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# EVALUATION OF THERMAL INDUSTRIAL AIR HEATERS BASED ON SOLAR SYSTEM

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**Abstract**

**The usage of solar energy heating systems increased greatly during the last decade. Need to make a setup which acquires much of the Sun's radiation as per the output requirement. More than one hundred years ago, black painted water tanks were used as simple solar water heaters in a number of countries. As the development takes place total setup gets advanced. Our main objective is to keep the system in such a way that, yields a better result. The major equipment includes collector, heat-exchanger, storage tank, and pumps & pipes.**

***Keywords:***

**Solar energy;**
**Solar water heaters;**
**Collector;**
**Heat-exchanger;**
**Storage tank.**

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## 1. Introduction

Industrials air Heaters is on thermal energy applications. In this we treat the use of solar heating for domestic or institutional hot water supplies. Using the sun's energy to heat water is not a new idea. More than one hundred years ago, black painted water tanks were used as simple solar water heaters in a number of countries. Solar water heating (SWH) technology has greatly improved during the past century. Today there are more than 30 million m2of solar collectors installed around the globe. Hundreds of thousands of modern solar water heaters, such as the one shown in Figure 1, are in use in countries such as China, India, Germany, Japan, Australia and Greece.

Figure 1.1: Solar panel system

In addition to the energy cost savings on water heating, there are several other benefits derived from using the sun's energy to heat water. Most solar water heaters come with an additional water tank, which feeds the conventional hot water tank. Some solar water heaters do not require electricity to operate. For these systems, hot water supply is secure from power outages, as long as there is sufficient sunlight to operate the system. Solar water heating systems can also be used to directly heat swimming pool water, with the added benefit of extending the swimming season for outdoor pool applications.

### 1.2 Description of Solar Water Heating Systems

Solar water heating systems use solar collectors and a liquid handling unit to transfer heat to the load, generally via a storage tank. The liquid handling unit includes the pump(s) (used to circulate the working fluid from the collectors to the storage tank) and control and safety equipment. When properly designed, solar water heaters can work when the outside temperature is well below freezing and they are also protected from overheating on hot, sunny days. Many systems also have a back-up heater to ensure that all of a consumer's hot water needs are met even when there is insufficient sunshine. Solar water heaters perform three basic operations.

- Collection: Solar radiation is "captured" by a solar collector
- Transfer: Circulating fluids transfer this energy to a storage tank; circulation can be natural (thermo siphon systems) or forced, using a circulator (low-head pump);
- Storage: Hot water is stored until it is needed at a later time in a mechanical room, or on the roof in the case of a thermo siphon system.

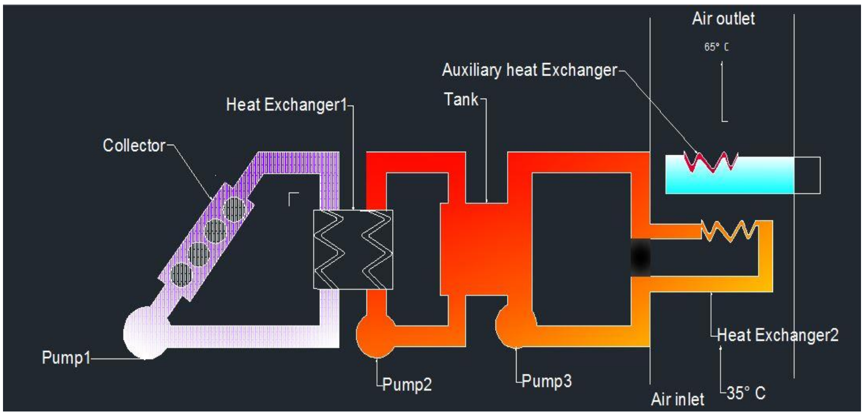



Figure 1.2: Air Pre-Heating Plant

## 1.3 Major Equipment in this Project

- There is five main components of an active solar water heater. They are the collectors, storage tanks, backup heating system, circulation system, and control system
- Most of the solar water heaters require a well-insulated tank. This two-tank systems preheats the water before it enters the conventional water heater.
- The collector is constructed with an Al box into an all copper absorber plate, then a low-iron tempered glass to cover the plate is added to create a greenhouse affect that can deliver high temperatures.
- There are 3 different types of solar collectors for residential applications:
- Flat-plate collector
- Integral collector- storage systems
- Evacuated-tube solar collectors

## 1.4 Applications on Market

Solar water heating markets can be classified based upon the end-use application of the technology. The most common solar water heating application markets are service hot water and swimming pools.

### 1.4.1 Service hot water:

There are a number of service hot water applications. The most commonapplication is the use of domestic hot water systems (DHWS).

Figure 1.3: Domestic hot water

Other common uses include providing process hot water for commercial and institutional applications, including multi-unit houses and apartment buildings,and in schools, health centers, hospitals, office buildings, restaurants and hotels.Small commercial and industrial applications such as car washes, laundries and fish farms are other typical examples of service hot water.Solar water heating systems can also be used for large industrial loads and for providing energy to district heating networks.

### 2.1 Collectors

A Solar collector is a device for extracting the energy of the sun directly into a more usable or storable form. Solar energy (solar radiation) is collected by the solar collector's absorber plates. Selective coatings are often applied to the absorber plates to improve the overall collection efficiency. A thermal fluid absorbs the energy collected.

## 2.2 Working Principle

A solar collector works to convert and concentrate solar energy into a more usable form. For example, a thermal collector may use a parabolic array of mirrors to focus, direct, and reflect the light of the sun to a smaller point where the heat can be used to drive some sort of turbine engine by heating the driving fluid. Another type of collector may use a flat panel array of solar photovoltaic cells to convert solar energy directly into electricity. Some metals exhibit a photoelectric property whereby when the metal is exposed to light, it causes electrons to be emitted. These metals may be arranged in a valence-covalence band configuration which generates the actual voltage within the array.

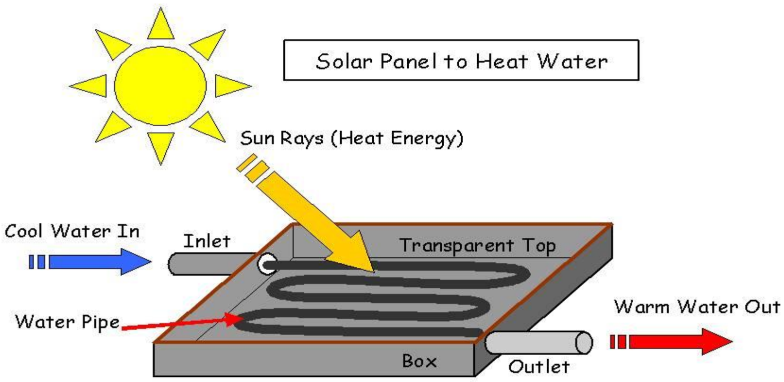



Figure 2.1: collector panel

Solar energy (solar radiation) is collected by the solar collector's absorber plates. Selective coatings are often applied to the absorber plates to improve the overall collection efficiency. A thermal fluid absorbs the energy collected.
There are several types of solar collectors to heat liquids. Selection of a solar collector type will depend on the temperature of the application being considered and the intended season of use (or climate).

By using these different types of collectors we can

- Increasing the principles of energy resources
- The ways how to use alternative energy more widely are being explored
- The air heated this way is not toxic and electrically neutral
- Solar air heating collector efficiency is not high but it has simple construction and is cheap to make and operate ( handmade)
- Solar air heating collector is good as extra heating device.

Solar collectors are either non-concentrating or concentrating. In the non - concentrating type, the collector area (i.e, the area that intercepts the solar radiation) is the same as the absorber area (i.e, the area absorbing

the radiation). In these types the whole solar panel absorbs light. Concentrating collectors have a bigger interceptor than absorber.
Flat- plate and evacuated tube solar collectors are used to collect heat for space heating, domestic hot water or cooling with an absorption chiller.

**TYPES OF COLLECTORS** — Development Cooperation

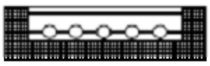
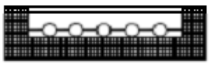
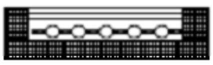
| | principle | $\eta_0$ [ ] | U [W/m² K] | collector working temp. | appropriate application area |
|---|---|---|---|---|---|
| simple absorber |  | 0.90 | 20 | 15 30 °C | swimming pool |
| simple flat-plate collector with glass cover (FP) |  | 0.80 | 4 | 30 – 80 °C | hot water |
| FP with selective surface (SS) |  | 0.80 | 3 | 40 – 90 °C | hot water space heating |
| FP with double anti-reflective coated glazing and gas filling |  | 0.80 | 2.5 | 50 – 100 °C | hot water space heating cooling |
| evacuated tube collector with SS (ETC) |  | 0.65 | 2 | 90 – 130 °C | space heating cooling process heat |
| ETC with compound parabolic concentrator (CPC) |  | 0.60 | 1 | 110 – 200 °C | space heating cooling process heat |

Table 1: Characteristics of collectors

Among all these we are using the flat-plate with double anti reflective coated glazing and gas filling collectors. Choosing of these collectors mainly depends on three functions of the elements in the collector.

1. absorbing maximum of energy from the atm and non-reflecting to the outside

2. With in a small difference in a temperature maximum amount energy should be transferred

### 2.3 Material Used

**TRANSPARENT COVER MATERIALS** — Development Cooperation

| cover | thickness [mm] | weight [kg/m²] | solar transmittance |
|---|---|---|---|
| Standard glass *) | 4 | 10 | 0.84 |
| Standard glass, tempered | 4 | 10 | 0.84 |
| Iron free glass, tempered | 4 | 10 | 0.91 |
| Antireflective coated glass | 4 | 10 | 0.95 |
| PMMA, ducted plate | 16 | 5.0 | 0.77 |
| PMMA, double ducted plate | 16 | 5.6 | 0.72 |

*) danger of breaking determined by high collector temperatures

Table 2: Properties of cover material

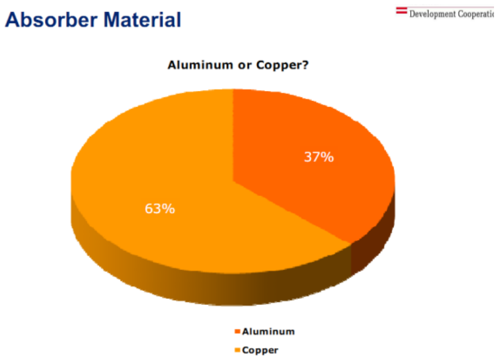



Figure 2.2: Absorb material

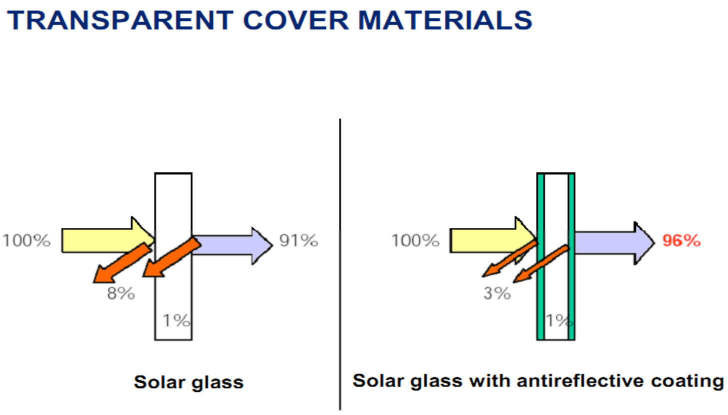



Figure 2.3: Coating of covers

## 2.4 Collector efficiency

Ameasure of collector performance is the collection efficiency, defined as the ratio of the useful gain over some specific time period to the incident solar energy over the same time period.

Temperature distribution in flat plate collector:

Here we are using Flat plate collector with double anti-reflective glazing and gas filling. Some of the solar energy absorbed by the plate must be conducted along the plate to the region of tubes. Thus the temperature midway between the tubes will be higher than the temperature in the vicinity of the tubes.

### 2.4.1 Overall heat transfer Co-efficient

$$U_t=\left\{\frac{N}{\left\{\frac{C}{(T_{pm}}\left[\frac{(T_{pm}-T_a)}{(N+f)}\right]^e} + \frac{1}{h_w}\right\}^{-1} + \frac{\sigma(T_{pm}-T_a)(T_{pm}^2+T_a^2)}{(\varepsilon_p+0.00591Nh_w)^{-1}+\frac{2N+f-1+0.133\varepsilon_p}{\varepsilon_g}-N}$$

Where

N = Number of Glass Covers {1,2,3}

$\varepsilon_p$= Emittance of Glass Covers1 {0.6,0.7 }

$\varepsilon_g$ = Emittance of Glass Cover2 {0.6,0.7,0.8}

$T_a$ = ambient Temp {25, 27, 30}

$T_{pm}$ = Mean Plate Temp {90,100}

b =Angle of Tilt (deg) {45,55,65}

f = (1+0.089*Hw-0.1166*Hw*ep)*(1+0.07866*N) ;

c = 520*(1-0.00005*beta*beta)

e1 = 0.430*(1-100/Tpm)

sigma = 5.67*0.00000001

hw = wind heat transfer coefficient(w/m2C)

### 2.4.2 Temperature distribution between tubes and the collector efficiency factor:

The temperature distribution between tubes can be derived if we temporarily assume the temperature gradient in the direction is negligible. The distance between the tubes is W, the tube diameter D and sheet is thin with a thickness X. Sheet metal is good conductor so the temperature gradient through the sheet is negligible.

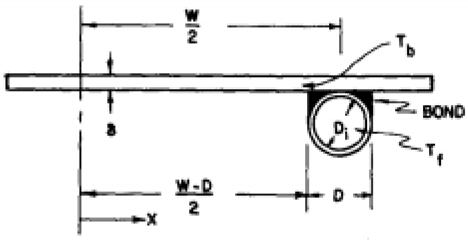



Figure 2.5: Fin with tubes

The fin as shown in fig is of length (W-D)/2.The energy balance on this element yield

$$S\Delta x - U_L \Delta x (T - T_a) + \left(-k\delta \frac{dT}{dx}\right)|_x - \left(-k\delta \frac{dT}{dx}\right)|_{x+\Delta x} = 0$$

Where s is the energy absorbed solar energy. Dividing through by Δx and finding the limit as Δx approaches zero yields

$$\frac{d^2T}{dx^2} = \frac{U_L}{k\delta}\left(T - T_a - \frac{S}{U_L}\right)$$

The two boundary conditions to solve this second order differential equation are symmetry at the centuries and the known base temperature

$$\frac{dT}{dx}|_{x=0} = 0, T|_{\tau=(W-D)/2} = T_b \qquad (1)$$

For convenience we can define two variables, m and Ψ,

$$m = \sqrt{U_L/_{k\delta}}$$
$$\Psi = T - T_a - {}^{S}/_{U_L}$$

And the equation (1) becomes

$$\frac{d^2\Psi}{dx^2} - m^2\Psi = 0$$

This has boundary conditions

$$\frac{d\Psi}{dx}|_{x=0} = 0, \Psi|_{x=(W-D)/2} = T_b - T_a - {}^{S}/_{U_L}$$

The general solution is

$$\Psi = C_1 \sinh mx + C_2 \cosh mx$$

The energy collected for both sides of tube is

$$q'_{fin} = (W-D)[S - U_L(T_b - T_a)]\frac{\tanh m(W-D)/2}{m(W-D)/2} \qquad (2)$$

It is convenient to use concept of a fin efficiency to rewrite equation

$$q'_{fin} = (W-D)F[S - U_L(T_b - T_a)]$$

Where

$$F = \frac{\tanh m(W-D)/2}{m(W-D)/2} \qquad (3)$$

The useful gain of the collector also include the energy collected above the tube region.The energy gain for this region is

$$q'_{tube=} D[S - U_L(T_b - T_a)] (4)$$

And the useful gain for the tube an fin per unit of length in the flow direction is the sum of equations (2) and (4)

$$q'_w = [(W-D)F + D][S - U_L(T_b - T_a)] \qquad (5)$$

Ultimately the useful gain from equation (5) must be transferred to the fluid. The useful gain can be expressed in terms of the two resistances

$$q'_w = \frac{T_b - T_f}{\frac{1}{h_{fi}\Pi D_i} + \frac{1}{C_b}}$$

We now wish to eliminate $T_b$ from the equations and obtain an expression for useful gain.By solving and substituting the result for useful gain is

$$q'_w = [(W)F][S - U_L(T_f - T_a)]$$

Where

$$F = \frac{1/U_L}{W[\frac{1}{U_L[D+(W-D)F]} + \frac{1}{C_b} + \frac{1}{\Pi D_i h_{fi}}}$$

**2.4.3 Heat transfer Co-efficient Btw The Fluid and The Tube Wall (Hfi)** =330.0

Enter Diameter of the Tube = 20,25,30

Collector side fluid temperature = 27,30,35

Thermal Conductivity of Tube materialK=385.0

Specific Heat Constant of Water = 4.18

To get Outlet Temp of Collector Side Fluid (f1)

**f1=((1/Ut)/(W*((1/(Ut*(D+(W-D)*f2))+1/(3.14*D*Hfi))))**

Enter collector Area = 100 $m^2$ to 140 $m^2$

Enter collector Side Inlet Fluid Temperature = 25 , 27 , 30

Solar Heat Constant Value = S3=1370

temp3=(Ut*f1)/(0.018*Cp)

Not=(1/(pow(2.71,temp3)

**Outlet Temp of Collector Side Fluid is Tf0 =Ta+(S3/Ut)+(0.9)*(Tf1-Ta-(S3/Ut)**

## 3. Heat- exchangers

Heat exchangersare devices whose primary responsibility is the transfer (exchange) of heat, typically from one fluid to another. In heat exchangers, there are usually no external heat and work interactions. They are widely used in refrigeration, air conditioning, space heating, power production and chemical processing. Common examples of heat exchangers are shell and tube exchanger, automotive radiator, condensers, evaporators, air pre-heaters and cooling towers.

**Calculations:**

The collectors absorbs the maximum heat energy and transfer to the glycol flowing in the copper tubes. The amount which is deliver by the collector outlet directly transfers to the heat exchanger.On the other hand of heat exchanger another fluid (water) will enters into it with an ambient tempareture.so
Mass flow rate of the Glycol is $m_1$=0.35kg/s
Mass flow rate of the water is $m_2$=0.45kg/s
Heat transfer coefficient of water $C_{p1}$=4.18KJ/KgK
Heat transfer coefficient of glycol $C_{p2}$=2.560KJ/KgK
**Heat exchanger outlet temperature** is $(x=2.56[\frac{T_{f0}-T_{f1}}{4.18}] + 30)$
Logarithmic Mean Temp= logmeantemp= $\frac{(T_{f0}-x)-(T_{f1}-30)}{\log[\frac{(T_{f0}-x)}{(T_{f1-30})}]}$
Area of Heat Exchanger area2=m2*Cp2*(Tf0-Tf1)$m_2 * C_{p_2} * (T_{f0} - T_{f1})$
H1=(Tf0-Tf1)*0.45*1.15
**Heat Exchanger Total Surface Area in area3**= area3=area2/(logmeantemp*0.45*4180)

## 4. Storage tank & pumps

Solar energy is a time defendant energy resource. So it needs to be stored to meet the needs. The performance of the collector decreases if it doesn't distribute the temperature drop since it leads to unnecessarily high collector temperature. So there is a need to add a storage sub-system to store the collector output and return it for further use.

Energy storage may be in the form of sensible heat of a liquid or solid medium, as heat of fusion in chemical systems, or as chemical energy of products in a reversible chemical reaction. Here, we opted water as storage medium because it is ideal material in which to store useable heat and also it constitutes major characteristics of thermal energy storage system.

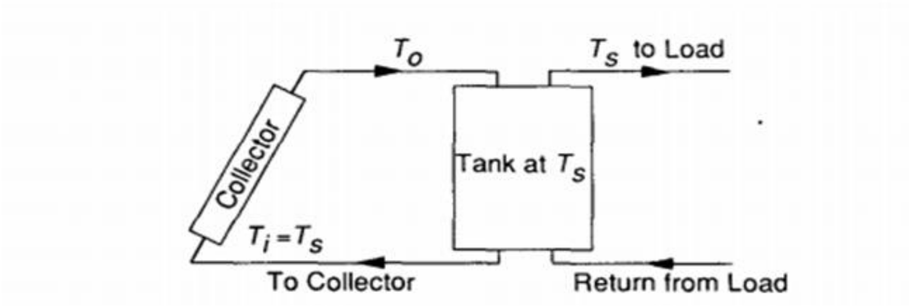



Figure 4.1 Schematic Diagram

## 4.1 Storage Tank- Energy Calculations

**T**he heat energy which is absorbed from the outlet of the heat exchanger is directly enters the storage tank and at the same time other side of the tank fluid (water) circulating between the load exchanger and tank.
temp5=0.45*1.0188*(20);

**Temp at which the fluid is entering into the stratified tank**$T_{s1} = T_{d1} - [\frac{temp5}{0.15*4.18}]$

The top layer in the storage tank has high temperature and in the bottom layers it has low temperature. This type of stratified storage tank is analysed based on the plug flow method, we can find out the energy which is delivered to the load exchanger using below formula.

$$T_D = \frac{V_C T_C + (V_L - V_C)T_1}{V_L}$$

Vc = volume of liquid coming from the collector side heat exchanger
Tc = heat exchanger outlet temperature

VL = volume of liquid coming from the load side
TL = temperature at the load side
Vc = mass of liquid / density (m3/s)
VL = mass of liquid / density (m3/s)
Tl=54
Rl=990
R2=970
R1,R2 = average densities of the water
Vl =Rl/0.45;
V1=Volume of Water Delivered to the Collector at temp Tc=x
Vc=R2/0.7
Volume of Water returned to the Tank

**Temp of the liquid leaving Stratified Tank**=Td=(Vc*(x+273)+(Vl-Vc)*(Tl+273))/(Vl)-273;

$$T_D = \frac{V_C(x + 273) + (V_L - V_C)(T_1 + 273)}{(V_L)} - 273$$

**The amount of Energy is delivered to the Load Heat exchanger**

$$l_s = 0.45 * 4180 * (T_{f0} - T_{s1})$$

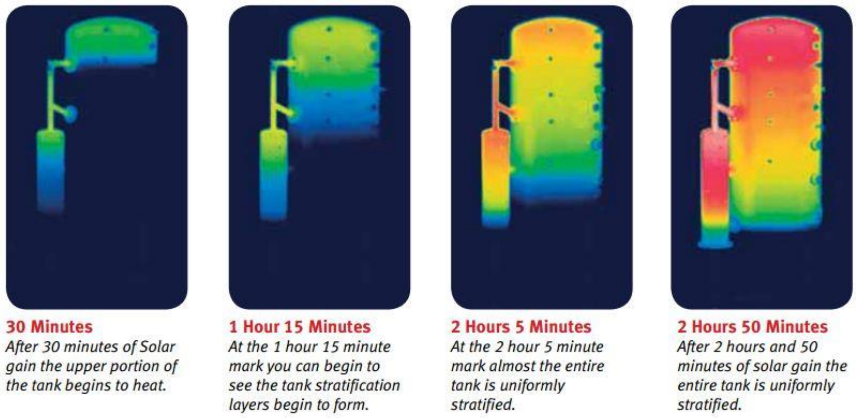



Figure 5.2 Stratification scenario

***Solar Water Heater v. Standard Water Heater***

| SOLAR WATER HEATER: FREE energy from the Sun | STANDARD WATER HEATER: COSTLY gas or electric |
|---|---|
| Annual operating cost: | Annual operating cost: |
| Storage Capacity: | Storage Capacity: |
| Life expectancy: 15-30 years | Life expectancy: 8-12 years |
| Lifetime operating cost: $1,000 | Lifetime operating cost: $10,000 |
| Does NOT pollute environment | Depletes fossil fuels |
| Increases equity in your home | No added value to your home |
| 25% return on your investment | No return on utility payments |
| Protection from future increases | At mercy of utilities/government |
| Hot water during blackouts! | No hot water during blackouts |

Table 3. Comparision with sources

## Program for the calculation:

```
#include<stdio.h>
#include<string.h>
#include<math.h>

void analyze(int,float,float,float,float,float,float,float,float);
float f,Ut,W2,f1,Tf0,x,logmeantemp,area3,Td,ts1,ls,H1;

int main()
{
        int n[ ]={1,2,3};
        float ep[ ]={0.6,0.7,0.8};
        float eg[ ]={0.5,0.6,0.7};
        float Ta[ ]={27,30,35};
        float Tpm[ ]={90,100};
        float beta[ ]={45,55,65};
        float W[ ]={100,150,200};
        float D[ ]={20,25,30};
        float tf1[ ]={27,30,35};

        int ni=0, epi=0, egi=0, Tai=0, Tpmi=0, betai=0, Wi=0, Di=0, tf1i=0;
        int count=0;

        FILE *fp= fopen ( "OUTPUT.HTML", "w" ) ;
                if ( fp == NULL )
                {
                puts ( "Cannot open file" ) ;
                return;
                }

fputs("<html><body><table border=1>",fp);
fputs("<tr><th>No.of Glass Covers</th><th>Emittance of Glass          Covers1</th><th>Emittance of
Glass Cover2</th><th>ambient      Temp(deg C)</th><th>Mean Plate Temp(deg C)</th><th>Angle of
        Tilt(deg)</th><th>Tubes Spacing(mm)</th><th>Diameter of the
        Tube(mm)</th><th>collctor Side Inlet Fluid Temp(deg C)</th>",fp);
fputs("<th>F value</th><th>heat transfer Co-efficient</th><th>Tubes            spacing(in
m)</th><th>Collector Efficiency Factor (F')</th><th>Temp     of Collector Side Fluid(deg C)</th><th>Heat
Exhanger outlet   Temp(deg C)</th><th>Heat absorbed in collector(KJ)</th><th>Total   Surface
Area(m^2)</th><th>Temp of the liquid leaving Stratified       Tank(deg C)</th><th>fluid entering into the
startified tank(deg           C)</th><th>The amount  of Energy is delivered to     Load(J)</th></tr>",fp);

fputs("\n",fp);
        for(ni=0;ni<2;ni++)
        {
                for(epi=0;epi<3;epi++)
        {
                for(egi=0;egi<3;egi++)
        {
                for(Tai=0;Tai<3;Tai++)
        {
                for(Tpmi=0;Tpmi<2;Tpmi++)
        {
                for(betai=0;betai<3;betai++)
        {
                for(Wi=0;Wi<3;Wi++)
        {
        for(Di=0;Di<3;Di++)
        {
```

```
                    for(tf1i=0;tf1i<3;tf1i++)
            {

                    //printf("%d %.1f %.1f %0.1f %.1f %.1f %.1f %.1f
%.1f\n",n[ni],ep[epi],eg[egi],Ta[Tai],Tpm[Tpmi],beta[betai],W[Wi],D[Di],  tf1[tf1i]);
++count;

char *input;

sprintf(input,"%d",n[ni]);
            fputs("<tr><td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);
sprintf(input,"%.1f ",ep[epi]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs(7"</td>",fp);

sprintf(input,"%.1f ",eg[egi]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);

sprintf(input,"%.1f ",Ta[Tai]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.1f ",Tpm[Tpmi]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.1f ",beta[betai]);
            fputs(     "<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.1f ",W[Wi]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.1f ",D[Di]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.1f ",tf1[tf1i]);
            fputs("<td style='color:blue'>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);
```

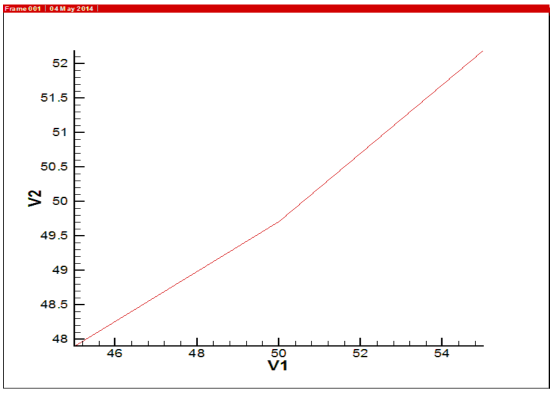
```
analyze(n[ni],ep[epi],eg[egi],Ta[Tai],Tpm[Tpmi],beta[betai],W[Wi],D[Di],tf1[tf1i]);

sprintf(input,"%f ",f);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.5f ",Ut);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.2f ",W2);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.4f ",f1);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.3f ",Tf0);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);




sprintf(input,"%.3f ",x);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.3f ",H1);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);


sprintf(input,"%.3f ",area3);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);

sprintf(input,"%.3f ",Td);
        fputs("<td>",fp);
        fputs ( input, fp ) ;
        fputs("</td>",fp);
```

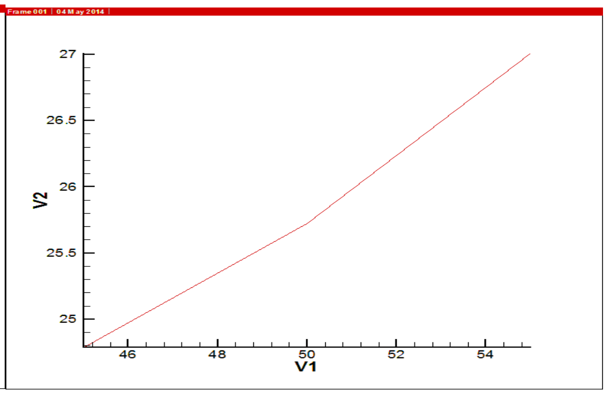
```
sprintf(input,"%.3f ",ts1);
            fputs("<td>",fp);
            fputs ( input, fp ) ;
            fputs("</td>",fp);


sprintf(input,"%.3fJ ",ls);
            fputs("<td>",fp);
            fputs ( input, fp ) ;
            fputs("</td></tr>",fp);

fputs ( "\n", fp ) ;


}}}}}}}
                                                        }

fputs("</table></body></html>",fp);
            fclose ( fp ) ;
            printf("Total Inputs:%d\n",count);
            getch();
}

void analyze(int N,float ep,float eg,float Ta,float Tpm,float beta,float W,float D,float tf1)

{
                                                            // printf("\t\t\t Industrial Air Heater Calculations\n\n\n\n");
            float Hw=9.5,e1,temp;
            float c;
            float sigma;
                                          // printf("Enter No.of Glass Covers value:\n");
            scanf("%f",&N);
            printf("Enter Emittance of plate (ep) value:(Enter value btw 0 to 1)\n");
            scanf("%f",&ep);
            printf("Enter Emittance of glass (eg) value :(Enter value btw 0 to1)\n");
            scanf("%f",&eg);
            printf("Enter ambient Temp value:\n");
            scanf("%f",&Ta);
            printf("Enter Mean Plate Temp value:\n");
            scanf("%f",&Tpm);
            printf("Enter Angle of Tiltvalue:(Enter angle btw 0 and 70degrees)\n");
            scanf("%f",&beta);*/
            c=520*(1-0.00005*beta*beta);
            f=(1+0.089*Hw-0.1166*Hw*ep)*(1+0.07866*N);
                                   //printf("F value: %f\n",f);
            e1=0.430*(1-100/Tpm);
sigma=5.67*0.00000001;
                                   //printf(" e1 value %f \n sigma %.10f\n",e1,sigma);
            temp=(N/((c/Tpm)*(pow(((Tpm-Ta)/(N+f)),e1))))+1/Hw;
            Ut=(1/temp)+((sigma*(Tpm+Ta)*(pow(Tpm,2)+pow(Ta,2)))
/((1/(ep+0.0    0591*N*Hw))+((2*N+f-1+0.133*ep)/eg)));
                        //printf("Overall heat transfer Co-efficient is: %.5f \n",Ut);
                        //printf("\t\t To caliculate Collector Efficiency Factor F' \n\n\n");
            float Hfi=330.0,f2,par1,temp2,S2,m,K=0;
```

```
                //printf("Enter Tubes Spacing:(W in mm) \n");
        scanf("%f",&W);
        //
        W=W/1000;
        W2=W;
                        //printf("Tubes spacing value in  %fm\n",W);
                        //printf("Hfi- Heat transfer Co-efficient Btw The Fluid and
The  TubeWall: 300\n\n\n");

                //printf("Enter Diameter of the Tube:\n");
        scanf("%f",&D);

        D=D/1000;
                        //printf("Collector side tube diameter value in  %f m\n",D);
        S2=0.5/1000;     //Thickness of Sheet

K=385.0;        //Therma Conductivity of Tube material
        m=sqrt(Ut/(K*S2));
        par1=m*((W-D)/2);
        temp2=tanh(par1);
        f2=temp2/par1;
        f1=((1/Ut)/(W*((1/(Ut*(D+(W-D)*f2))+1/(3.14*D*Hfi))));
        f1=f1/10;
        float Tf1,S3,Cp,temp3;

Cp=4.18; //Specific Heat Constant of Water
        //printf("\n\nCollector EfficiencyFactor (F')Value is %0.4f\n\n",f1);
        //printf("\t\tTo get Outlet Temp of Collector Side Fluid  \n\n",f1);
        //printf("Enter collctor Area:\n");
        //scanf("%f",&area);
 /*

printf("Enter collctor Side Inlet Fluid Temp:\n");
        scanf("%f",&Tf1);
        */
        S3=1370;    //Solar Heat Constant Value
        temp3=(Ut*f1)/(0.018*Cp);
        //not=(1/(pow(2.71,temp3));

Tf0=Ta+(S3/Ut)+(0.9)*(Tf1-Ta-(S3/Ut));
        //printf("Outlet Temp of Collector Side Fluid is %0.3f\n\n",Tf0);
        //printf("\t\t Collector Side Heat Exchanger Caliculations\n\n");
        float area2;

x=(2.56*(Tf0-Tf1)/4.18)+30;// Collector side Heat exchanger outlet temperature
        //printf("Heat Exhanger outlet Temp: %0.3f\n",x);
        //printf("\n\t\tArea of Heat Exchanger:\n\n\n");
        float m2=0.45,Cp2=2560,Rl,R2;
         area2=m2*Cp2*(Tf0-Tf1);
        logmeantemp=((Tf0-x)-(Tf1-30))/log((Tf0-x)/(Tf1-30));

                //printf("Logarithmic Mean Temp:%0.3f\n",logmeantemp);
        area3=area2/(logmeantemp*0.45*4180);
        H1=(Tf0-Tf1)*0.45*1.15;
        printf("Heat Exhanger Total Surface Area in :%0.3f m^2\n",area3);
                //printf("\nAccording to Plug Model: The avrg Temp of the Fluid
      Delivered to the load \n\n\n");
```

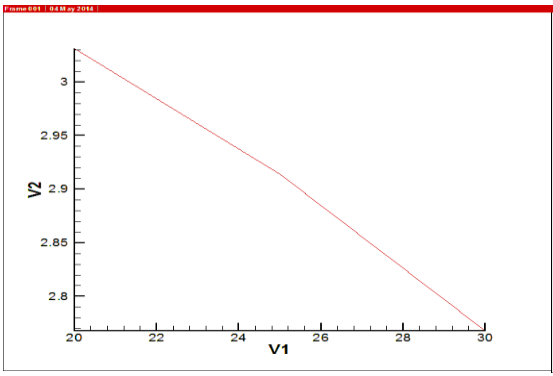
```
            float Tl=54;Rl=990,R2=970;   // R1,R2 are average densities of the water
            float Vl,Vc;
            Vl=Rl/0.45;                            //Volume of Water Delivered to
the Collector at temp Tc  Tc=x
            Vc=R2/0.7;                                   //Volume of Water returned to the Tank
            Td=(Vc*(x+273)+(Vl-Vc)*(Tl+273))/(Vl)-273;

        //printf("Temp of the liquid leaving Stratified Tank:%0.3f\n\n\n",Td);
            //printf("To know the temp at which the fluid entering into
the stratified tank:\n\n\n");
            float temp5;
            temp5=0.45*1.0188*(20);
        ts1=Td-(temp5/(0.15*4.18));

        //printf("Temp at which the fluid is entering into the startified tank:
        %0.3f\n\n\n",ts1);
            ls=0.45*4180*(Tf0-ts1);


            //printf("The amount  of Energy is delivered to the Load Heat
        exchanger: %0.3f J\n\n\n ", ls);
       //printf(" | %f %.5f %fm %0.4f %0.3f %0.3f %0.3f %0.3fm^2 %.3f
       %.3f %.3fJ\n",f,Ut,W,f1,Tf0,x,logmeantemp,area3,Td,ts1,ls);
}
```

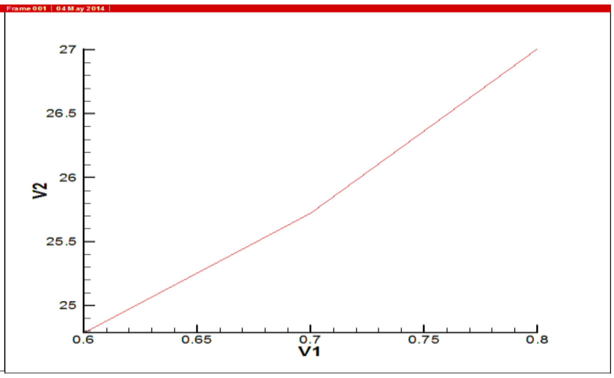
## 5. Graphical Analogy



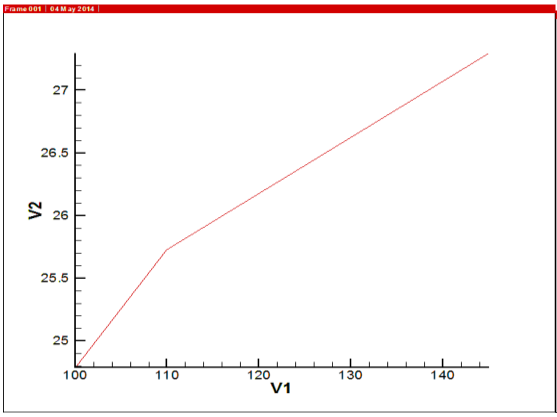



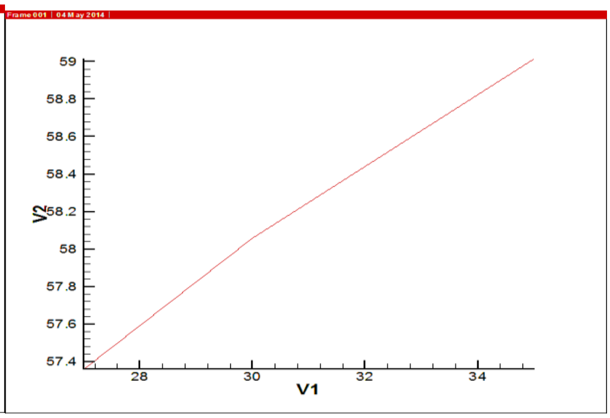

**Angle of tilt vs Temperature of collector side fluidAngle of tilt vs Heat absorbed in collector**



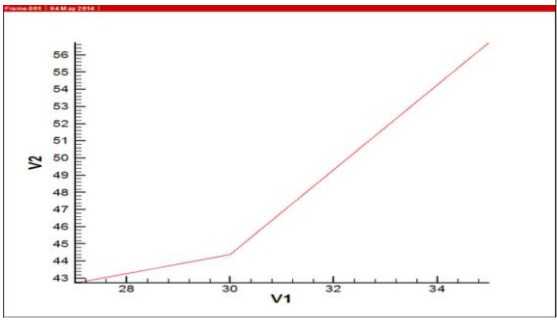



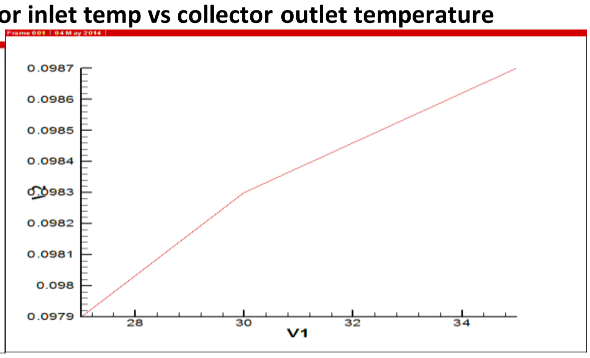

**Diameter of tubes vs Heat transfer coefficientEmmitence value to the Heat transfer absorbed in collector**




**Area vs the Energy absorbed in collector Collector inlet temp vs collector outlet temperature**




**Collector inlet temp to tank outlet temperatureCollector inlet temp to the collector efficiency factor**

## Conclusions

Inorder to sweepover all the difficulties standup with Elecrical Energy system,Mechanical Enegy, Chemical energy systems ; we espouse to SOLAR ENERGY HEATING SYSTEM , as it shows advantages.

By the use of the computer program MS Excel and developed mathematical expressions it is possible rather simply with small labor and time consumption to simulate the necessary working regime of the collector and to calculate the corresponding technical parameters of the collector.

The selective and tracking the sun solar collector in the middle of summer can produce 1.5 times more heat energy as the stationary placed selectivesolar collector of the same working surface.

Angle of tilt & Usage cover material will cause the effect on Collector

The performance of the Storage tank depends on the kind of fluid being selected.The thermodynamical properties become the reason for effectiveness of the Storage tank .

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