Experimental Measurement of Effectiveness for desert air cooler and comparing with comfort Condition for people

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1. Abstract

This study is to calculate the actual effectiveness of evaporative cooler and then calculate the supply air temperature from the cooler and comparing with comfort condition for space users . The experemental effectivness of desert air cooler is equal to (76 %)

*This paper is studying variation of temperature for 24 hours from each month in summer season and apply this reading for all month day (i.e 24 *30*5 =3600 hours) where selecting design day from each month.*

The experimental measurement proofed that is less than the comfort condition requirement about (38) % from summer season which is leading to thinking by a replacement although the cheap and poor of power consumption by the desert air cooler comparing with air conditioner working by refrigerant.

القياسات العملية لكفاءة المبردة الصحراوية و مقارنتها مع ظروف الراحة لشاغلي الحيز

الخلاصة

تعنى هذه الدراسة بحساب كفاءة المبردة التبخيرية عمليا و كذلك حساب درجة حرارة الهواء المجهز من خلال هذه المبردة و مقارنتها بضروف الراحة لشاغلي الحيز. ان كفاءة المبردة التبخيرية العملية هي (٧٦ %)

ان القياسات العملية اخذت لمدة ٢٤ ساعة من كل شهر في فصل الصيف و من ثم تعميم القراءات على طول الشهر (يعني ٢٤*٣٠*٥ = ٣٦٠٠ ساعة) بحيث تم اختيار يوم تصميمي خلال كل شهر

تبين من خلال القياسات العملية التي اجريت بان المبردة الصحراوية لا توافي متطلبات الراحة لشاغلي الحيز حوالي (٣٨ %) من موسم الصيف مما يدعونا للتفكير بالبدائل على الرغم من رخص و قلة استهلاك الطاقة من قبل المبردة الصحراوية مقارنة باجهزة التكييف التي تعمل بمائع التثليج.

***Key words**: evaporative air cooler , desert air cooler, air cooler, air washer*

2. Introduction

Air conditioning is the treatment of air and conroll of temperature , humidity , purity and the diffusion and this to consist of comfort condition for users of space fig. (1) . The adiabatic sturation is the scientific name of desert air cooler which is processing in costant wet bulb temperature and air supply from evaporative cooler is decrease to wet bulb temperature if the supply air is saturation completely fig.(2). The dry bulb temperature will decrease because the sensible heat will gone to evaporate the water which make the air is saturation, thats mean the sensible heat is conversion to latent heat and the enthalpy remain constant approximatly [1].

indirect evaporative cooling stage is less than the energy saved from reducing the load on the refrigeration apparatus. As a result, for existing refrigeration and air conditioning, the overall efficiency may increase because the energy cost and demand are reduced. For new installations the refrigeration unit may be downsized resulting in (1) reducing overall cost for the project, and (2) as well as reducing operational cost and peak demand. Indirect evaporative cooling may also reduce the total time the refrigeration equipment must be operated during a year, which reduces wear and tear on the refrigeration equipment. Evaporative cooled air can be discharged across air-cooled refrigeration condenser coils to improve the efficiency of the condenser. Chapter 50 of the 1999 ASHRAE Handbook—Applications includes sample evaporative cooling calculations. Manufacturers' data should be followed to select equipment for cooling performance, pressure drop, and space requirements[2].

B.H Jennings , find out that the effective of evaporative air cooler or desert air cooler is about 70% and increase to 90% for air washer [3].

McGraw-Hill found out that the effective of desert air cooler is about 80% and is about 65-70% for evaporative air cooler manufactures manually [4].

3.Experemntal procedure

During summer season we start to measure the wet bulb and dry bulb temperature for outdoor condition and this measurement repeat for 24 hours in day and for 1 times per month for 5 months . we taking three days from each month in summer season. And then we choose one measurement for one day every month in summer season. The dry and wet bulb temperature is taken in ***Baqubah city of Iraq country*** *in 32^o longitudinal .*

After that we measure the air temperature supply from evaporative cooler and that is to calculate the experemental effectivness of air cooler. ***Table .1*** *represent sample of the measurements and the results of supply air temperature.*

Instruments of experiments are the evaporative air cooler , dry bulb thermometer & wet bulb thermometer. The evaporative air cooler for test have the following specifications .

Instrument name	*Capacity (ft^3/min)*	*Water capacity M^3*	*Made in*
Direct evaporative cooler	*4500*	*0.08*	*Iraq*

4. Theoratical Treatment of the Data and Results

The data obtained by measurements are used to calculation supply air from desert evaporative cooler. To calculate the supply air temperature we fallowing these steps and will expand this calculation for 24 hours per day for summer season months and that's by applying a program in C++ language to represent that's results.

- The equation to calculate the effectiveness of evaporative air cooler as following [1]

$$E = \frac{t_1 - t_2}{t_1 - t_w} \ldots\ldots\ldots\ldots\ldots\ldots.(1a)$$

where

E = effective of evaporative air cooler

t_1 = dry bulb temperature input to air cooler

t_2 = dry bulb temperature output to air cooler

t_w = wet bulb temperature and its of course is constant during this process.

The maximum decrease possible for dry bulb temperature is represent (t_1 – t_w) when the supply air from evaporative cooler is saturated which is called wet bulb depression.

- Now by substitution the value of t_1, t_2 & t_w for an hour from a day we get the effective

$$E = \frac{44-31}{44-27} * 100 = 76.74\%$$

- to calculate the temperature supply of evaporative air cooler we applying this equation by substitution in equation (1)

$$t_2 = t_1 - (t_1 - t_w) * E \quad ....(1b)$$

Then we get the temperature of air supply from evaporative aircooler

Now we will compare the air temperature supply from evaporative cooler with comfort zone as shown in figures (3, 4, 5, 6 , 7 & 8)

*- This calculation procedure will repeat for 120 times by applying a program and extended for all summer season (24 *30*5 = 3600 hours) .*

- To calculate the ratio of the temperature out of the comfort range

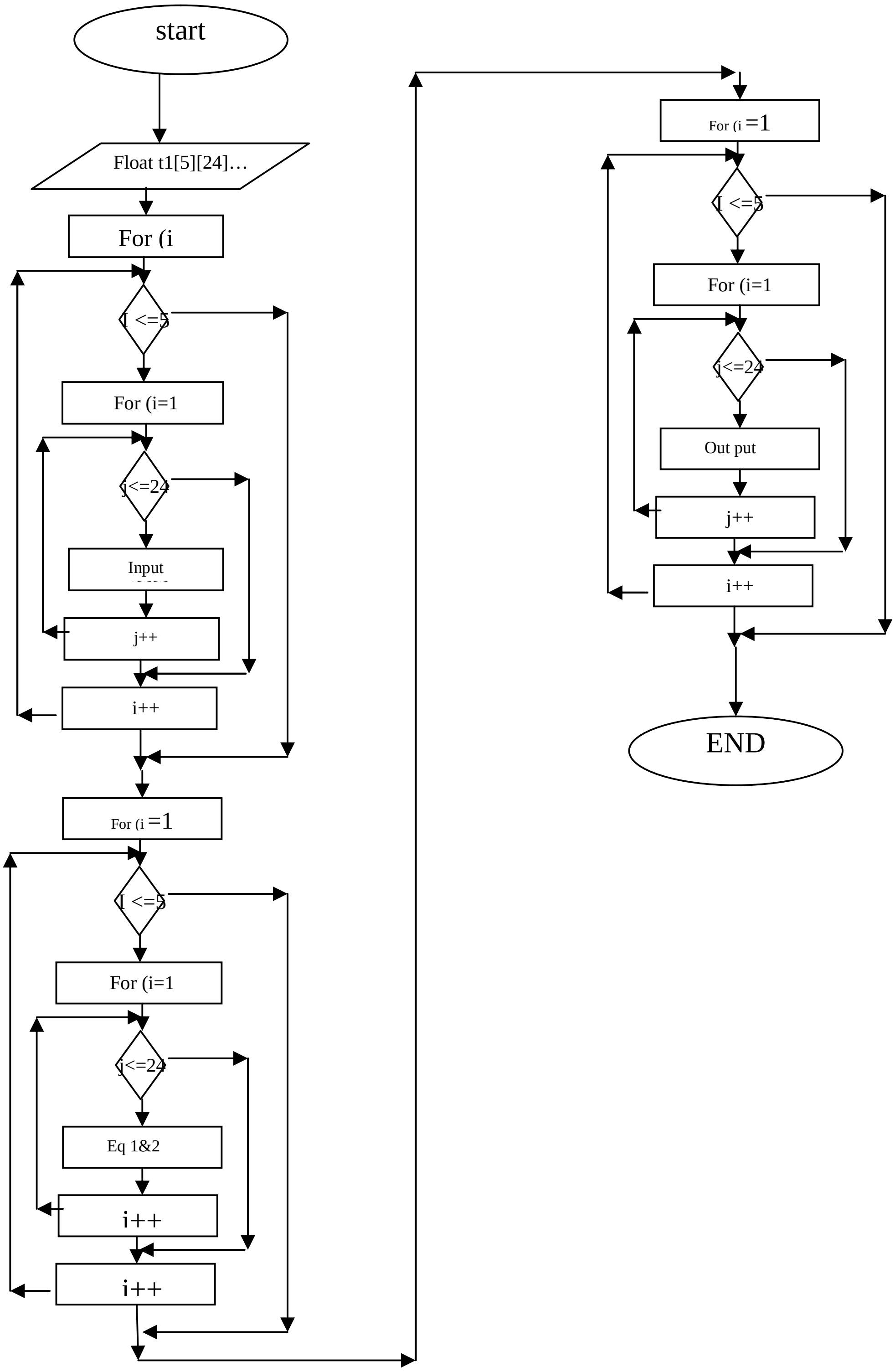
$$percentage\ of\ out\ comfort\ zone\ range = \frac{part}{total} * 100 = \frac{No.of\ hour\ out\ of\ range\ for\ test\ days(fig(3-7)}{No.of\ hour\ for\ test\ days(5\ days * 24\ hours)}$$

$$percentage\ of\ out\ comfort\ zone\ range = \frac{46}{120} * 100 = 38\%$$

- calculation technique :

To calculate the effectiveness and supply air temperature for 120 times and extend to 3600 hours we using the following flow chart and program in C++ language.

- flow chart


start
Float t1[5][24]…
For (i
I <=5
For (i=1
j<=24
Input
j++
i++
For (i =1
I <=5
For (i=1
j<=24
Eq 1&2
i++
i++
For (i =1
I <=5
For (i=1
j<=24
Out put
j++
i++
END

Program of calculation for supply air temperature in C++

```
# include <iostream.h>
main ( )
{
float t1[5][24] , tw[5][24], E, t2[5][24];
// This program is to calculate supply air temperature in degree from direct evaporative air cooler;
cout<<"please input the effectivity of the air cooler"<<endl;
cin>>E;
for (int i = 1; i <= 5;i++)
{
cout<<" please input measurement for dry &wet bulb temperature ( t1 & tw) for  month number "<<i<<endl;
for (int j=1; j <= 24 ; j++)
{
cin>> t1[5][24];
cin>>tw[5][24];
}}
for (int i = 1; i <= 5;i++)
{
for (int j=1; j <= 24 ; j++)
t2[i][j] = t1[i][j] – (t1[i][j] –tw[i][j])*E;
}
for (int i = 1; i <= 5;i++)
{
for (int j=1; j <= 24 ; j++)
cout<<t2[i][j];
}}
```

5. Results & Discussion

The results obtained in this study which are given in figures shows clearly the variation of supply temperature during summer season and the flactuating during the day

- Evaporative air cooler effective

from the measurement of dry and wet bulb temperature and then applying the equation no.1 for several times we find that the affectivity of evaporative air cooler test is 73% to 80% in range during the *summer season months and we take an average of these values as 76% and applying this value of effectiveness.*

- Comfort zone for supply air temperature

In the principle of evaporative air cooler operation is that , the process during adiabatic saturation for dry air and decrease it's temperature to wet bulb temperature and as the definition of air conditioning we must control the temperature , humidity & diffusion fig(2), but in this way air cooling we can not control by humidity because the principle is depend on adiabatic saturation for air(i.e humidity is 90%-100% for supply air) so and from fig (1) we choose the 25.5 C^o as reference for comfort air temperature [2].

- Variation of supply air temperature per hour in summer season .

fig (3) shows the variation of supply air temperature during day 21 in may month (i.e in fig temperature (C^o) Vs Time (hour)) and from result we can note that the temperature of supply air is 20 C^o at 1:00 am which is mean the weather inside room is cool and starting to increase slowly to 21 C^o at 7:00 am and then continous to increase 25 C^o at 11:00 am which is approximately equal the comfort temperature. But at 12:00 am the supply air temperature is become out of comfort range (i. e equal 27 C^o) then continue to increase in supply air temperature till 2:00 pm with 28.5 C^o and the start to decrease to 27 C^o at 4:00 pm after that inter the comfort range again at 6:00 pm and continue in decrease till 21 C^o at 12:00pm and then repeated the same loop for second day and other days of may month. The behavior of supply air temperature and variation is approximately the same in June , July & September (i.e fig (4, 5 & 7).

Fig (6) shows the variation of supply air temperature during day 21 in Aughest month and is clearly that the supply air temperature is out of comfort range almost of day (i.e from 10:am till 12:00 pm) which that mean is not suitable for using exactly in this month.

6. Conclusions

This study is proof that the desert air cooler is not active for all time in summer season and the temperature of supply from *evaporative air cooler is out of comfort zone range about (46) hours which represent (38 %) of summer season. We must look for the replacement the evaporative air cooler by air conditioner but there is several limits to replace it like power consumbed and expensivity of device which is difficult for a many of people.*

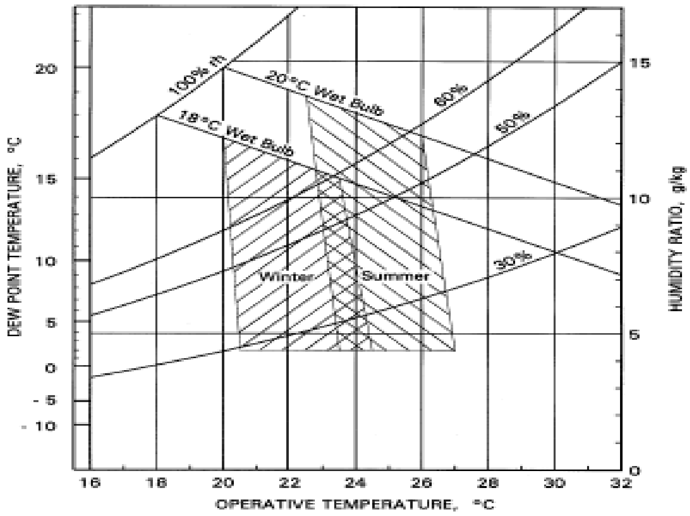


Fig (1) ASHRAE Summer and Winter Comfort Zones(Acceptable ranges of operative temperature and humidity for people in typical summer and winter clothing during primarily sedentary activity)

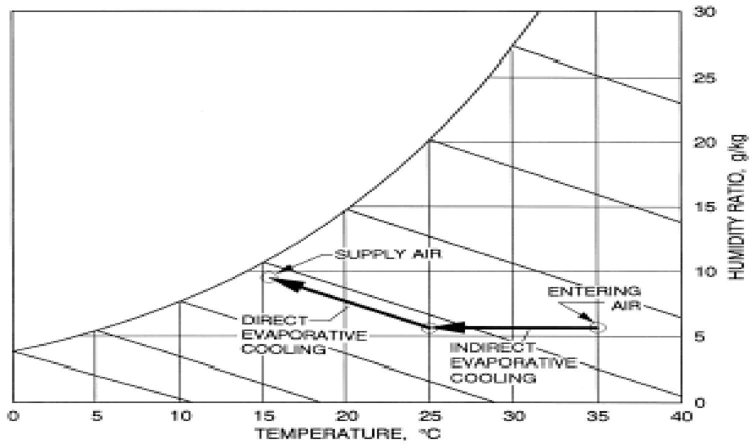


fig (2) Combination Indirect/Direct Evaporative Cooling Process

time	dry	wet	supply temp
1	27	18	20.25
2	26	18	20
3	25	17.5	19.375
4	24	18.5	19.875
5	23	19	20
6	23	19.5	20.375
7	24	20	21
8	27.5	20	21.875
9	29.5	21	23.125
10	32	21.5	24.125
11	34	22	25
12	35.5	23.5	26.5
13	37.5	24.5	27.75
14	37	25	28
15	36	25	27.75
16	36.5	23.5	26.75
17	35	23.5	26.375
18	34.5	20.5	24
19	32	20	23
20	30	20.5	22.875
21	29	20	22.25
22	27.5	19.5	21.5
23	27	19	21
24	27	19	21

Table (1) dry , wet & supply air temperature in day 21 of may month

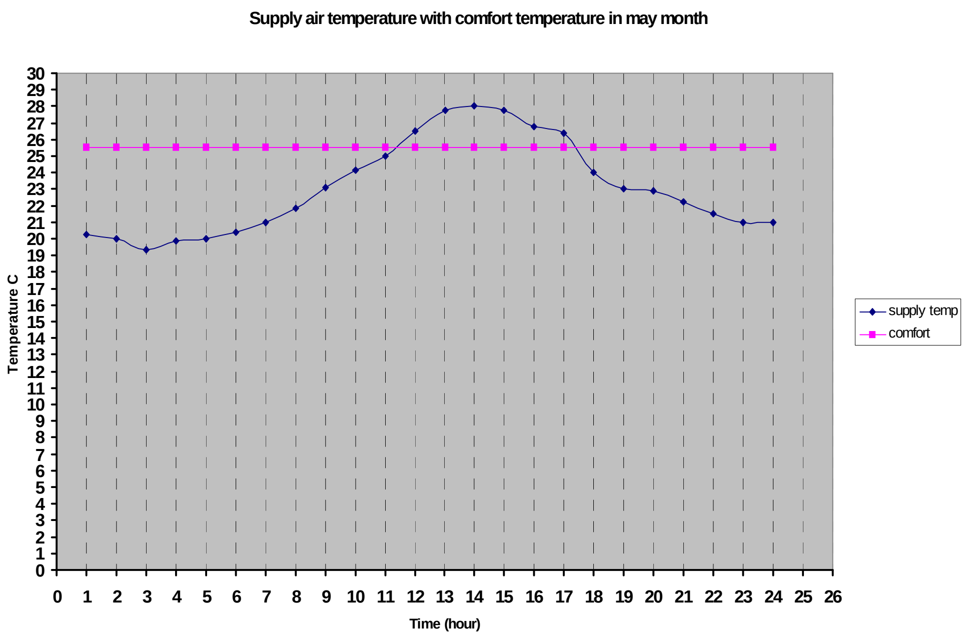


Fig (3) the supply air temperature comparing with comfort air temperature in may month

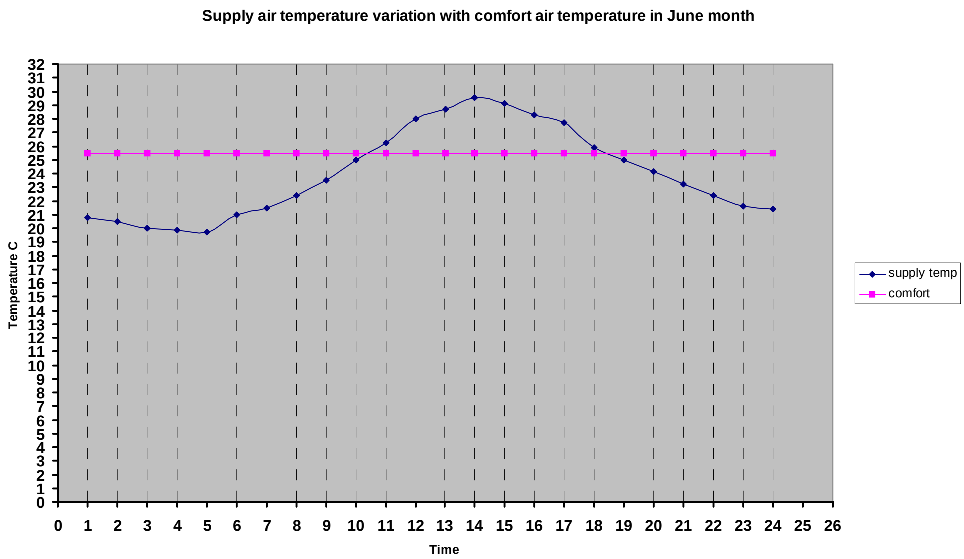


Fig (4) the supply air temperature comparing with comfort air temperature in June month

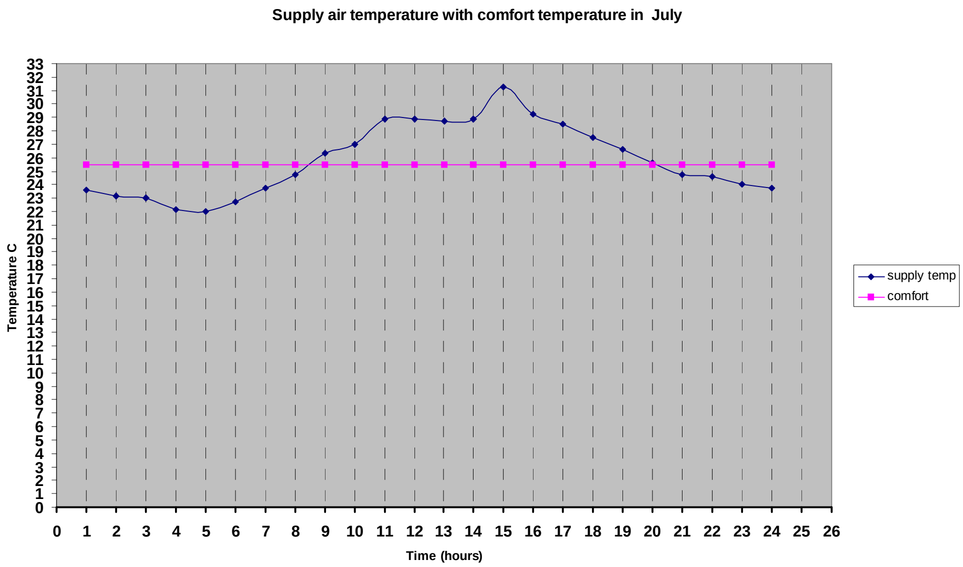


Fig (5) the supply air temperature comparing with comfort air temperature in July month

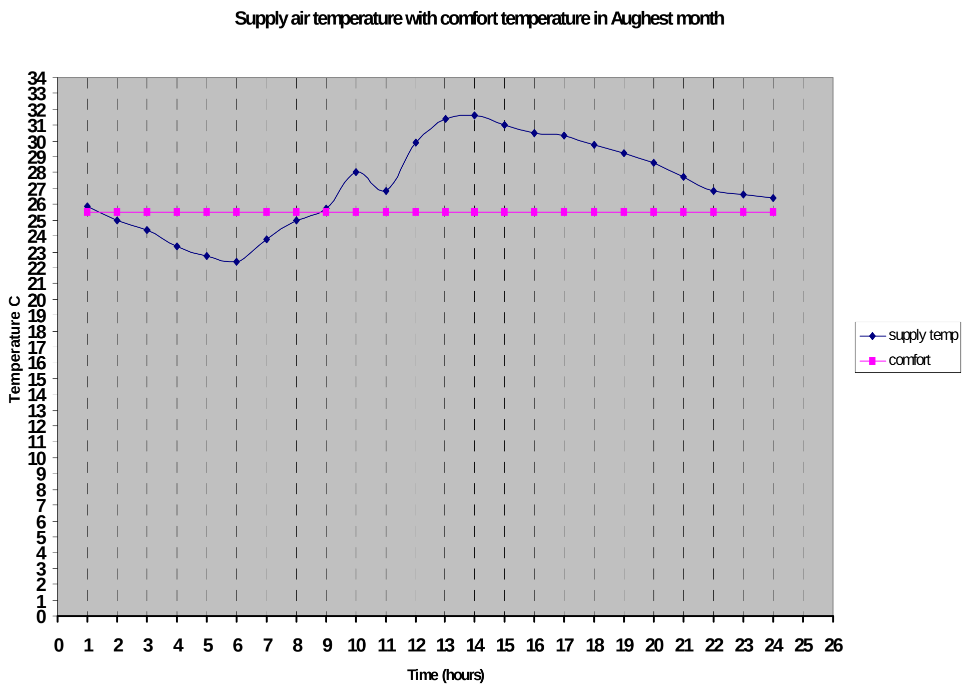


Fig (6) the supply air temperature comparing with comfort air temperature in Aughest month

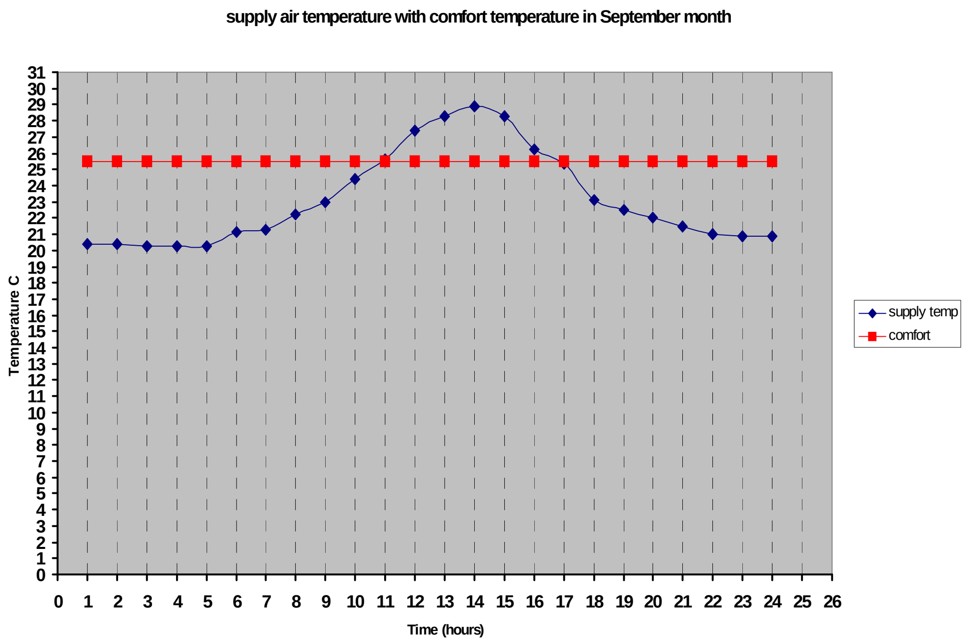


Fig (7) the supply air temperature comparing with comfort air temperature in September month

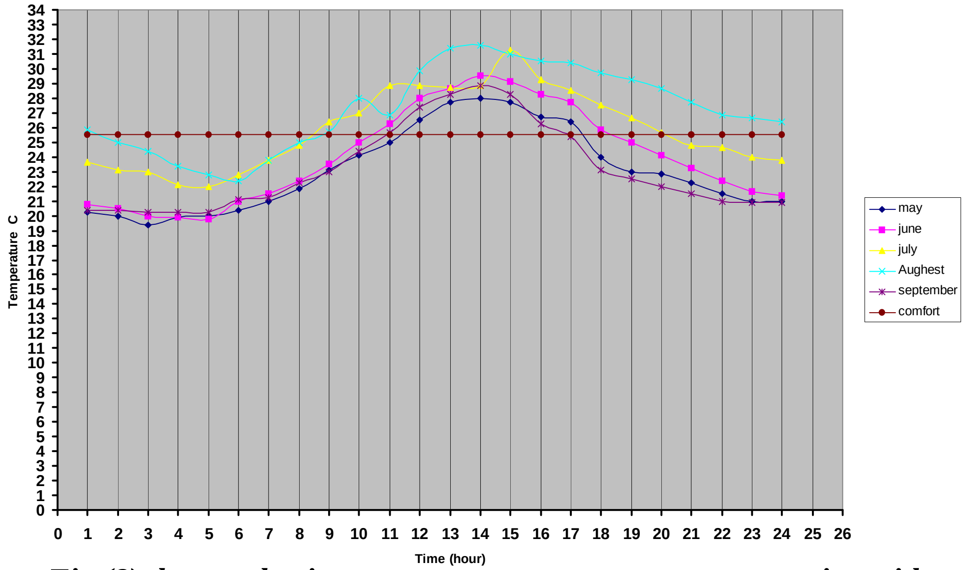


Fig (8) the supply air temperature comparing with comfort air temperature in summer season

7. References

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