Essential oil extraction from herbs using solar Energy

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Abstract: The use of essential oil as medical therapy and called aromatherapy in the world has hugely increase.

However the process of distillation requires a large amount of energy which makes the essential oil very expensive. More over, today, most of the production is very centralized. This centralized production means that the industrial is not placed near the farmer which lead a high cost of transportation and above all a waste of oil.

In the other side the advantage of a decentralized oil production is that the distillation of fresh herb, directly cut from the field, will extract the maximum of oil and the farmer will be able to increase his incomes.

The idea of the project is to create a decentralized system using the energy from the sun.

Keywords: essential oil, solar energy, distillation system, optimisation, wood/sun hybrid system

1 what is aromatherapy?

1.1 definition

It means the use of aromatics i.e. aromatic plants from which essential oils are extracted[1].

An essential oil is a very concentrated liquid extract obtained after steam distillation of an aromatic plant.

Aromatherapy is the use of essential oils for the improvement of physical and mental health by strengthening the body's self-healing

1.2 Breve history of aromatherapy

For ages, every civilisations have used plants as treatment or in order to venerate there deities . The native australians, the old Indian, chinese Egyptian, and Greek civilisations, were already using plants and there aromatics proprieties.

At these time, the plant were pressed and the use of an alambic in order to make a real distillation were diffused in europe during the XIIst century.

During the middle age, pharmacists were called “aromatherii”. Then the invention of printers allows the fast diffusion of plants knowledges as a medicine.

Finally the research in aromatherapy, was developed in France during the XXst century.However the industrial revolution of the XXst century created more hope in the chemistry of synthesis then in natural medicine.

Nowadays, the humanity is confronted with so much problems such as global pollution, a loss of fertility of the soil, a selling out of resources etc, the industrial development is questioned and more and more people are reconsidering the power of nature such as the use of essential oil.

1.3 Extraction of essential oil

Most essential oils are obtained by steam distillation, without descaling agents and at low pressure.

In this process, which takes place under low pressure, steam is forced through a vat filled with aromatic plants. The steam separate the essence from the plant and binds with it, forming a homogeneous gas that then exit the distillation vat. The gas goes through a coil immersed in cold running water. This cause condensation, with the resulting liquid being made up of two separated parts. Since the density of the essential oil is below that of

water (density <1), the former floats on top of the latter and is collected by over-flowing.

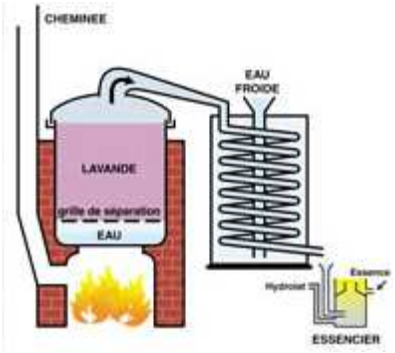

fig1 : classical distillation unit

1.4 Distilled part of the plant

Some aromatic plants can synthesize different essences according to its organs. It is therefore of first importance to isolate the distinct secreting organs before distillation in order to avoid a mix of different essential oils.

2 Solar distillation

2.1 Why using solar energy for distillation?

For all of these reason:

- Free of cost
- environmental friendly
- autonomous system (rural development)
- unlimited supply

Then a solar concentration system has been chosen because it is capable of delivering a temperature of 300°C on is focus point which is guaranty to obtain steam in the boiler.

2.2 Breve history of solar concentration in Europe

The idea to concentrate the sun rays in order to get a high energy is not new [2].

Indeed, in 776 BC, the greek civilisation already concentrated the sun in order ignitethe olympic flame.

Then the more important discoveries were during the XVII and XVIIst century withsome personnage such as Buffon, Lavoisier, or Augustin Mouchot [3]who could already obtain a temperature of more1000°C in concentrating the sun radiation and build some thermal mechanism connected with the concentrating system.

3 System description

3.1 Project requirements

- Easy utilisation
- simplicity of construction
- with classical material (such as steel)
- relative low cost of construction

3.2 The Scheffler reflector [4]

The fact that this reflector has a fixed focus point which assures an easy utilisation is its major characteristic. Then, it responds, as well to all of the other project requirements

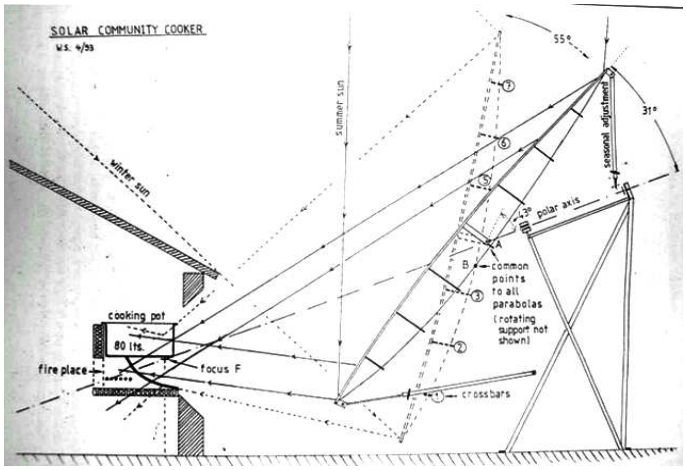

fig 2: operation of the scheffler reflector

3.3 The distillation system

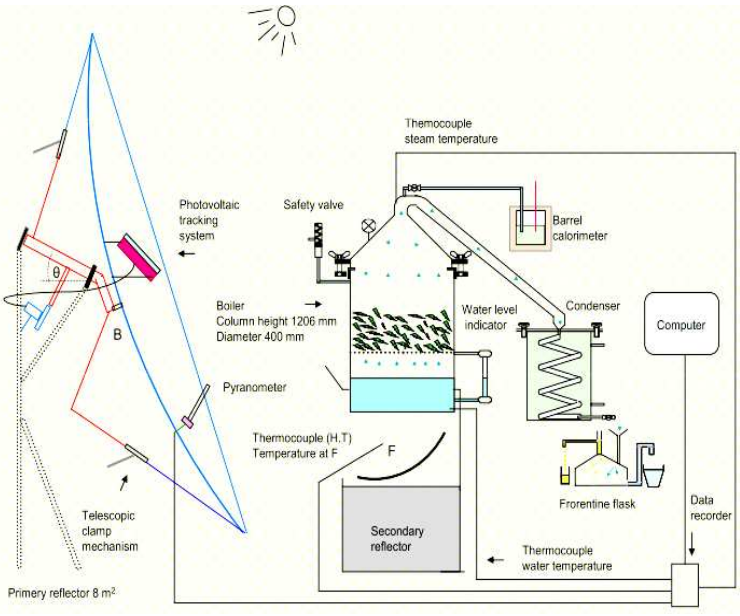

fig3 : distillation unit scheme

4 performance calculation on the distillation system

The efficiency η can be calculated such as :

$$\eta = \frac{E_{process}}{A.G} 100$$

With :

A : the aperture area of the reflector during the process in m^2,

G : the amount of energy received as direct radiation during the process in kWh

$E_{process}$: the energy used in the process such as :

$$E_{process} = (m_w + Mc.m_h) C \Delta T + x.m_s . H$$

with :

m_w : the mass of water placed in the boiler in kg,

m_h : the mass of herbs placed in the boiler in kg,

Mc : the moisture content in the plant,

C : the water calorific capacity in kWh/kg.K,

ΔT : the elevation of temperature during the latent phase in K,

x : the dryness fraction

ms :the mass of steam evaluated with the obtained amount of hydrosol in kg,

H: latent energy of water in kWh

4.1 Indication to obtain the aperture area

Because of the flexibility and the possible rotation of the reflector in order to have a fixed focus point , the aperture area varies along the year.

As shown in fig.18 In our case the aperture area will be more important during the winter time.

The formula of the aperture area depends on the culminated altitude of the sun during the day which is such as:

$$h = (90 - L) + \delta$$

with :

L ,the latitude of the site, in the project case L = 50°

δ, the sun declination ,

Then some projection must be calculated in order to get the aperture area.

4.2 Dryness fraction calculation

In the boiler can exists an atmosphere composed of steam and water particles. The process is more efficient when the amount of water particles is as low as possible because these particles keep some energy which is not use in the process.

To measure this dryness fraction of the steam in the boiler, the use of the Barrel calorimeter has been chosen [5].

The advantages of this system is principally its simplicity of build and of use.

ll of the realised experiment have a calculated dryness fraction between 80% and 100%. A 100% dryness fraction is not really possible to obtain because there always some condensation on the surface of the boiler.

5 Results and discussion

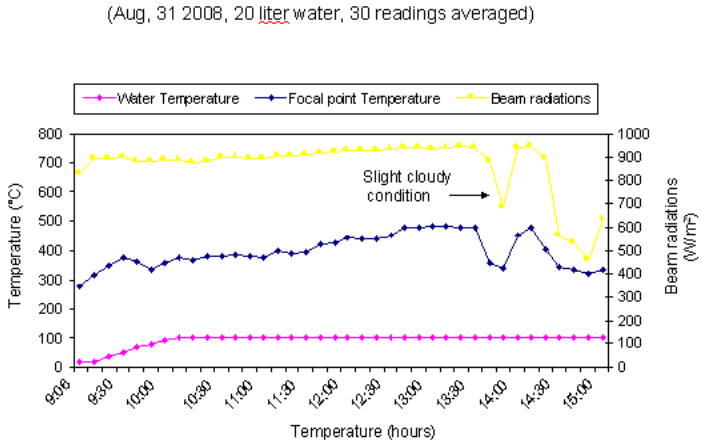

fig4: data record during an experiment

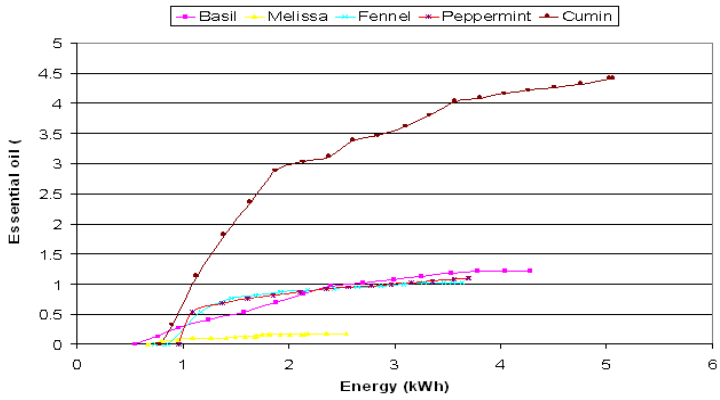

fig5: extraction of different oil in function of the used energy

Herbs	Pepper-mint	Cloves	cumin	Rose-marie	Melissa
weight(kg)	9.1	0.8	1.2	3.0	2.85
Part used	Leaves	Buds	seeds	leaves	leaves
Distilation type	Steam	Hydro	Hydro	Steam	Steam
Plant condition/ Moisture content	Fresh 74 %	Dry 11 %	Dry 9 %	Fresh 72 %	S/T dried 10 %
Power (kWh)	3.18	7.74	12.4	4.04	3.24
Essential oil (ml)	28.2	44	9.01	4.6	1.4

fig6: characteristic of oil extraction from some herbs

Finally if we calculate the efficiency of the system supposing an aperture area of 5,4m2 the 31th of august 2008. we have:

$$\eta = 43{,}3\%$$

for an average of used power of :

$$P=1{,}58\ kW$$

this number can be explain by the numerous causes of losses which are:

- the primary and the secondary reflector has an evaluated reflexivity of 84% (source: ref[4]),
- there is some error in the focus of the radiation,
- after the secondary reflector, some radiation is not directed to the boiler,
- the boiler has some thermal losses.

6 Thermal losses calculation

An evaluation of the thermal losses in the boiler have been done [6]. The total losses are estimated to 390W.

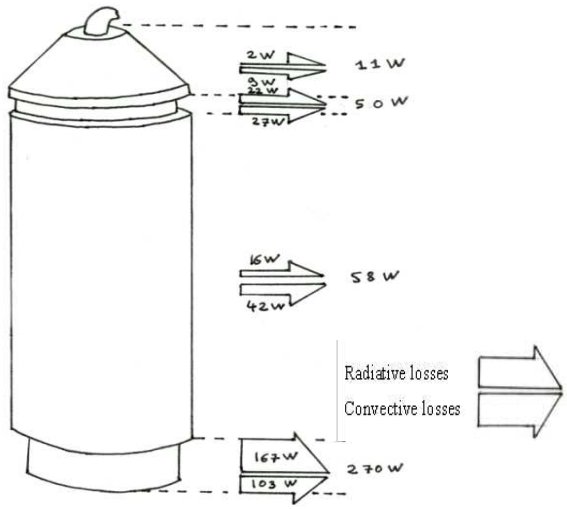

Fig7. Repartition of thermal losses on the boiler

7 Hybrid system

A Sun concentration system works only with direct radiation. During cloudy days, when the radiation is diffused the process is not possible. So a hybrid system using wood as secondary energy has been thoughtand built in order to compensate for this disadvantage.

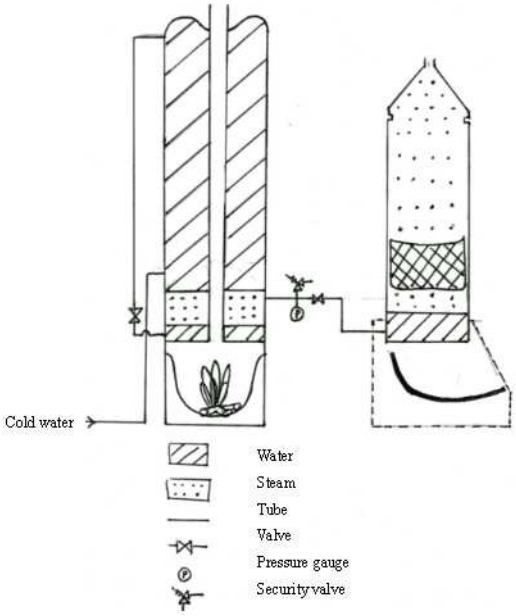

Fig8: hybrid system scheme

8 Conclusions

The solar distillation is a successful process because it works with quiet good efficiency for a sun application.

However some part must to be done such as:

- the experimentation of the hybrid system,
- the detailed calculation of the Aperture area of the reflector,
- the price study of the system.

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10 References

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