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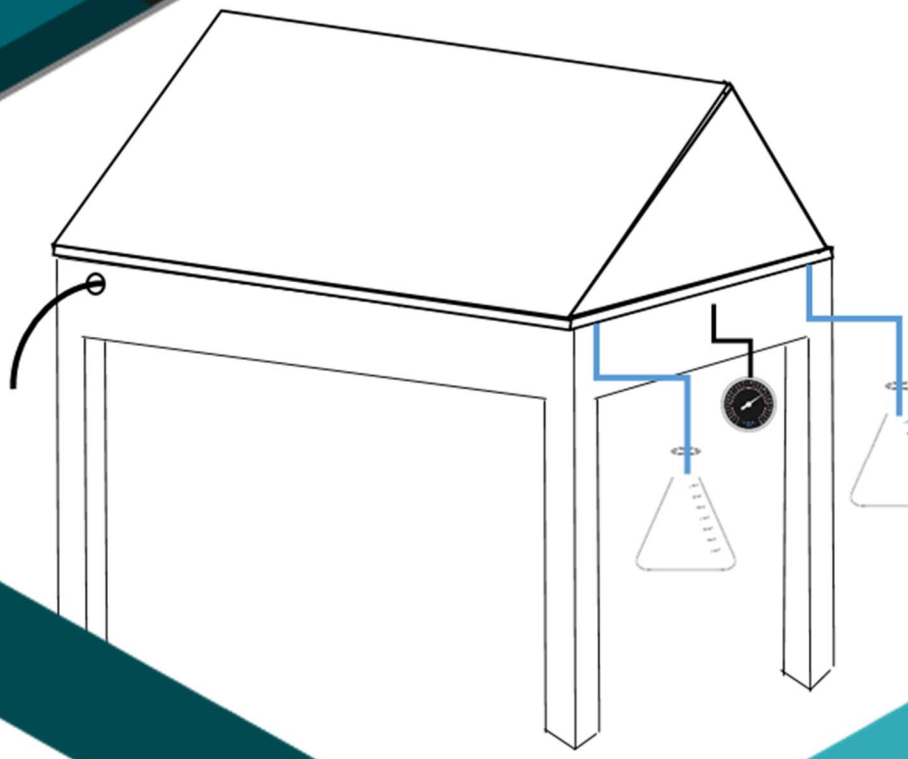

Distillation of Water
By Solar Energy

Prepared by Engineer

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Introduction:-

Nowadays we do not always realize that fresh water is very precious. Whether we use it for drinking, cleaning purposes and many other things cannot mentioned all.

Because natural sources of freshwater have always been very scarce on the world, it became necessary to make seawater drinkable. There are many ways to convert seawater into potable water. Among the processes, which are now commercially employed, the distillation of brackish, or seawater is considered to be one of the simplest and is the most widely adopted. In this method, the water is evaporated using thermal energy and the resulting steam is collected and condensed as the final product. Distillation extracts salts, minerals, heavy metals, chemicals, and. other non-biological contaminants from the raw water. It also eliminates all algae mud, sources of turbidity and biological contaminants. A solar still is an excellent water supply system for small-scale production. It uses solar energy alone to produce water by distillation. Solar stills are in many respects an ideal source of fresh water for both drinking and agriculture in arid zones.

Unfortunately, however, the productivity of present day solar stills is only about 1.5m3 per square meter per year and, as the investment, Costs are roughly proportion. In this, type of solar still. It is has the surface area of (0.9*0.73) mA2.

& Two types of thermometer:

a- Metallic thermometer for measuring the surface water temperature in the still.

b- Mercury thermometer for measuring the environment temperature.

The testing of the still starting from the first day March until 23-May. In the world must university and scientific establishment studies the solar energy and used to services the peoples. One of them is obtain the fresh water to drinking by the solar energy.

The process of myself is distillation the natural water by utilization the solar radiation.

In the chapter one we studies the introduction fundamental and types of solar still.

Chapter two is construction and the operation of the still.

Chapter three show the effected of the thermodynamic and the equations.

Chapter four & five calculation, diagrams, discussion and results.

Chapter 1:
Solar Stills

1-1 Introduction:

Many countries in the world employed the solar stills in the different parts of the life spaces. Especially at the distillation of saline water, many successively experiments operated at these processes, in order to obtain the economic stills, which supplies the fresh water for drinking & agriculture.

In these countries, which are at high solar irradiation through period of year, the distillation is at high efficiency. For example. Iraq is the one of this countries which can employed this processes.

The presence of the fresh water to the drinking & agriculture is very useful of concentration of public, which helps the economic national solar distillation for the production of potable water from saline water has been practical for many gears.

Solar distillation planned, covering 51000ft of land was built in (1) Las-Saline, Chile, in 1872 to provide fresh water from salt water for use at a nitrate mine-single- glass covered flat- plate collectors with salt water flowing down word over slanting roofs were used to vaporize some of the water, which was then condensed on the air-cooled underside of the roof.

This plant ran efficiency for over 40 year and produced up to 6000 gallon of fresh water per day until the nitrate mine was exhausted (3) After this experiment previous there is no treatment to employed the solar energy but at the beginning of 1950 the world opining directed to use the solar energy to the another advantage which services the peoples for example the solar energy employed to heat the water and for air conditioning & refrigeration or to obtain the electric power, so that many scientific group establish in the universities &center of research in the many countries in order to employed the solar energy.

While in the American united states (USA) in the 1953 establish the first office of saline water (4) which makes experiment in distillation scope added to associated which the universities research centers of American & forgers to executed larger programs in many different scope to distillation the saline water with lower cheap.

1-2 the fundamental of stills:

The principle of solar stills depends on the insulated chamber, which consist of water covered with incline glass. This chamber oriented to worlds the south in order to receive the solar radiation. But the transmitted characteristic of glasses permit to transmit all the incident solar radiation which the wave length less than 3 micron & avoid the solar radiation which the wave length exceed than this value, when the solar radiation reached the chamber caused to increase the temperature of the water and after that radiated thermal wave exceeded 3 micron, which prevented by the glasses to transfer. Many thermodynamic operation accurse in the chamber caused to evaporate the water from the surface continuously which caused to increase the evaporation pressure in the still, when reached the glass cover at temperature less than the evaporation temperature, the results of this operations is distillation of the water which assembled in the channel beside the chamber, and flow out to utilization.

1-3 The kind of stills :

We see at the previous principle of the distillated operation is simplest and easy to obtain the fresh water & not needed a high technical, although the scientific mans in many countries in the world studies this process to obtain a high production and low cost.

Practically the treating of this object at two stand point:

1- Discover new design at the high production compared (Harding opinion) which covered by two inclination glass at a roof shape.

2- Selecting cheap materials to build the still at the far region from the countries.

At the follow, we study the important results of the research, which relates to two point above.

First: basin type single effect roof shape, solar still as illustrated at figure (1-1). This figure illustrated the principle opinion of this still which was built in Chile in 1872 the any changed in this spaces is modification in the cover design only, but still at basin type-sink effect.

The research man suggested & studded the especial design of the cover at follow:

A-changed the slope of cover surface from the horizontal plane which proffered with place of the still in order to transmitted large Gauntly of solar energy enter the still (6).In order to obtain Alltel volume of still it should be the angle of cover

exceeded 20-25.

The experiments proved by experimental found that the cover angle (20-25) in order to obtain the small volume of still which helps the condense water to slip at the inside surface of the still without drops in the chamber.

B- Employed the two sides of still which illustrated this fig (1-2) by replaced the east and west sides by glasses sides, which increased the area and after that the evaporation water condensed on.

C- Employed the one glass-L-shape- as illustrated at figure (1-3).

The surface of the glass-oriented forwards the south by the experiments found that this

L-shape design is at high efficiency with the roof-shape (7), from the fig (1-3) we see that the general shape is English letter [L] so that [Abbs & Elneser] named this stills by basin type single effect.

Many exchanges employed on this shape:

1- Put horizontal mirrors at the inside wall of still, when the solar radiation cross the glass cover to the enter of the still and incident at the inside wall, this solar radiation reflection to the surface of the water in the chamber caused to increase the water temperature.

2- Employed basin type stepped solar still equipped with charging system which illustrated in figure (1-4) supplied with stepped small chamber and pump which Pumped the saline water to the high chamber and after that flows to the other chamber step by step, the evaporation of the water accurse in this chamber and the fresh in this chamber and the fresh water go out to channel at the side of still, this type of still used to obtain a little quantity of fresh water employed in the home.

3- Employed the previous still supplied with condense reservoir (8) which shown in figure (1-5) added condensed surface in still, at that time the thermal flow during the condenser operation of evaporation absorbent by the saline water in the condense tank before inters the still.

<u>Second:</u> solar stills single effect with cloth pieces:

M-telexes (9) design first still with black cloth tensed correctly at the top and bottom side while put in middle box as shown figure (1-6).

The sides walls of the box manufactured by wood but the upper & the lower surface cover with glass, the top of block cloth joint with tank consist of water this cloth is moistly at all time without the saline water flow to the bottom of the box, this still subjected to the solar radiation is oriented to words the south with an

inclination at angle equals the angle of still at the glass lower, there is channel of fresh water collection. while at the end of cloth there is a channel, which collect the saline water flow through the cloth without evaporation, figure (1-7) shown at the design of still with cloth but it's multi effect, which operated under low pressure and temperature at multi stage, which the partial pressure changed from stage to another.

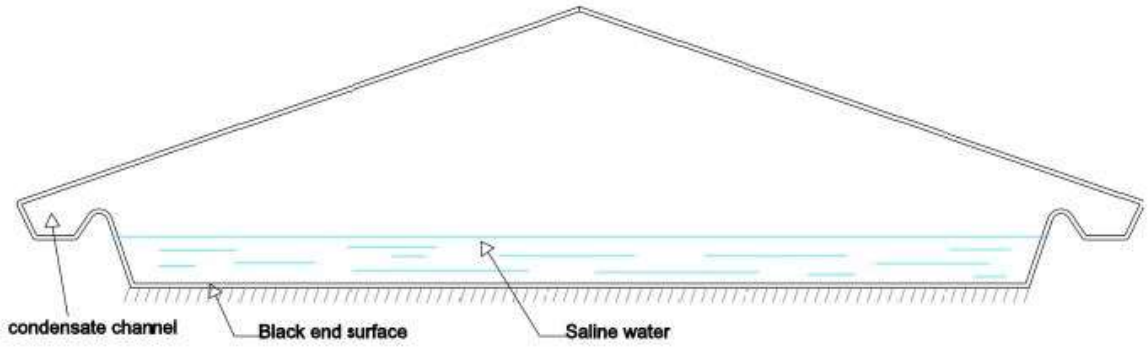

Fig. 1-1 Roof type solar still tray chamber

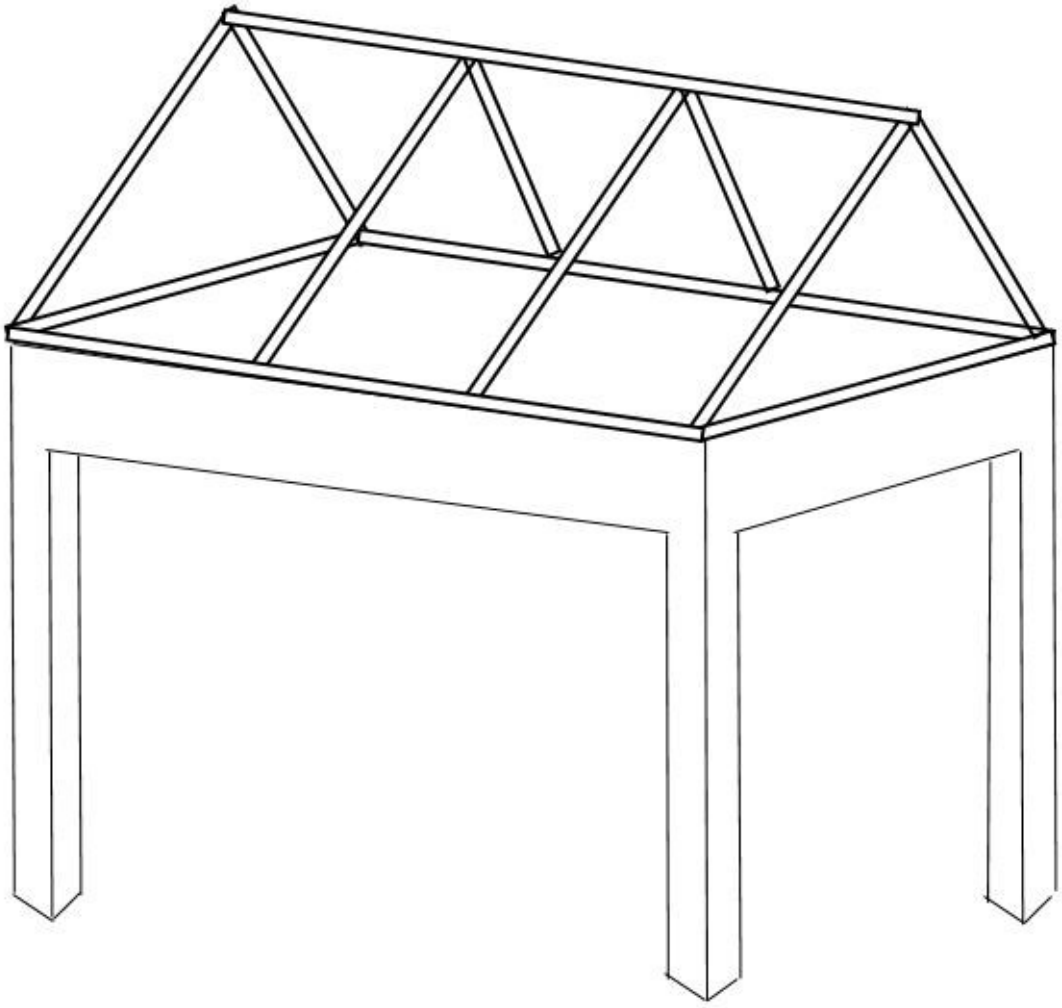

Fig. (1-2) Solar still Roof Type

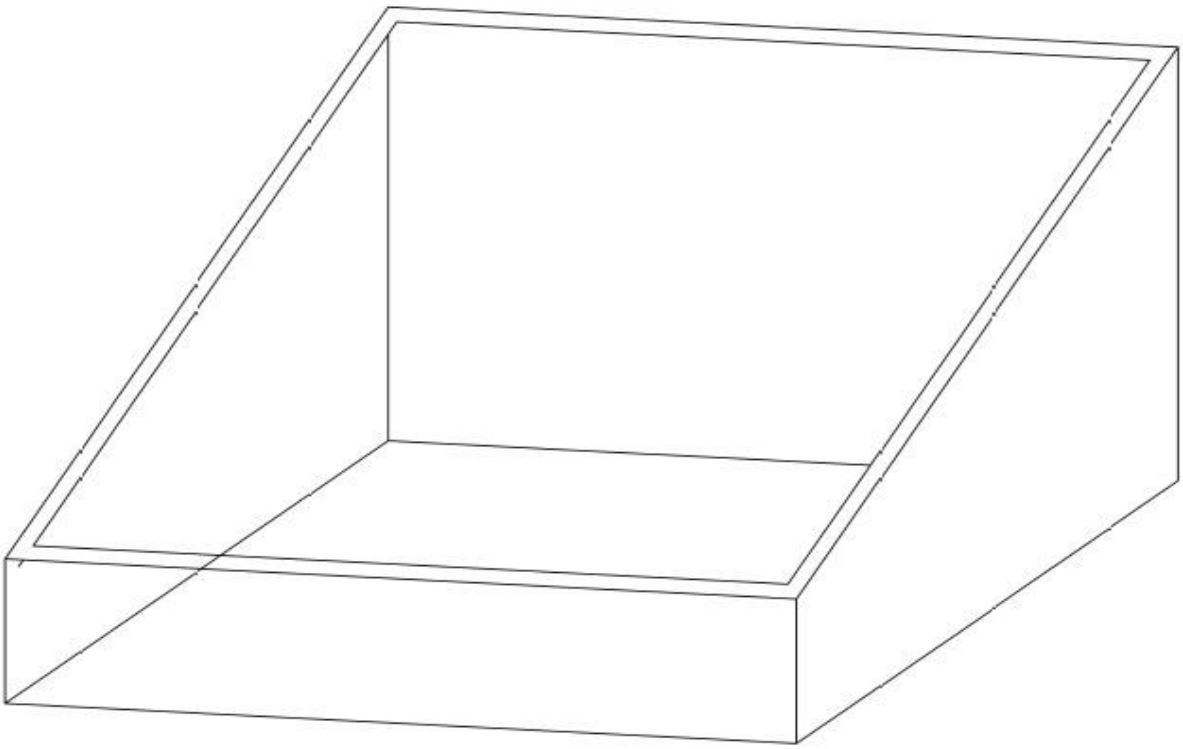

Fig. 1-3 solar still L shape tray chamber

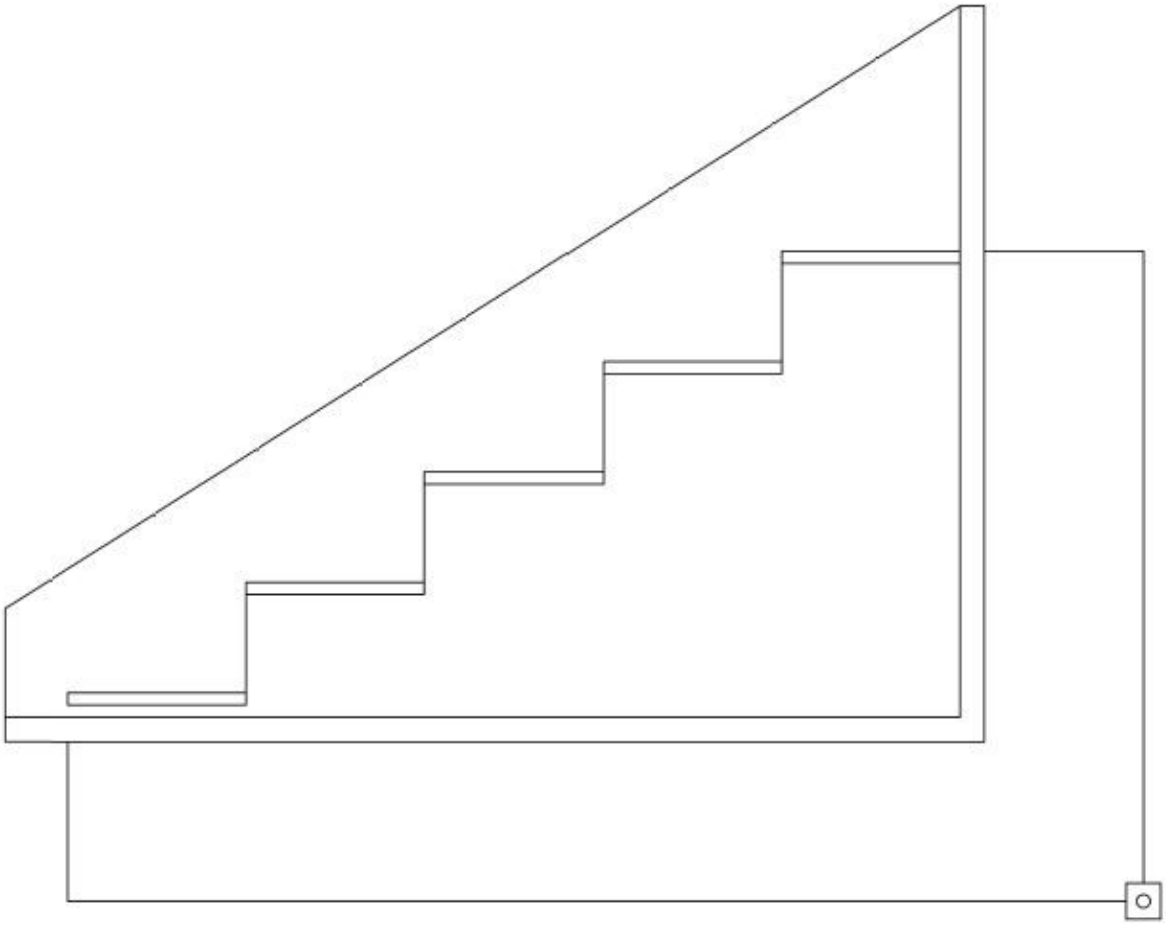

Fig. 1-4 solar still single effect with many chamber

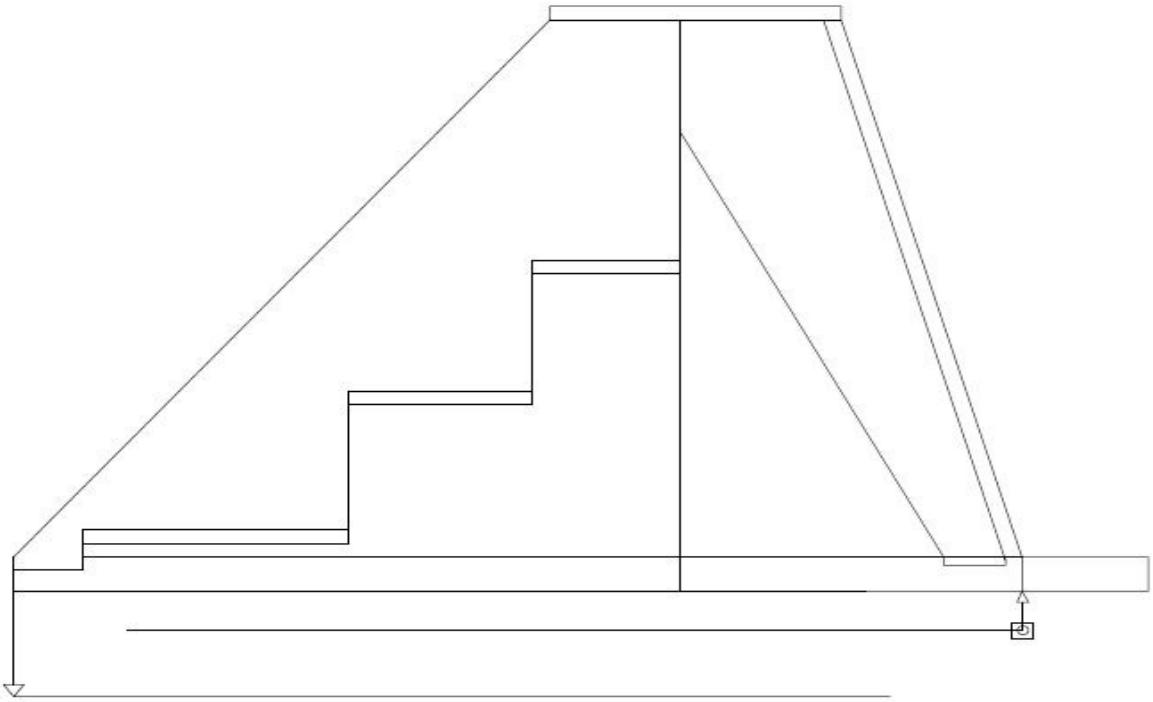

Fig (1-5) solar Still single effect with steps chamber supplied by condenser resservoir

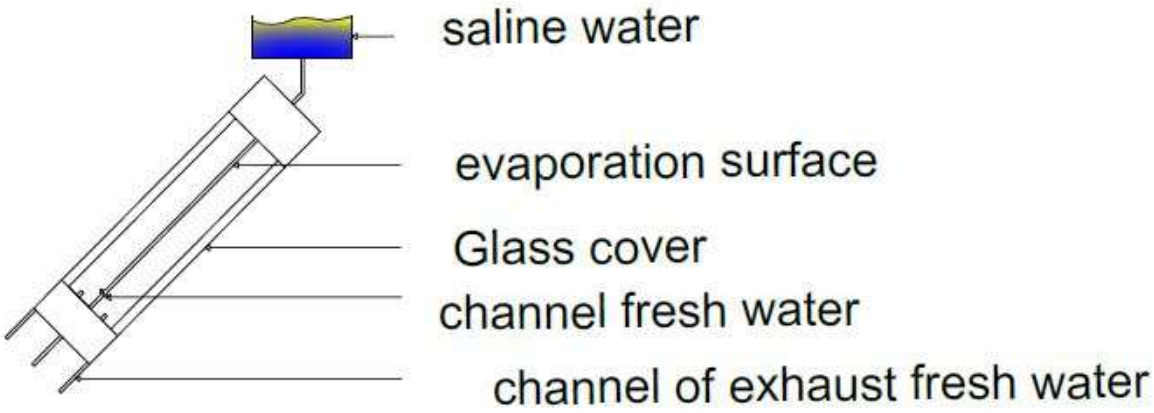

Fig (1-6) solar still with inclined single effect

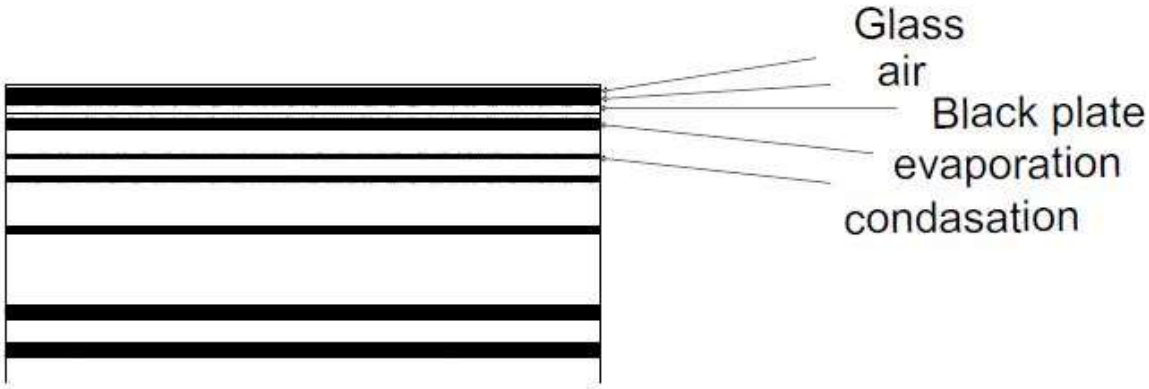

Fig (1-7) Inclined solar still multi effect

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Chapter 2: -

The construction & operation of the still

2-1 The material, which is used in building of the still:

Before we indicate the materials, which enters the building of the still, we should know the different parts for this still after that we indicate the employed materials studies and experiment specially the single effect still with chamber.

We can divided the solar still as follows:

1- Still body and chamber of saline water.

2- The glass covers.

3- Collection channels for fresh water.

1- still body and chamber of saline water, there are two types:

a- still at permanent base : The volume of this type is large and area of this base exceeds ten times this volume.

b- Still at small volume: which transform from place to another, the base area is not exceeded lm the first type of this stills the base and walls build by cement ,but know build by stronger plane in order to prevent any deformation of the base after that the saline water wasted to the earth and at the result decreased the efficiency. While it should cover the base of Still and the walls by insulted materials as a plastic or asphalt, which prevent the water thermal losses.

While the second types of stills wood materials build it so that it should be used metal chamber at insulated cover to prevent the heat losses from chamber to the surrounding.

2- The stills cover:

The glasses always employed for the cover of stills which permits to transfer the solar radiation so that the glass is used a take the cover the stills. The glass plate fixed inclination on the above chamber of still roof-shape , many time the glass fixed from permit to open the still and we can easily to clean the chamber by removing the undesirable materials which accumulated in this chamber at the result of evaporation, the production of the stills depends on the angle of inclination of glass, when the angle is small inside volume of the still small too and vice-versa when the angle is small, the thermodynamic operation through the still is quickly and the thermal losses is less while the very small

angle caused to related the condenser water on the glass the still chamber.

3- collection chamber of fresh water:

If the body of the still manufactured by the wood or concert the collection channels should be made from metallic materials, in order to fixed this channels you need accurate technical to keep the fresh water otherwise the fresh water, flows through fixed place after that reduced the production when the still wooden still, the flow of this water caused to distortion the still at result short life of operation.

2-2 Design of Solar stills:

Stand point at this research is design a solar still to distillation the saline water with high efficiency & lower cost, in order to employed from a certain groups which are operated in agriculture and the nitrate mine to obtained the fresh water from the saline zoom.

At the design of this still it should be consist the following point:

1- Easy design, possible building.

2- High efficiency.

3- High strength for the climate factors temperature, winds and rains.

4- Lower cost, easy maintenance, and easy operation.

So that we build and tested this still in our workshop by the metal materials with glass cover

1 surface this still is Basin-type, single affect, Roof shape which is illustrated in fig (2-3)

the still is irradiated by direct and diffuse solar radiation as well as some infrared from surrounding. The long-wave length radiation is absorbed by the glass but the solar radiation reaches the saline water, this still is at good glass blackened tray surface and 80mm thick layer of water are used, typical roof still dimension are illustrated in figures (2-1), (2-2), (2-3) and (2-4), the glass roof should have slop of (35-45) with horizontal surface.

2-3 the operation of still:

After preparation the still to operate and cleaned the surface of glasses from the dust.

The operation period is (24) hour daily, through this period we recorded:

1- The efficiency.

2- The temperature of still water surface.

3- The solar radiation.

This is done after all three hours, started morning at (9) o'clock afternoon, the production accounted through the (24) hours.

The production means the volume of distillation water by litter per (m^2) area of still chamber, during this operation we used thermometer in order to record the temperature of surface water in still chamber.

We obtained the daily efficiency of still which is depended on the amount of incident solar radiation on the tray of the chamber, we assume the amount of heat which is required to be heated and evaporated (1kg) of water is equal* (69.27w/lit).

Efficiency =(daily production 697.2(w/lit)104(m/s)/amount of incident solar energy/day)*100.

We compute all the data, which is obtained from the period of operation, which, is illustrated in the table (4-1).

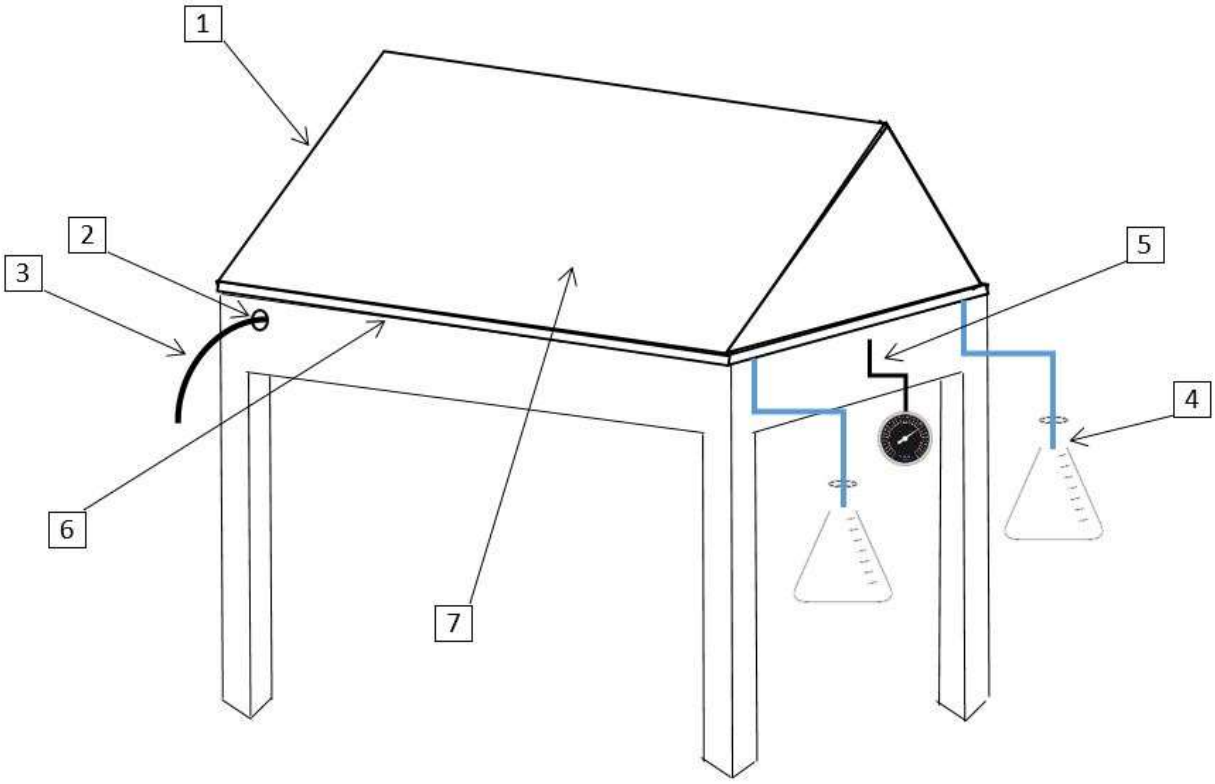

fig (2-1)

1-glass cover.
2-water income.
3-float.
4-vessel of pure water.
5-metallic thermometer.
6-isolator.
7-still.

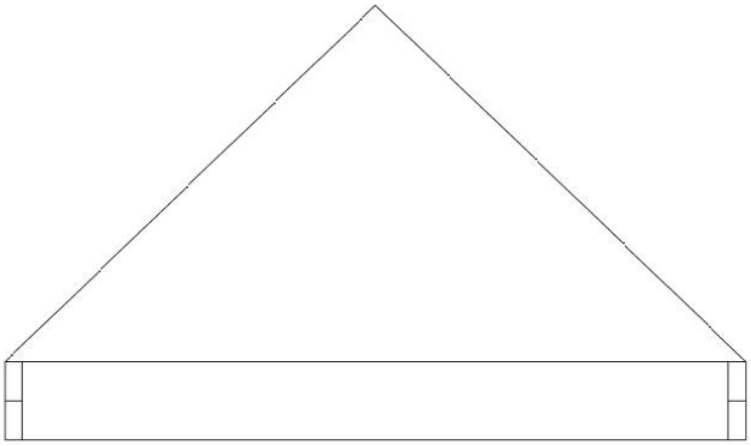

Fig (2-2)

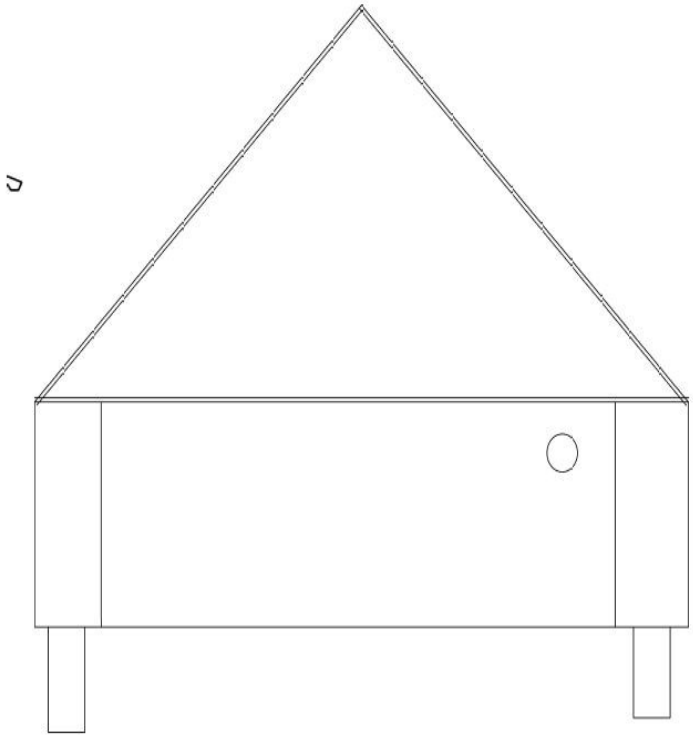

Fig (2-3)

Chapter 3: -
The effected of thermodynamic & Equations:

3-1 The energy transfer in the solar stills:-

The stills not received all incident solar radiation to the distillation process, but a portion of the energy losses without any advantage and if the losses of the energy is little the efficiency of the still at high production and high efficiency, for this reason in order to product still at high efficiency, we should understanding and the thermodynamic process inner and outer the still during the distillation process.

1-The direct & indirect solar radiation which incident on the glass covers still absorbed from the black tray of still. The amount of this absorption depended on the evaluation of solar intensity, which is losses as result of reflection of the incident solar radiation on glass cover, and reflection from the tray added to that the glass cover, which absorbed Alltel of this energy.

2- The amount of thermal energy which absorptive from tray transferred to the water which in the still by conduction and convection & apportion of this energy transferred to the environment by the tray as result of high temperature of the water in the still.

3- The energy which absorptive by the water transfer to the glasses at three ways:

a- Evaporation from the water surface in the still, which is transferred, to the inside cover of glasses by convection and after that condensed and the potential energy delivered through this condensation.

b- Circulation the air inside the still.

c- The thermal radiation from the surface of the water to the glass cover, which is, absorbed ambush of this radiation, and after that transferred to the atmospheric directly (14).

4- The thermal radiation, which reached the surface cover of, still transferred to the environment radiation and convection.

5- Added that to the heat transfer processes other heat transfer occur by the water which is entered to the still when we what to distillated this water and this water stored this temperature which increased during the distillation.

The figure (3-1) illustrated the heat transferred in side to outside of still (is).

You can improve the study of thermodynamic by studies:

1- Heat balances at the surface of water in the chamber.

2- Heat balances at the cover surface of still.

i

3-2 The state of Heat on the surface of water:

Assume the solar irradiation (W/mA2) {amount of solar energy per unit areas & unit time}.

Which passes through the glass cover of still defined *QA* (kW/mA2).

The heat Balance State at the surface of water in the chamber, we can write that as follow:

$Qa=qw+qb+qc+qr+qe$ (1)

Where:

qw: the irradiation of solar which implied to increase the water temperature (kW/mA2).

qb: thermal energy losses through base of chamber and the walls of still (kW/mA2).

qc: heat flow rate by natural convection from water surface to the glass cover (kW/mA2).

qr: heat flow rate by radiation from the surface of water to the glass cover (kW/mA2).

qe: the employed energy to evaporation (kW/mA2).

You can evaluated *(qw)* by this formula:

$qw = cwb*dtw/dt$…… (2)

Where:

Cwb: thermal capacity of the still water (J/mA2.c).

dtw/dt : changed the rate of water temperature (i5).

$qb- hb (Tw-Ta)$…… (3)

Where:

Tw: temperature of the chamber water c.

Ta: atmospheric temperature around the still .

hb: heat transfer coefficient (kW/mA2.c).

*hb= (K/d)*aw…….* (4)
K: thermal conductivity (kW/m.c)
d: chamber base thickness (m)
aw: base area of chamber (mA2) in order to reduce heat losses employed insulated material for still(i 6).

*Oc= 8.8*10 A-4 [tw-tg+(pw-pg/2.65p-pw)Tw/ A(l/3) *(Tw-Tg)……(5)*
tw: water temperature in still c.
tg: glass temp.
pw: from table, which is obtained partial pressure of water vapor at temp. Tw.
pg: from table which depends on the tg is obtained-partial of water vapor at temperature Tg.

qr-0.9&*(tw /K4-tgA4) ……..(6)*

il Stefan-boltzman constant =5.6697*10A-8 nr•).

*qe-16.276*10 A-3 qcpw-pg/tw-tg……..(7)*

3-3 **The State of Heat on the** Glass **Cover: -**

The fig. 3-1 which is illustrated the direction of solar energy flow and thermal energy inter and outer the still so the heat balance of the glass cover we see:
qe+qr+qc+gas=qgh+qgL……. (8)
qe,qr,qc previous defined
qgs, represented the solar radiation which absorptive by the cover (kW/m2) which calculated by this equation :
gas -SgsH ……**(9)**
Where: -
oWgs: the absorption coefficient of the cover material .
H : solar irradiation at the horizontal surface.
qgh : energy losses when the temperature of the glass cover rise which calculated by this equation:-
qgh-cgs*dtg/dt……...(10)
cgs : thermal capacity per unit area of the cover
dtg/dt : heat exchange rate for cover
qgl : represent the thermal flow from the still cover to the surrounding at the result

„ of the absorption of thermal radiation that calculated by this equation: -

qgl-qra+qea……(11)

Where: -

qra: represented the thermal energy to the ambient which losses from glass cover, which calculated by this equation :-

qra=e *s((tgA4)-(ts A4))……...12

e :the cover transient

S: Stefan and Boltezman coefficient.

tg: temperature of glass.

ts: temperature of apparent sky, which is less than(ta) by (12) c.

Which calculate by this equation: -

qra =EgS((tgA4)-(ta-12)) ……..13

qca dosses of thermal energy by convection from glass to the ambient which writing by this equation.

qca -hco (tg-ta)……14

Where: -

tg: glass temperature.

ta: ambient temperature.

hco : convection coefficient from glass to the ambient.

hcoX/k—0.028reA0.8 …….15

X:the width of still.

K: thermal conductivity of thin airs which around the glass cover.

Re: Renold number.

Re= ***e *s ……***

I

'tf/velocity of the air outer the still (m/s).

fO. density of the water (kg/m2).

ju: The water viscosity (Kg/m.sec).

And we find the efficiency by this equation: -

(dailyproduction *6972)/Qa…… (17)

Where: -

10. Efficiency of still

Qa: solar intensity

3-4 Measurement of amount thermal energy losses inters the still: -

The particle study of this process needed measuring of energy which losses during the evaporation. Qr, qc, qb, qe in order to know the amount of solar energy which is passes through the glass (Qa) to enter the still and after that to compared it with the incident energy on the horizontal surface outer the still q.

Since in this research we don't have the divide of thermal couple to measuring the intensity of solar radiation, so that we cannot improve this comparison, but studied this thermodynamic operation theoretically.

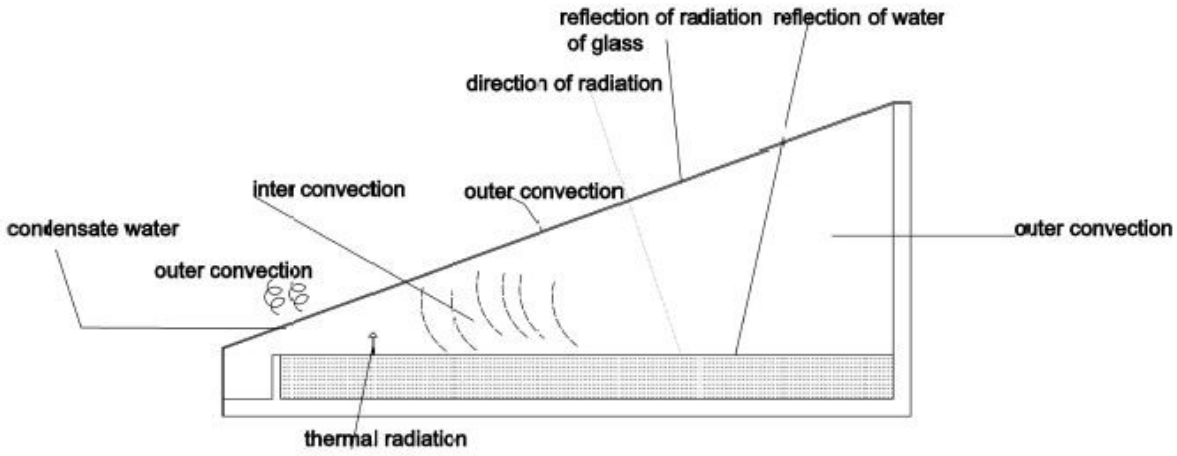

Fig. 3-1 direction of energy flow in to the still with a single effect

CHAPTER 4: -

Discussion, Results & Curves

Discussion: -

The purpose of this model projection is obtained the fresh water by solar energy. The apparatus that is used for this state explained on it in the chapter 1&2 it depended on the following surrounding parameter.

1- Temperature of surrounding.

2- Wind velocity in order to locate the climate effect.

3- Solar intensity radiation.

This fact are seen in the table that the efficiency is more change with the surrounding parameter.

During this test, we extract that when this we design such project in suitable size according to the employed position is very useful and it have high daily production.

The method of manufacturing is easy and low cost so it can be implement in most position such as (factory, workshop, etc).

The production is fresh water and it very important weather we use it for drinking, cleaning purposes a medicine area and other area.

We have a table shows average production and solar radiation and the efficiency

Table

solar radiation (w/m^2)	average value of production l/m^2	Efficiency with rate of solar radiation
263	1.5	39%
262	1.52	40%
261	1.6	45%
260	1.8	49%
268	2.3	74%
290	3.12	76%
294	2.9	85%
295	3.4	80%
300	2.12	49%
305	2.9	65%
310	3.2	72%
312	4.3	95%
315	3.19	70%
320	3.3	74%
325	3.3	72%
330	4.1	87%
335	4	84%
340	3.6	74%
345	4.2	84%

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