Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecatrónica

Tesis

Design of Linear Steam Distillation Machine with Arduino Remote Connection Via Messaging

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Para optar el Título Profesional de
Ingeniero Mecatrónico

Huancayo, 2023

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Design of linear steam distillation machine with arduino remote connection via messaging

Design of linear steam distillation machine with arduino remote connection via messaging

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Abstract. This study aims to design a piece of distillation equipment, with greater efficiency and extraction capacity. Currently, there are steam distillation machines, most of these equipment has the capacity to distill between 1 to 100 kilograms of material. In the present design, a linear vapor trace distillation is applied, with a capacity to distill 200 kilograms of schinus "molle"; on the other hand, the equipment will have connection to a mobile phone through Arduino, from which it will be possible to make emergency stops. This research was obtained through calculations showing that 1.89 liters of essential oil can be extracted from every 200 kilograms of molle. Finally, it is concluded that the current still is theoretically more efficient, extracting much more oil than the other still. Also, it has the capacity to distill all those roots, stems, leaves, flowers, and seeds that have an essence.

1. Introduction

Human beings had their first contact with plants for medicinal use around 3000 BC, and then around 2,500 BC, applying them as medicines. [1]. Later on, the Egyptian alchemists made up different types of gadgets made of metals to evaporate volatile substances. [2]. Currently, in the global market, essential oils are in great demand for their applications: in the food, pharmaceutical, and cosmetic industries [3]. These essential oils have extraction methods such as steam distillation [4], extraction of oils by cold pressing and organic solvent [5], Solvent Extraction, Supercritical Fluid Extraction, and Microwave Extraction [6]. The use of each of these methods has its advantages and disadvantages, but the steam extraction method has proven better results in the quantity and purity of essential oils [7]. For this process, it is fundamental to have a large amount of material. Thus Peru has about 25,000 species of flora of which 7,500 are unique in the world [8]. For this reason, the design of the essential oil distiller is viable. On the other hand, certain problems were found with distillation equipment, one of them regarding the low distillation capacity, resulting in 2.11 ml of oil from every 100g of leaves. [9]. Although it is true there are some pieces of equipment that have greater distillation capacity [10] the deficiency of these types of equipment is related to the absence of an automatic control system. The advantage of having an automatic control system in a distillation process is the simplification of work [11]. This maximizes the production efficiency, offering greater operator safety, and improving the quality and purity of the essential oil [12]. That is why the linear distillation equipment has a greater distillation capacity which can distill 301.59 liters or 0.30159 m^3, making it an industrial level distiller.

It also has a system that has as variables time, temperature, and water level in the still, having the function of sending alerts to the mobile phone operator in charge through the SIM800L module [13], Additionally, an important function is to make emergency stops from the mobile phone through text messages. This module will receive certain signals from the Arduino Hardware [14]. In this way, the main function of the Arduino Mega will be to control the time and record the values of the temperature sensors and the water level of the still. If there are values outside the normal range, it will be reported by text message or call [15] through the SIM800L module.

2. Methodology

In "Figure 1" the distillation equipment is shown, in which each component is indicated:

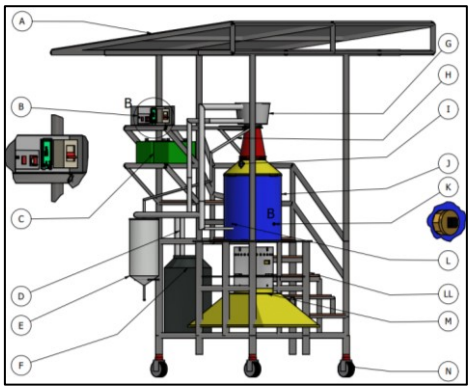

Figure 1. Linear distillation equipment.

A.- Solar Panels: The main function of solar panels is to convert the sun's radiation into electrical energy, which makes them applicable to many activities. [16]**.** For this reason, solar panels were used in the distillation equipment to produce renewable, free, and eco-friendly energy. B.- Control board: The control board contains the entire electronic system, therefore it has the following components: the contactor, Arduino mega, SIM800L module and other electronic components, as shown. C.- Battery: Considered as the best source of energy until these times [17], two dry batteries will be used to power the control system, due to their capacity to store energy from solar panels. D.- Cooling pipes: These pipes will be made of PVC since they will carry out the task of conducting cold water towards the distillation system, which is located in the upper part of the still, and another conduit that allows it to return to the tank in this way, fulfilling a repetitive cycle. E.- Decanting pear: It is made of glass to facilitate the visualization of the different types of liquids, so its main function is to store the already distilled material (essential oil and hydrolates). This is to easily separate the liquids after the distillation process is complete [18]. F.- Water Tank: The tank with a capacity of 250 to 300 liters of water will fulfill a good cooling of the system. G.- Refrigeration system: This system is located in the upper part of the alembic and is made of 2-millimeter thick stainless steel. H.- Latex hose: It has the function of conducting the distilled material towards the decantation pear and it is made of latex to avoid some type of contamination that can change or alter the properties of the essential oil. I.- Analog thermometer: This device will indicate the distiller temperature in real-time. J.- Distillation cylinder: The distillation equipment is made of 4 mm thick stainless steel, which is used for the food industry [19], was chosen for being resistant to corrosion. K.- Temperature sensor: This sensor was used because it withstands high temperatures and has a good measurement range of -100 ° to 200 ° [20], which is ideal for the linear alembic. L.- Level sensor: A water level sensor that is compatible with the atmega microcontroller and withstands high temperatures is required [20]. LL.-Metallic Structure: Low carbon steel tubes will be used, due to their resistance and anti-corrosion properties. M.- Turbo kitchen: The use of this component is essential since it consumes little firewood and results in better temperatures. By having a turbine that injects air, the turbine performs complete combustion and reduces pollution by 95% [21]. In addition, the turbine can be turned on and off using the Arduino and a mobile device. N.- Wheels: They will serve

to mobilize the distiller within a laboratory area.

2.1. PROCESS 1

The linear still (Figure 2) has a very important characteristic, which is related to its cooling system in the upper part that avoids too much heat or steam losses. It also increases the amount of essence production and reduces distillation time. Besides that, the refrigeration system will be responsible for transmitting temperatures below 10 °, thus condensing the vapor to a liquid state. Finally, it will fall through a latex hose to a decantation pear, for its subsequent separation between oils and hydrolates.

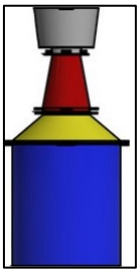

Figure 2. Lineal distiller.

2.2. PROCESS 2

The distillation cylinder has the following measurements: height: 80 cm and radius 40 cm. En este cilindro (Figura 3) se llena de agua hasta los 6.36 cm de altura, seguidamente se le pone una malla o canastilla la cual hace que no tenga contacto el agua con el material a destilar ya sean: tallos, raíces o semillas. It is important to cover and secure the diameter reducers (Figure 4) as some material for a faster distillation with a greater amount of essential oils can also be added.

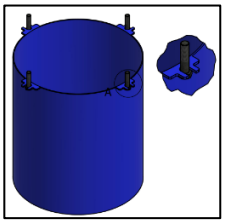

Figure 3. Distillation cylinder.

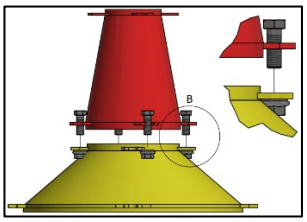

Figure 4. Diameter reducers.

2.3. PROCESS 3

The cooling system (Figure 5), which will be found in the upper part of the still, has the function of filling the bucket with cold water from the lower side of the bucket. It also has the mechanism to vent the water through the upper side of the bucket.

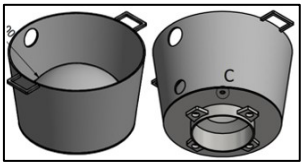

Figure 5. Cooling system.

On the bottom side of the bucket is where the steam will arrive, which will run towards a hemispherical dome "B" of (figure 6). In addition, at the top, it will transfer cold to steam, which will condense into drops of water and fall into the bucket that has a hole for ventilation. Later it will be stored in a decantation pear to be separated between oils and hydrolates.

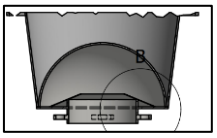

Figure 6. Cooling system cut-off.

2.4. PROCESS 4

Data is sent through an Arduino mega and a SIM800L module, the first one programmed to make a telephone call in alarm signal to the operator in charge, through the SIM800L module. Besides, with this device, it is also possible to know the distiller status, as well as turn it on and off through text messages from a phone. Can be appreciated in "Figure 7" the component connection diagram that shows how to assemble the following ones: Arduino mega. - It is hardware. The free software, which is responsible for collecting data from the sensors (level and temperature), will send a signal to the SIM800L device.

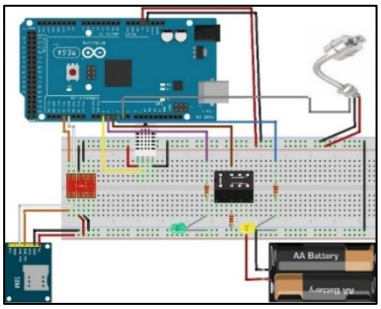

Figure 7. Connection diagram.

It is important to note that the device connection is wired and has the function of sending an alert by call or message to the mobile device of the operator in charge of distillation. Level Sensor: The level sensor is in charge of measuring the water level in the still. Then, if there is no water, it will send a signal (wired) to the Arduino and this to the SIM800L module so that it alerts the operator “Lack of water”. Temperature Sensor: The temperature sensor will sense the temperature of the still every second and it will send that data (wired connection) to the Arduino. Then the Arduino will be in charge of buying temperature data as programmed for each type of plant, sending those signals to the SIM800L module. Lastly, this drive will send these messages such as "low temperature" or "very high temperature". Modulo SIM800LThis SIM800L module is an intelligent temperature warning system with 2 types of alerts, one by sound and the second by notification via email or SMS. In this particular case, its function is to receive signals from the Arduino to send text messages or calls to the operator in charge. Thereby the operator is informed of the distillation status.

3. Results

Everything begins considering the amount of essential oil that is intended to be obtained. Therefore, it is evaluated if it is possible to extract 1 liter of oil from Molle, Cypress, Eucalyptus, Copaiba; by the "steam entrainment" method. As data, the actual measurements of the design are collected: height: 80cm (60cm is the size of the basket for the material to be distilled), and radius 40 cm. To calculate the quantities of the still, will proceed to demonstrate mathematically utilizing formulas and equations:

Calculating the capacity of the machine through integrals: $\int_0^{60} \pi\, x\, 40^2\, dx$

The integration of a constant is carried out:

$\int a\ dx = a(x) \rightarrow\ \ [\pi\, x\, 40^2].{}_0^{60} = [1600\pi x].{}_0^{60} = 96000\ \pi = 301592.8947$

Where it gives as maximum capacity (Volume) $9600\pi\ cm^3$ *o* $30159.289\ c$m³ = 0.301592 m³. Calculating the extraction amount of molle oil, considering that theoretically, molle oil has an approximate density of 0.846 g / c m³, the extraction of essential oil from molle will be analyzed taking the following data:

$$\underline{ð} = m / v \quad (1)$$

n=0.8%

Molle oil density ≈ $\underline{ð}$=0.846 g/ml

Applying the simple 3 rule by using the plant yield to determine the amount of material needed to obtain that amount of essential oil.

X (grams of grass) => Y (grams of oil) = m

100(grams of grass) => Z (grams of essential oil) = n

Would be proposed:

Y (grams of oil) = (n * X (grams of grass)) / 100

Y (grams of oil) = 0.8% * X (grams of grass) / 100

Y (grams of oil) =0.008 * X (grams of grass)

Isolating the mass from equation (1), leaving then:

$$m=\underline{ð} * s \quad (2)$$

The equipment with a capacity of 0.301592.89 m³, is calculated to store 200 kilos of molle.

0.008 * X (grams of grass) = 0.846 g/ml * α

α = (0.008 * 200 000g) / 0.846 g/ml

α = 1891.25ml

α= Amount of oil to be produced

Therefore, we could say that the distiller will work with 200 kilograms of molle to achieve a production of 1.89 liters or 1891.25ml of essential oil of molle. Due to the difficulty in obtaining the material, the calculation was made to collect half a liter of essential oil that requires 52.91 kilos of molle. Furthermore, some of the molle oil properties combined with other chemicals are that it is a good repellent [22], as well as it is useful for treating respiratory diseases such as flu, asthma, and bronchitis. It also acts as a relaxant and anti-inflammatory [23].

Table 1 summarizes the calculations of the approximate quantity of the oils: Molle, Pine, Eucalyptus, and Copaiba.

Table 1. Calculation of distillation.

Material	Material quantity (Kg)	Density (g/cm3)	Oil quantity (ml)	Oil quantity (l)
Molle	200	0.846	1891.25	1.8
Pine	270	0.9	2400	2.4
Eucalyptus	250	1.2	1666.667	1.6
Copaiba	150	0.966	1242.236	1.2

4. Discussion

The steam distillation process is one of the most used methods in the world to distill all kinds of essences. According to an investigation carried out in the Mantaro valley, where they extracted the molle oil by the steam drag method, a maximum result was obtained of 10.7 grams of essential oil from 5 kilograms of material (molle) [24]. On the other hand, with linear distillation equipment, 47.28 grams of oil can be

extracted from 5 kilograms of molle. Besides that, the still will have a control system, which will notify if there is any failure in the distillation process, sending messages to a mobile phone (of the operator).

5. Conclusions

In recent years, essential oils are being widely used in the pharmaceutical industry, aromatherapy, perfumery. That is why many companies seek to distill more oils in less time. For those reasons, the distiller presented as a project is theoretically more efficient, extracting much more oil than the other distillers, in addition to its capacity to distill all those roots, stems, leaves, flowers, and seeds that have essence.

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