential oils from aromatic plants.

The old traditional method being adopted by farmers is least available in record. **Anas & Abusad [2019]** have surveyed and collected a series of problems associated with peppermint industry in rural India and about the many problems faced by the Indian farmers in processing of harvest for extraction of peppermint oil. The problems included unsafe material handling, direct contact of hay with skin, delay in process cycles, compact preparation inside hot vessel, removal of processed hay and many more. They have categorized problems as technical problems, ergonomics problem, economic and management related problems and so on. They also suggested various methods to solve these problems related with handling of the compact and making the whole process mechanized with and without electricity. [22]

Anas *et. al*.[2020] in their paper "Sustainable Model for Mechanization of Peppermint Oil Extraction Plants for Rural India" discussed about the feasibility of a 3-Dimensional model for movement and compaction of hay. Computerized model was made and motion study was done. They have attempted to reduce the time wasted in filling the drum with hay. They have also made the technique/ process more safe for the farmers It was found that that model could help the farmers to produce more oil in less time with large capital investment. However it was complex method and it required large area and large capital investment. [23]

However, most of advanced methods mentioned above are very expensive and require technical skills. Hence they are not suitable for Indian context. The mechanized models so far made are not accepted by our farmers because of complex mechanism of handling, high installation cost and lower profits. As a result we see the models have not replaced the old traditional methods of extraction of peppermint oil. The proposed mechanized model has very less installation cost, can be easily handled and besides that, increase in efficiency will be obtained when implemented. The mechanization of plant will not only make the process faster but also will be very safe to operate.

CHAPTER 3

STUDY OF PLANT AND COLLECTION OF PROBLEMS

3.1 PEPPERMINT HYDRODISTILLATION PLANT USED IN RURAL AREAS (BY SITE SURVEY)

In order to isolate peppermint oils by hydro distillation, in this processfirst man prepare the stock in boiler and compress it manually by his feet i.e. compression of peppermint stock in the boiler is done by man when they are in direct contact with peppermint stock from his feet. The peppermint stock is packed in a still and a sufficient quantity of water is added and brought to a boil; alternatively, live charge is added under the boiler for heating the boiler for the generation of steam in the boiler. Due to the influence of hot water and steam, the peppermint oil is freed from the oil glands in the plant tissue. The vapor mixture of water and oil is condensed by indirect cooling with water. From the condenser, distillate flows into a separator, where oil separates automatically from the distillate water.

S No	Name of the Component
1	Drum used for hydrodistillation contain raw material (peppermint) and water
2	Space for Fuel inlet
3	Resultent oil and water mixture after condensation
4	Removable Lid
5	Condenser unit

Figure 8: Plant for extraction of peppermint oil (Rural areas of India)

3.1.1 COMPONENT OF PEPPERMINT PLANT

- Boiler drum
- Burning chamber

- Condenser unit
- Isolation of oil and water unit

3.1.1.1 BOILER DRUM

Boiler drum is important part of peppermint plant, in this drum one grid is inbuilt at lowest part of drum which separate the water and stock of peppermint. The thickness of drum sheet is 8 gauges which can which withstand at the pressure develop in boiler. Boiler height is 5 feet and diameter is 5 feet. So when the water is boiled the steam is generated , this steam contain water and oil which is freed from plant, This steam is inter in the pipe which joint boiler unit to condenser unit.

Figure 9: Internal view of Boiler drum

3.1.1.2 COMBUSTION CHAMBER

A combustion chamber is that part of a peppermint plant in which the fuel/waste of peppermint stock is burned. This chamber is place under the boiler drum for generating desirable heat for converting water into steam.

Figure 10: Combustion Chamber

3.1.1.3 CONDENSER UNIT

A combustion chamber is that part of a peppermint plant in which the fuel/waste of peppermint stock is burned. These condensers are heat exchangers which convert steam from its gaseous to its liquid state at a pressure below atmospheric pressure. The purpose of a condenser is to condense the exhaust steam from a steam boiler to obtain maximum efficiency, and also to convert the boiler exhaust steam into liquid mixture of oil and water (referred to as steam condensate) so that the oil is isolate from the liquid mixture.

Figure 11: Condenser Unit

3.1.1.4 ISOLATION OF OIL AND WATER UNIT

After condensation the liquid mixture of oil and water is collect in vessel in outlet chamber.

Due to density difference the oil is isolate from that mixture and get purify for further use.

Figure 12: Isolation of oil and water unit

3.2 COLLECTION OF PROBLEMS

The peppermint plant use in rural areas of India for the production of peppermint oil is work on traditional basis, so there is a lot of drawback is arising in the working of peppermint oil. The efficiency of plant is also unknown. So we need to find out that problem and develop proper solution for those problems. Following are the main drawback/problems which are normally arising in the production of peppermint oil.

- Too much time consume to compress the dry peppermint leaves in drum.
- When labours are direct contact with peppermint leaves for compression then peppermint react badly to labors skin.
- Lot of time taken to put the leaves in drum, 2 person to put leaves, 2 person two settle (compress) the leaves in drum.
- When the plant material is being compressed in distillation vessel, the whole plants sits idle i.e.lots of idle time.
- Only 2 drum engaged in a plant for a day.
- No proper sealing.
- No pressure gauge and no uniform heating. Hence hazardous to human being if the boiler is burst.

Figure 13: Labourers putting in peppermint hay and compacting them with bare feet

Figure 14: Labourers compacting the hay with bare feet

Figure 15: Workers removing processed hay out of boiling vessel

Figure 16: Spreading of processed hay over ground for drying

Figure 17: Removal of processed hay and loading onto rickshaw trolley

3.2.1 MAIN PROBLEM (PREPARATION OF COMPACT)

In the production of peppermint oil the preparation of peppermint stock in the boiler drum, in this process following problem arising.

- Too much time taking to fill the peppermint stock in the boiler manually.
- To compress the stock in the boiler 2 person are set to compress the stock in the drum which is painful and peppermint react badly to the human skin when man get in direct contact with peppermint stock.
- So the complete preparation of stock in the boiler drum is too much time taking process.
- When the plant material being compressed in distillation drum then whole plant sits idle because nothing else can be done at that time.

- After complete cycle of peppermint oil production, the removal of waste is time taking and hazardous for man because there is hot gasses leave from the stock.

CHAPTER 4

PLANT LAYOUT

The propose plant layout of peppermint plant is made on the basis, to develop following properties,

- Proper and efficient utilization of available floor space
- Transportation of work from one point to another point without any delay
- Proper utilization of production capacity.
- Reduce material handling costs
- Utilize labour efficiently
- Reduce accidents
- Provide for volume and product flexibility
- Provide ease of supervision and control
- Provide for employee safety and health
- Allow easy maintenance of machines and plant.
- Improve productivity

4.1 PLANT LAYOUT OF PROPOSE PEPPERMINT PLANT

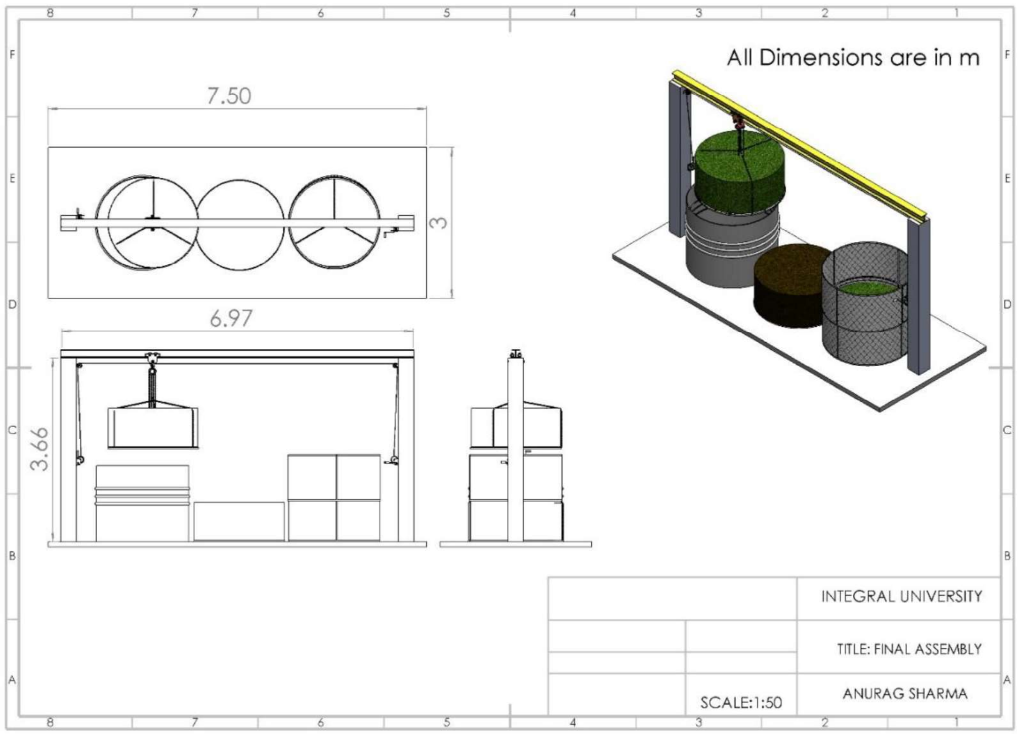


Figure 18: Plant layout of peppermint plant

Dimension of various components in plant

- Effective plant area = 7.5 x 3 m^2
- Dimension of boiler drum,
  Diameter = 6Ft (1.82m)
  Height of boiler drum = 5Ft (1.52m)
- Dimension of compaction container,
  Diameter = 6Ft (1.82m)
  Height of compression drum = 3Ft (0.92m) (collapsed)
- I-beam = 23Ft (7.0104m)

4.2 DIFFERENT COMPONENTS OF PROPOSED PEPPERMINT PLANT

In the production of peppermint oil various important components are assembled together to make a production unit to achieve certain goals. So the design of different component is necessary for achieving desirable goal. The details of the Plant components are given in Table 1 and Fig. 7

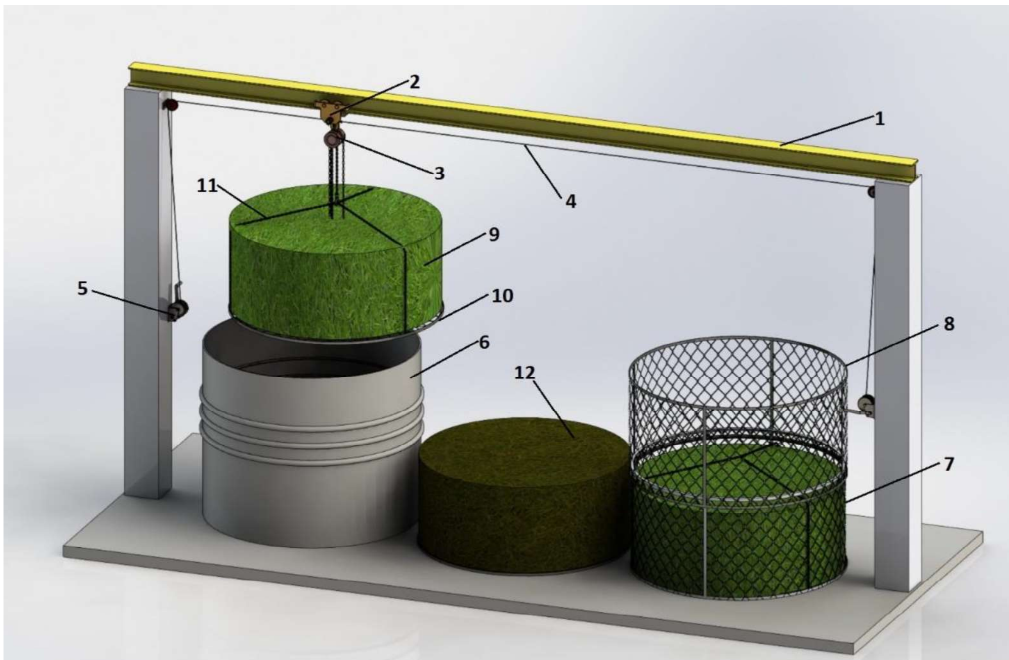


Figure 19: Plant components

Table 4. List of components

Sl. no.	Component name	Material	Specification/ Capacity
1	I-beam	Structural Steel	SC 140 (140mm x140mm x 3.3Kg/m)
2	I-beam trolley	-	0.5 Ton
3	Chain block	-	0.5 Ton
4	Wire rope	Stainless Steel	3/16 in
5	Hand winch	-	362 Kg

6	Boiling vessel	Alloy Steel	Diameter = 72in Height = 60in
7	Lower compacting container	Mild Steel Frame, Galvanized Steel mesh	Diameter = 71in Height = 36in
8	Upper compacting container	Mild Steel Frame, Galvanized Steel mesh	Diameter = 72in Height = 36in
9	Prepared hay compact	Peppermint hay	Diameter = 70in Height = 30in
10	Base net	Mild Steel Frame, Galvanized Steel mesh	Diameter = 71in Height = 1in
11	Chain Sling	Alloy Steel	3 Legs, 2m
12	Processed hay	Peppermint hay	Diameter = 70in Height = 30in

4.1.1 I-Beam

In this assembly, the I-beam holds all the suspended entities that are I-beam trolley, chain block, chain sling, base net, and prepared/processed compact and allows their transport across the floor.

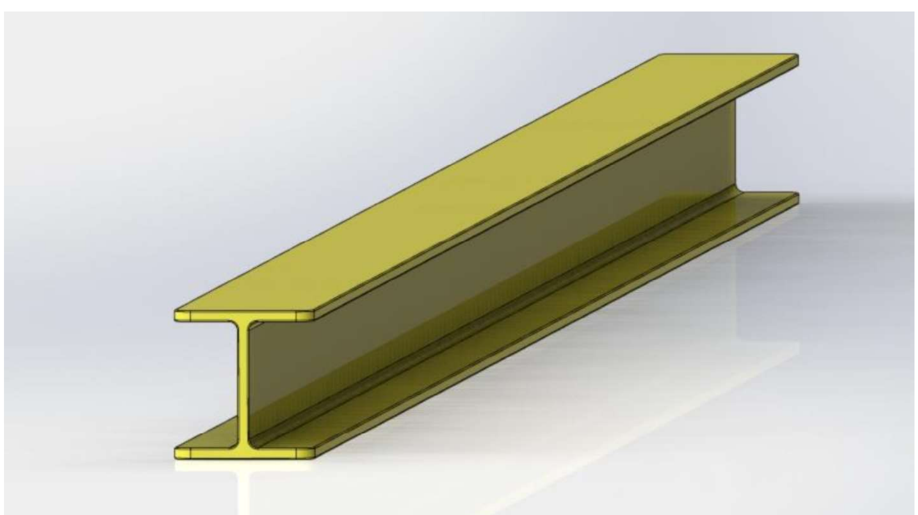


Figure 20: I-beam

4.1.2 I-beam trolley

I-beam trolley is an industrial apparatus that is used to move heavy loads across the I-beam. I-beam acts as rails and the four wheels of the trolley rest on the lower flange of the beam. The loads can be suspended from the trolley body. It is available in various capacity in the market. The capacity of the trolley used in this assembly is 0.5ton.

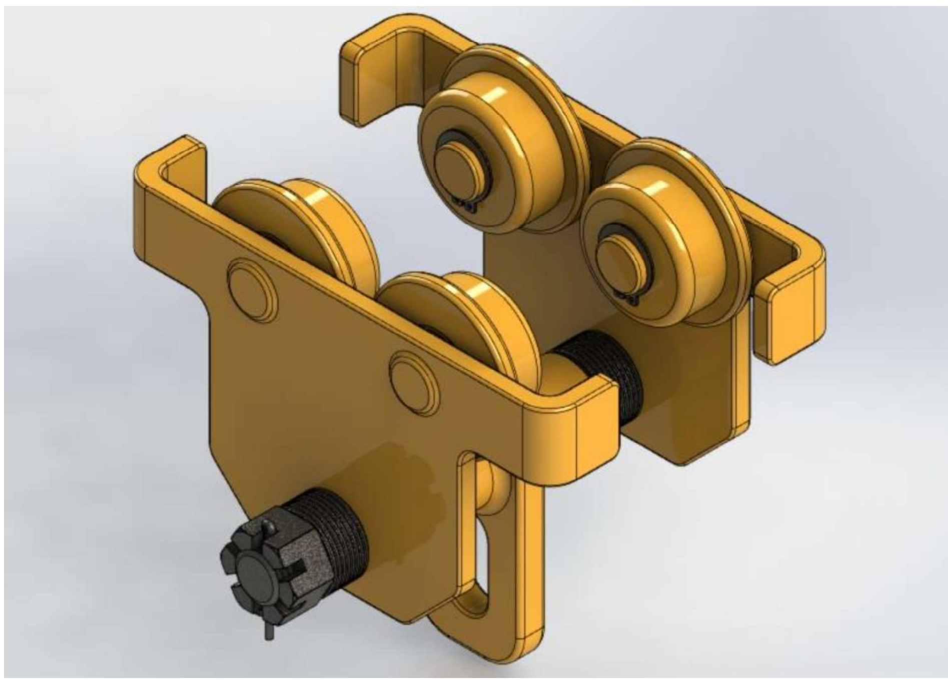


Figure 21: I-beam trolley

4.1.3 Chain block

Chain block is a mechanical device that is used to vertically lift or lower heavy loads. It has two wheels that have two chains wound around and the two wheels are links through a series of gears. When the hand chain is operated, the load chain that is connected to the load being lifted through a hook, is lifted with a massive mechanical advantage. These are available in various capacities and the one used in this assembly has a capacity of 0.5ton.

Figure 22: Chain block

4.1.4 Hand Winch

Hand winch is a mechanical device that is used to pull in (wind up) or let out (wind out) or otherwise adjust the tension of a rope or wire rope. It consist of a drum on which the wire rope is wound. The drum is connected to a crank through a series of gears that give the crank some mechanical advantage and makes the winding of wire rope with heavy loads easier. In this assembly, hand winches are present on both the concrete columns and are used to move the trolley in either directions. When one hand winch is wound up and other one is wound out, the trolley is pulled in either direction. The use of hand winch for this purpose makes is easier to move the trolley when load is attached.

Figure 23: Hand winch

4.1.5 Compacting container

Compacting container is a two piece telescopic wire mesh walled container nearly the size of the boiling vessel. It is used to prepare compact of hay simultaneously while one cycle of distillation is going on in the boiling vessel. The use of a separate container for hay compact preparation eliminates the waiting time which was there while the distillation cycle was going on.

Figure 24: Compacting container

4.1.6 Base net

Placing a base net below the compact facilitates the lifting, lowering and formation of a cylindrical compact. It is made up of circular frame with wire mesh base. The hooks of chain slings are connected to the frame of the base net.

Figure 25: Base net

4.1.7 Chain slings

Chain slings can be single or multiple legged and are used to connect the load with the lifting mechanism. Multiple legs ensure stability of load while in air. In this assembly chain slings legs are connected to the base net and upper part is connected to the hook of chain block.

Figure 26: Chain slings

CHAPTER 5

RESULTS AND DISCUSSION

5.1 DEVELOPMENT OF COMPACT PREPARATION AND TRANSPORT SYSTEM

The system used in rural India has its main drawbacks in compacting process. The labourers get in direct compact with the in process hay when they stomp it by their bare feet. This results in skin irritation. Also the process is time taking, as the workers have to wait for the distillation cycle to get completed and the boiling vessel gets vacant, then only they can start filling and compacting the net batch of hay. The process of removal of processed hay is also dangerous as they work with the warm hay in presence of residual steam.

So we developed a system that will reduce the compaction time and overall cycle time while making the whole process safe for the workers in comparison to the traditional system.

5.1.1 Compaction System

The compaction system uses a separate container in which the compact can be prepared beforehand and when the distillation vessel is emptied, this prepared compact can be put in it instantly without any delays. This compaction container is in two parts and the parts are telescopic. They are made of angled channel frame and wire mesh walls. They can prepare two compacts at a time, one over other.

For the preparation of compact, the container is for collapsed. Then a base net is inserted inside it. The base net gives a base for the compact and helps to lift the compact, which will otherwise not be possible. Also the base net is used to attach the chain slings for the lifting. Hay is put in and compacted using feet but the workers will be advised to put on long boots as to prevent the direct contact with the hay.

When one compact is made of the size of collapsed container, the container is expanded and space for another compact is made. Again another base net with chain slings is inserted and another compact is made in the same way.

5.1.2 Transport System

With the advantage of separate preparation of the compact, the problem of transport of them arises due to their size and weight. To make the transport of these compacts, I-beam are used to for their overhead transport. Chain blocks move the compacts vertically and I-beam trolley move them horizontally across the floor.

5.1.2.1 Load calculation for determination of I-beam size

Beam length L = 23ft = 7.0104m

Total Load P = (Trolley mass + Hung mass)x9.81

= (18 + 250)x9.81 = 2629.08 N

Allowable deflection $\delta_{max} = L/500$ [24]

= 7.0104/500 = 0.0140208 m = 14.02mm

Assuming simply supported beam with concentrated load, maximum deflection will occur when trolley is mid span

Hence $\delta_{max} = PL^3/48EI$ …(2)

For steel Young's Modulus E = 200GPa

Solving for I,

I = 627 x 104 mm^4

SC 140 H-Beam (BIS)[25] has a I value equal to 1470x104 mm^4.

Mass of **SC 140** is 33.3Kg/m

Max deflection with self weight inc. $\delta_{max} = (PL^3)/48EI + (5wL^4)/384EI = 0.00991m$ = 9.91mm

This value is less than Allowable deflection, hence this beam is selected.

5.1.2.2 Load capacity for determination of hand winch capacity

Trolley wheel diameter = 4in = 71 mm

No. of wheels = 4

Mass of Compact = 200kg

Total mass to be hung = Mass of Compact + (Base Net + Chains + Chain Block) = 200 + 50 (assumed) = 250kg

Load per wheel W = (250x9.81)/4 = 613.125 N

Coefficient of rolling friction for steel on steel $C_r = 0.001$

$F = C_r W/R$ [26] …(1)

= 0.001x 613.125/{(71/2)x(1/1000)}

= 17.27 N

Total rolling friction on 4 wheels = 17.27x4 = 69.08N

Starting force (2 to 2.5 times of rolling friction) = 69.08x2.5 =172.71N = 17.55 Kgf

5.1.3 Height of hand winch on columns

The average elbow height of male workers in northern regions of India is 1102mm.[27] Best ergonomic height of crank should be 0.9 times of the elbow height for maximum torque transmission and least discomfort of the worker.[28] Hence the suitable height chosen for hand winch placement on the pillar becomes 992 mm from the ground.

5.2 TIME CALCULATIONS

5.2.1 Time taken for lifting and lowering of compacted compact with chain block

Travel ratio of 0.5 ton chain block = 41:1 (assumed as available in market)

Let's assume that worker moves the hand chain at a constant velocity VH = 1 m/s

Load chain velocity

V_L=1/41 m/s= 0.002439 m/s =0.96024 in/s (1 m=39.37 in)

Total time to lift or lower load chain by 6 feet

= (6x12 in)/(0.96024 in/s)

=74.98s ~ 75s approx.

Total time to lift or lower load chain by 3.5 feet

= (3.5x12 in)/(0.96024 in/s) = 43.74s ~ 44s approx.

5.2.2 Time taken to move the trolley in one direction

Gear ratio of hand winch = 2.9:1 (assumed as available in market)

The trolley travel per revolution of winch handle =75.87 mm/rev (assumed to be const. with each rev.)

Hence, 1 rps on handle = 1/2.9 = 0.3448 rps on drum

The trolley velocity V_T =0.3447x75.87 mm/s =26.16 mm/s

Time to move 3.81m (centre distance of drums)

= 3.81x1000/26.16 s = 145.6s ~ 146 s

5.2.3 Total time taken in removal of two processed compacts

Total time for removal T_R = Time taken to (move from beam centre to vessel centre + lift first compact + move back to beam centre + lower the first compact + move back to vessel + lift second compact + move back to centre + lower second compact)

T_R = 146/2 + 44 + 146/2 + 75 + 146/2 + 75 + 146/2 + 75

T_R = 561s = 9m21s

5.2.4 Total time taken in transport of two compacted compacts

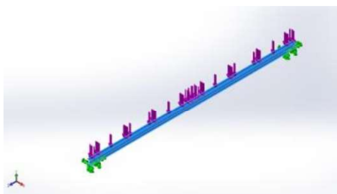
Total time to fill = Time taken to (move from beam centre to container centre + lift first compact + move back to vessel centre + lower the first compact + move back to container centre + lift second compact + move back to vessel centre + lower second compact)

= 146/2 + 44 + 146 + 75 + 146 + 75 + 146 + 44

=749s = 12m 29s

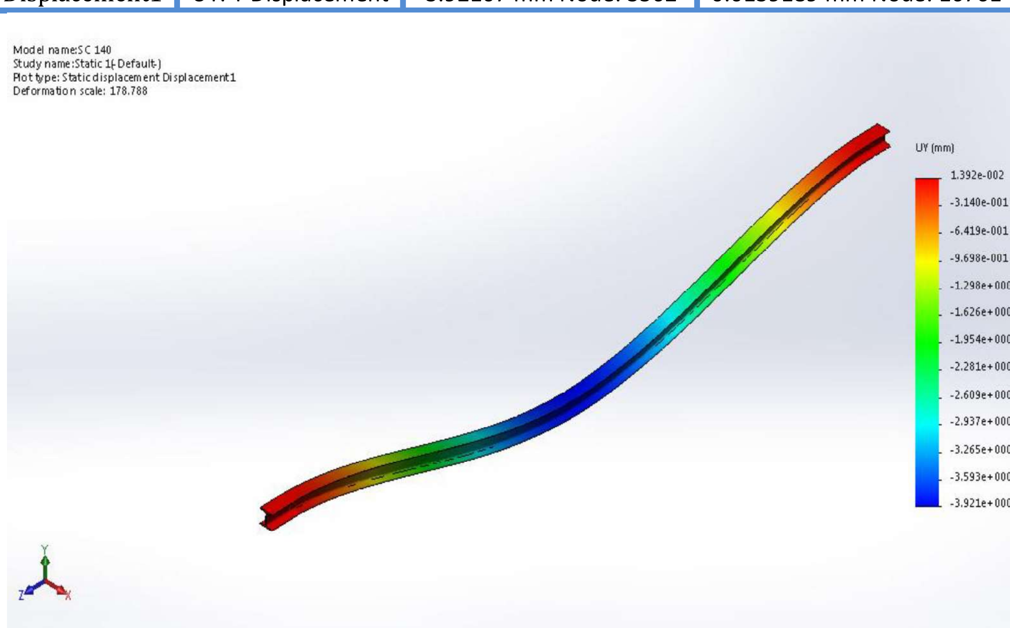
5.3 SIMULATION OF BEAM

Material Properties

Model Reference	Properties	Components
	Name: **AISI 1010 Steel, hot rolled bar** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **1.8e+008 N/m^2** Tensile strength: **3.25e+008 N/m^2** Elastic modulus: **2e+011 N/m^2** Poisson's ratio: **0.29** Mass density: **7870 kg/m^3** Shear modulus: **8e+010 N/m^2** Thermal expansion coefficient: **1.22e-005 /Kelvin**	**SolidBody 1(Split Line2)(Part1)**

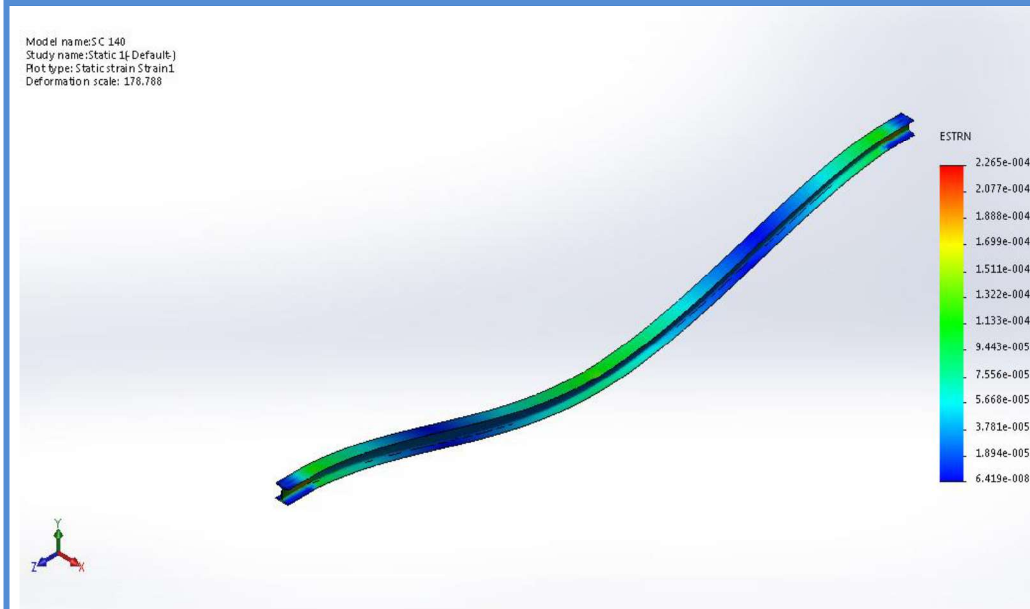
Study Results

Name	Type	Min	Max
Displacement1	UY: Y Displacement	-3.92107 mm Node: 3562	0.0139189 mm Node: 16761



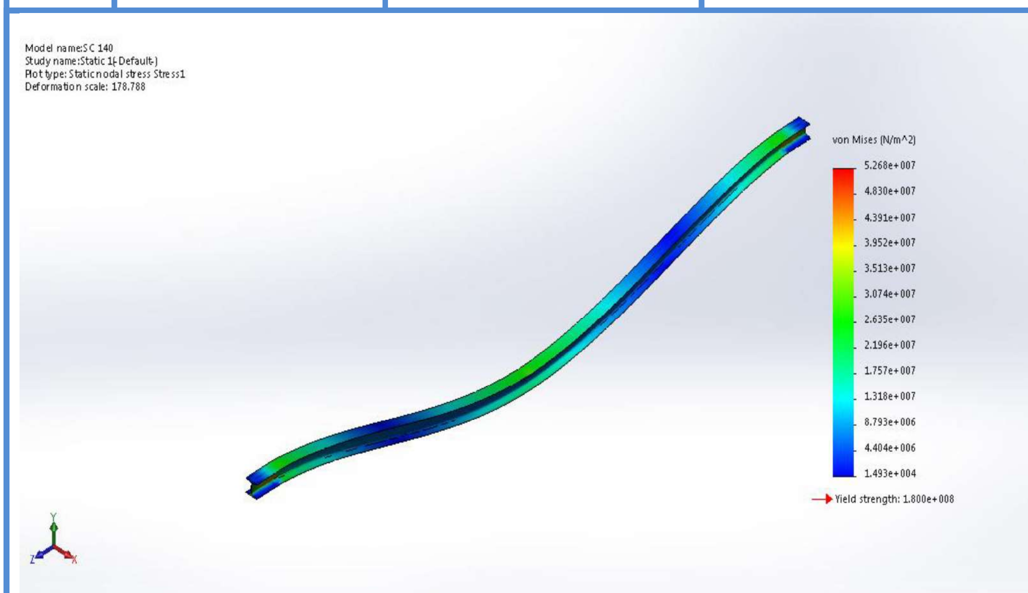
SC 140-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	6.41873e-008 Node: 15701	0.000226543 Node: 2438



SC 140-Static 1-Strain-Strain1

Name	Type	Min	Max
Stress1	VON: von Mises Stress	14927.3 N/m^2 Node: 15701	5.26844e+007 N/m^2 Node: 2438



SC 140-Static 1-Stress-Stress1

5.4 WORKING OF THE APPARATUS

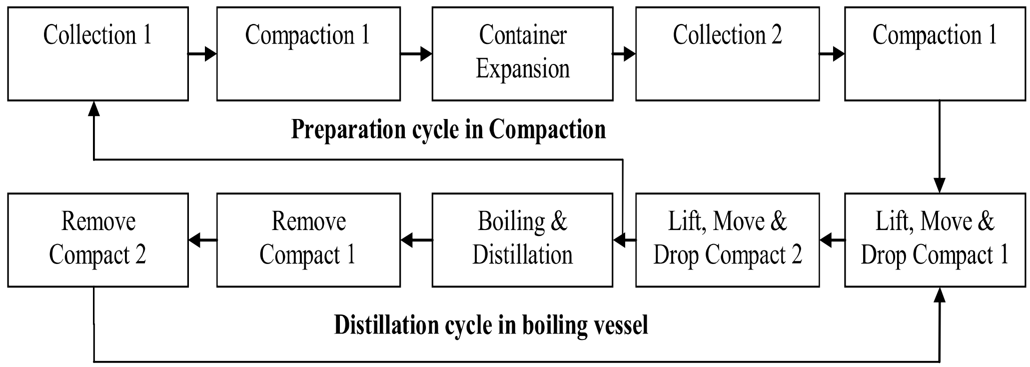


Figure 27: Block diagram of working of apparatus

The main stages of working mechanisms are as follows:

1. Leave collection 1: The hay is collected in a net of wire in compaction container that is about the size of boiling vessel.

2. Leaves compaction 1: The workers compact the hay by walking on it. They can't be bare feet. They have to wear long rubber boots to avoid contact of skin with the hay, otherwise it results in skin irritation (Fig 28a).

3. Compaction Drum Expansion: The Compaction drum is telescopic and can be pulled upward when half of it gets filled and compacted. This creates space for preparation second compact (Fig 28b).

4. Leave collection 2: More hay is collected and filled inside the new space generated after the expansion of compaction container.

5. Leaves compaction 2: Similarly more hay is compacted to form a second compact.

6. Transport of compact 1 & 2: The chain block is used to lift the net that is now filled with compacted hay (Fig 28c). The hand winches on both columns are used to move and align the compact hovering above the boiling vessel (Fig 28d). And again the chain block lowers the compact into the boiler drum. Both the compacts from compaction drum are transported to boiling drum one by one in the same way. Then the vessel lid is fixed over the boiling vessel by chain block and then it is fastened by nut bolts. It is heated at the base, containing water up to 300 mm. The steam so produced extracts the oil from the peppermint leaves. The oil is separated from steam when it is condensed in the condenser and the oil is collected in a container.

7. Removal of the processed compact: The cover is unfastened and lifted by chain block. The chain block further removes the compacts of processed hay one by one, loaded on a rickshaw-trolley, which can be kept beside the boiler drum, and transported over to smoke emission chamber (drier unit) the hay is scattered in the field for faster cooling and drying.

With the addition of a compaction container, the labourers can prepare another round of compacts while two compacts are already in the boiler being distilled. As soon as the first two compacts are removed from the boiling vessel after processing, the pair of prepared compacts can be put inside the vessel for the next round. This would save the otherwise waiting time while the vessel was full and distillation was going on.

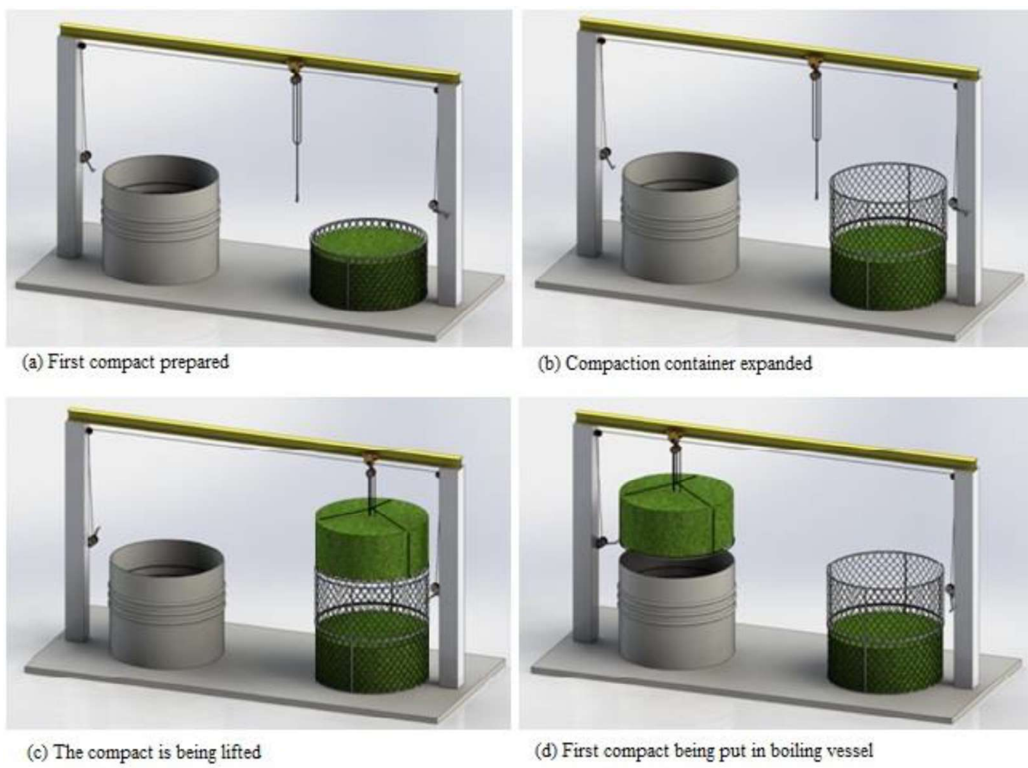


Figure 28: Illustration of compaction and transport of peppermint hay

CHAPTER 6

CONCLUSION

6.1 TIME TAKEN BY PROPOSED METHOD AS COMPARED TO EXISTING PLANT

Table 5. Comparison of time taken by traditional and proposed plant

Sl. No.	Process of hydro distillation of peppermint plant	Time taken by exiting plant	Time taken by proposed plant
1	Stock Preparation	2 hours in main boiler drum	1.5 hour in compaction container
2	Steam distillation process	4.5 hours	4.5 hours
3	Removal of waste	3 hours	10 min
	Cycle Time	**9 hrs 30 min**	**5 hrs**

From the above table it is clear that the proposed plant reduces the cycle time by **4 hrs and 30 min.**

6.2 INCREASE IN PRODUCTION

The table below compares the traditional plant and the proposed plant. It can be clearly seen that the proposed method has higher investment but it also increases the final profit of the plant by reducing the number of the labours involved and the cycle time.

Table 6. Comparison of Mechanized model with Traditional model

S No	Description	Traditional plant	Mechanized plant
1	Installation cost	Rs 2,20,000	Rs 3,20,000
2	Working area covered	5.5 x 5.5 m^2	7.5 x 3.0 m^2
3	Preparation time of compact (hay)	2 hours in main boiler drum	1.5 hour in compaction container
4	Time required for removal of processed hay	3 hours	10 min
5	Distillation time	4.5 hrs	4.5 hrs
6	Cycle time	9.5 hrs	5 hrs
6	Peppermint hay weight in 1 tank	400Kg	400Kg
7	No. of labourers	4	2
8	Labour cost	Rs 1600/ day	Rs 800/ day
9	No. of boilers used in one day	02	05
10	Earning per day of the plant@Rs1000/ cycle	Rs 2000/day	Rs 5000/day

Referring Table 3, it is clear that the earning per day is increased by Rs 3000 per day and labour cost is halved compared to traditional approach. The time required for removal of used leave is highly decreased. The chain pulley arrangement utilizes 9-10 minutes for removal of used/ processed hay.

It is depicted from above discussion that the incurred cost of setting up this can soon be covered with increased profit of the plant. It is also depicted that hand winch can be used ergonomically for moving the compact from compaction container to the vessel and vice versa.

6.3 BETTER SAFETY FOR THE WORKERS

The plant improves the safety of the works in the following ways:

1. During compaction process the labourers now would not get in direct contact with the peppermint hay and the skin and eye irritation that used to occur will now be prevented.
2. Exhaustion due to heavy physical labour is reduced in the proposed plant due the use of mechanical devices (hand winches and chain block).
3. The workers don't need to work inside the hot vessel to remove the processed hay. Now the whole compact can be removed at once with the help of the mechanism.

CHAPTER 7

FUTURE SCOPE

Mint in India is now grown on an area of around 300,000 ha, involving an estimated 800,000 ha. 2 cuts are taken during the season, yielding around 20-25 tons of green herb. From a production of around 10,000 tons in 2000, production is now estimated to be close to 50,000 tons. India dominates global production with around 80% of global supply, followed by China and Japan, each producing around 10%. India exports around 25 to 30,000 tons in a range of forms (menthol crystals and powder, dementholised mint oil, arvensis oil etc.), with the balance of production used domestically. India domestic consumption accounts for around 40% of global consumption, with China (20%), Europe (15%, with Germany and Netherlands the major users) and the USA (15%) accounting for the bulk of consumption.

Demand for mint and mint products is expected to continue to rise. Whilst demand is not growing in Europe and China, overall worldwide growth of the broad category of fast moving consumer goods (FMCG) in which mint is used – cosmetics (toothpaste, mouthwash, shaving creams, shampoos etc.), chewing gums, household cleaning products etc. – are continuing to show strong growth. Overall, it is estimated that global demand continues to increase by 3-5% a year. In this scale of market, this is a substantial additional volume that is required by the market each year, and creates significant opportunities for new entrants.

Major production costs are labour, fertilizers for cultivation, and fuel for distillation (and irrigation).

The model proposed here is a concept and a real world model will give more accurate insights about the drawbacks associated with it. As for future work the following issues can also be taken care of:

- This proposed model has to be fixed on ground. Hence a dismantable and portable model can be prepared using gantry cranes.
- A hay compaction mechanism must be developed in order to speed up the process of compaction that is otherwise be done using feet.

- The tool that the workers use to put in hay, can be ergonomically improved.

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