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Improved Night Cooling System for Home

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***Abstract*: This paper proposes a new approach of cooling system for home. The main advantages of this cooling system are it consumes very low power, no emission of harmful gas and support for health. The basic principle of the system is free cooling is taking place when the external ambient air entropy is less than the indoor air enthalpy and the cool external air is transferred to the building room directly. The efficiency of the external cool air system in the past years is very low due to external air velocity .Due to this drawback this system is not popular. But this paper a new model is proposed to increase the efficiency of cooling. In this paper free cooling is achieved by in conjunction with air collector systems and rotary fan systems. The proposed Air conditioning systems either provide supply 100%fresh air using outside air. So this can be use in the cases of hospitals, densely occupied areas such as theatres etc. This system is only effective when the outer temperature is less than inside temperature.**

I.INTRODUCTION

Cooling methodology is classified into four methods [1]. Passive cooling, passive and natural cooling (night cooling), mixed mode cooling, mechanical cooling. Passive design minimizes unwanted heat gain by the way of building shape, shading, well insulated and air tight envelope. Passive/natural cooling methodology outside air is ventilate and cool the building without power system. The next method is mixed mode system. This system a small power motor is used to provide the cooling. Full mechanical air cooling is a compressor based air cooling system shown in figure1.

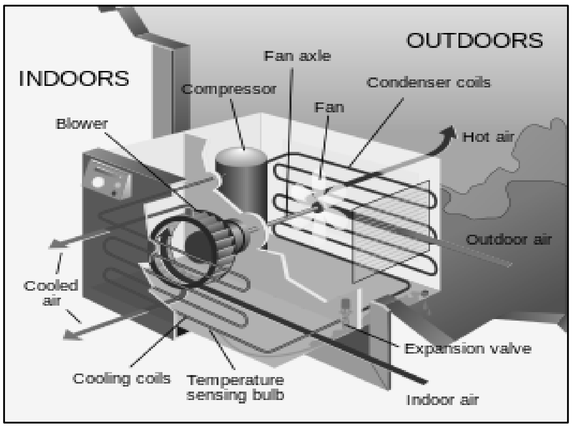

Figure 1.general mechanical cooling system for home

Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions [2]. An air conditioner is a home appliance, system, or mechanism designed to change the air temperature and humidity within an area. The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used[3], commonly for comfort cooling in buildings and motor vehicles mechanical cooling system are used.Advantage of compressed air cooling technology is the efficiency is very high. It can be used anywhere, easy installable.

Drawback of the mechanical compressed air cooling technology is very high power consumption Due to the presence of electrical reciprocating air compressor, the motor consumes lot of power. The second problem is the moisture content is (humidity) removed from the inside air when the cooling is more . Due to this people affects the skin dryness, de hydrations and skin problems. Major problem with this type of cooling system proper heat isolation is needed in the inside room ,to maintain the cool. Hence the external air is not allowed inside the room. So the oxygen level is decreed considerable amount and the people is affected by the headaches. More over Many fire accidents, gas leakage accident is reported in past years and several people are killed during the night times.Ceiling fans and table fans are very effective in calculating the air in the room. Paradoxically because if heat rises, ceiling fans may be used to keep a room warmer

Free cooling is an alternate idea to overcome the drawback present in the compressed air cooling technology [4]. Conventional free cooling may be used with mixed outside air and recirculation systems by the use of modulating dampers or pipes[5]. Dampers are provided on the outside air intake ductwork, exhaust air ductwork and the recirculation ductwork [6]. In the event of cool outside air the quantity of outside air is increased and the quantity of re-circulated air is reduced to provide the required supply air temperature. In this way cooling by means of refrigeration equipment is avoided altogether at certain times of the year and often at night times. This system of free cooling is popular and use thermostats or sensors to determine when the outside air is cool and the proportion the outside air damper should be opened.

More accurately the proportion of outside air should be increased when the outside air enthalpy is lower than the room enthalpy[7]. In reality, temperature sensing is more popular because thermostats are less costly and are less likely to drift out of calibration. When the outside air temperature (alternatively enthalpy) is higher than the room temperature (alternatively enthalpy) in summer the dampers will modulate to the minimum outside air position to keep the load on the refrigeration equipment to a minimum. In summer when the outdoor air enthalpy is higher than the indoor ambient enthalpy then the modulating dampers would modulate to minimum outside air and the humidifier would not be used.

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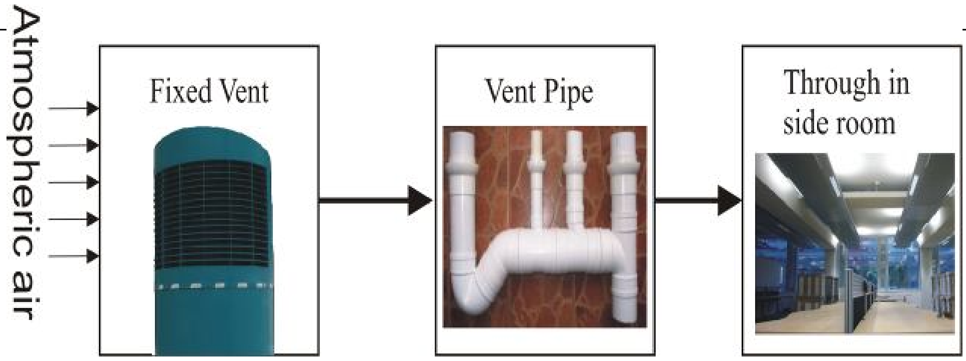

Figure 2: block diagram of General free cooling system

Drawback of conventional air cooling system is listed below. Based on figure3 the free cooling is effective when the air is passed in the opposite direction. But the wind flow direction is not same in one direction. It varies with the climate. Second drawback is wind flow is not always present. At this condition if the temperature also low, conventional air cooling system is not effective. The conventional system air filters are not used. Because the filters reduced the flow of wind flow. Due to this the dust and insects are possible to enter the room.

Due to these problems the existing is not popular. But the proposed systemovercome these problems. The proposed system automatically focuses the air by using yaw system which collects the air at any direction. So if wind flow at any direction, the proposed system collects the air efficiently. Due to non availability of air flow time at very low temperature the proposed cooling system, rotary fan collect the cooled air and fed in to the room to maintain the cooling. .The proposed system used low power induction motor arrangement which consumes less power when the external air flow is high. Due to this the system consumes very less power. The main Advantage of this system is, it work in entire through the year in night times. The design of the proposed time not allows the rain water during the rainy season. The filter arrangement in the system doesn't allow the dust, mosquitoes in the room.

II. SYSTEM DESIGN OF INTEGRATED NIGHT COOLING SYSTEM

Heat is transferred to the outside room by means of Convection .Convection means a transfer of energy between an object and its environment .The heat is transferred from the gas or liquid with the highest temperature to the gas/liquid with the lower temperature. There is a difference between forced and natural/free convection. When heat is transferred from one place to another because of a pump, fan or other mechanical devices forced convection has been performed. Natural or free convection is performed when heat is transferred due to temperature differences in the fluid .The heat transfer is described by Fourier's law

$$\frac{q_x}{A} = -k\frac{dT}{dT} \qquad (1)$$

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Where q_x is the heat, A is the cross-sectional area and k is the thermal conductivity. The thermal conductivity is replaced by the convective coefficient. Heat transfer for a wall, or floor, where the area and thermal conductivity are constant is given in equation (1)

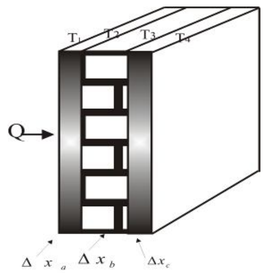

Figure 3: brick wall heat dissipation

$$q = \frac{k_a}{\Delta x_n}(T_1 - T_2) = \frac{k_b}{\Delta x_n}(T_2 - T_3) = \frac{k_c}{\Delta x_n}(T_3 - T_4) \quad (2)$$

T_1 and T_4 are the temperatures on the inside and outside layer respectively. Rearranging with respect to temperature and adding the equations for the different solids give the following expression for the heat flow through the wall.

$$q = \frac{T_1 - T_4}{(\frac{\Delta x_a}{k_a A}) + (\frac{\Delta x_b}{k_b A}) + (\frac{\Delta x_c}{k_c A})} \quad (3)$$

A hot air with temperature T_1 on the inside of the surface and a cooler air on the outside surface with temperature T_4 . The convective coefficients for the inside and outside are h_i and h_o respectively. The proposed cooling system is designed according to the following procedure:

1. Calculated Heat and Cooling Loads

Essentially the term heat load refers to the amount of heat that must be removed from any space in a given period to meet user requirements. Calculated heat and cooling loads by

- Calculating indoor heat loads
- Calculating surrounding heat loads

2. Calculated Air Shifts according the Occupants or any Processes

3. Calculated Air Supply Temperature. For cooling, where the inlets are near occupied zones , 2^o - 4^oC below room temperature may be suitable

4. Calculated Air Quantity Air Cooling

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In this system air is used for cooling, the needed air flow rate may be expressed as

$$q_c = H_c / \rho\, c_p\, (t_o - t_r) \quad (4)$$

Where ,q_c = volume of air for cooling (m^3/s),H_c =cooling load (W),t_o = outlet temperature (^oC) where $t_o = t_r$ if the air in the room is mixed.

The cool load is $H_h = 400\ W$, supply temperature $t_s = 27\ ^oC$ and the room temperature $t_r = 32\ ^oC$, the air flow rate can be calculated as:q_h = 400 (W) / 1.2 (kg/m^3) 1005 (J/kg K) (32 (^oC) - 27 (^oC)).If it is necessary to humidify the indoor air, the amount of supply air needed may be calculated as:

$$q_{mh} = Q_h / \rho\, (x_2 - x_1) \quad (5)$$

where ,q_m = volume of air for humidifying (m^3/s),Q_h = moisture to be supplied (kg/s)ρ = density of air (kg/m^3),x_2 = humidity of room air (kg/kg),x_1 = humidity of supply air (kg/kg),

5. Temperature loss in pipes

The heat loss from pipes can be expressed as:

$$H = A\, k\, ((t_1 + t_2) / 2 - t_r) \quad (6)$$

Where ,H = heat loss (W)A = area of pipe(m^2)t_1 = initial temperature in pipe(^oC)t_2 = final temperature in pipe(duct) (^oC).The heat loss in the air flow can be expressed as:

$$H = 1000\, q\, c_p\, (t_1 - t_2) \quad (7)$$

Where,q = mass of air flowing (kg/s)c_p *= specific heat capacity of air (kJ/kg K).*(6) and (7) can be combined to

$$H = A\, k\, ((t_1 + t_2) / 2 - t_r)) = 1000\, q\, c_p\, (t_1 - t_2) \quad (8)$$

For large temperature drops, logarithmic mean temperatures should be used.

6. Sizing pipes (Ducts)

Air speed in a duct can be expressed as:

$$v = Q / A \quad (9)$$

where,v = air velocity (m/s)Q = air volume (m^3/s*)A = cross section of duct (*m^2*)*

7. Overall pressure loss in ducts can be expressed as:

$$dp_t = dp_f + dp_s + dp_c \quad (10)$$

where, dp_t = total pressure loss in the system (Pa, N/m^2) dp_f = major pressure loss in ducts due to friction (Pa, N/m^2) dp_s = minor pressure loss in fittings, bends etc. (Pa, N/m^2) dp_c = minor pressure loss in components as filters, heaters etc. (Pa, N/m^2)

8. Major pressure loss in ducts due to friction can be expressed as

$$dp_f = R\, l \quad (11)$$

where,R = duct friction resistance per unit length (Pa, N/m^2 per m duct)l = length of duct (m).

III. PROPOSED SYSTEM OF INTEGRATED NIGHT COOLING SYSTEM

Figure 4 shows the block diagram of the proposed cooling system. The cooling system consists of small powered rotary air fan. Figure 4 shows the first part of the system, which is the filter arrangement. This arrangement is resist the atmospheric air pollutions contents and insists like mosquitoes. Due to this arrangement the fresh and clean air is enter the mouth of the proposed system. Then the second block is the air collector. This system is use with the two functions, it collect the atmospheric air and compress naturally. Hence the atmospheric air velocity and quantity increased naturally. This arrangement is directly fixed to the direction changer arrangement. This is the important arrangement of this system. The main air collector system is mounted on the free wheel mount. This bearing arrangement is mounted on the body of the system as shown in figure 5.

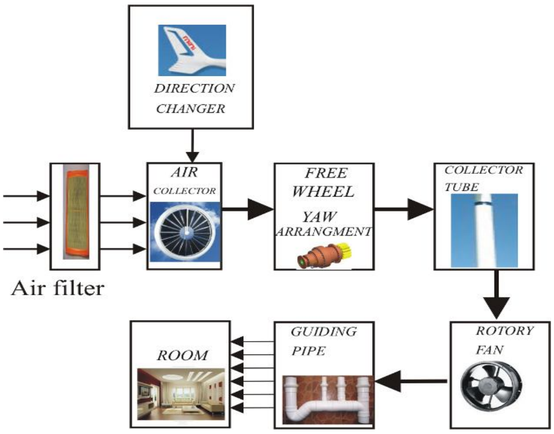

Fig 4: block diagram proposed integrated free night cooling system

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So this direction changer is in line with the flow of atmospheric air. In case the wind direction changes the air strike on the direction changer plate and move to the inline of the air flow. So the entire arrangement is faced to the air. In this way the direction of the proposed system changed and focused the opposite direction of atmospheric air. The collected cooled forced air is passed through the pipes. In the discharge end a radial fan is used to increase the speed and discharge the rate of the atmospheric air. Moreover in the non wind season the fan sucks the external air and flow through the pipe to make the room temperature is as low as possible. Figure 5 shows schematic view of the proposed integrated night cooling system.

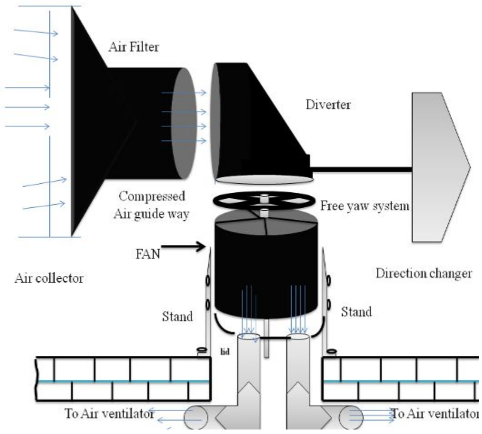

Figure5: schematic model of proposed cooling system

V. EXPERIMENTAL RESULTS

A prototype model is constructed and validated the proposed concept.

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Figure 6: Real implementation setup of proposed system

Miniature experimental setup was created, readings are taken and validated the proposed system:

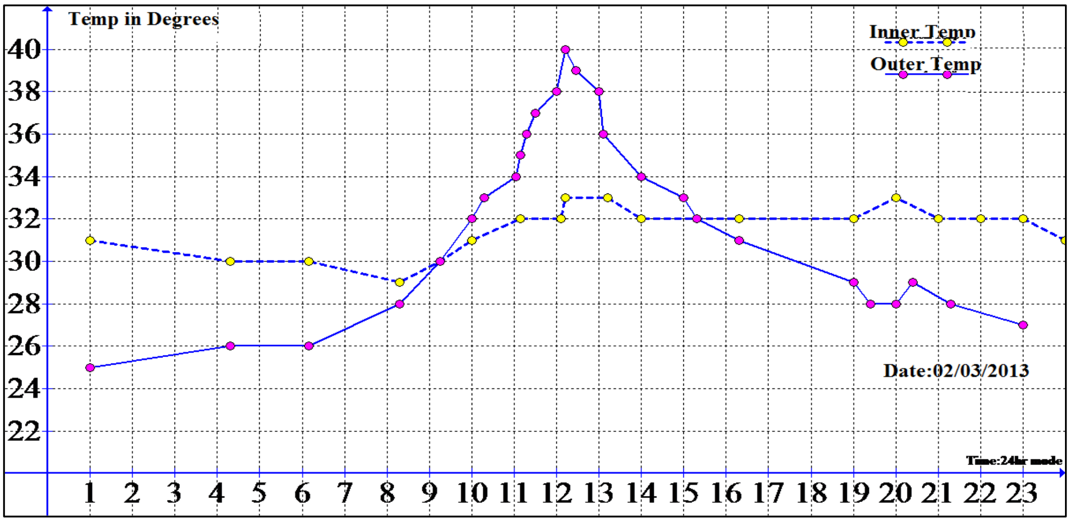

Figure 7: Temperature in inner room and outer in a concrete house without night cooling system

Fig 7 shows the graph plotted between the inner temperature and outer temperature. Red point with continuous line shows the outer temperature and yellow with a dotted line represented the inner room temperature. The figure shows the one full day temperature i.e. 24 hrs .Simultaneously taking the inner temperature also. Based on the result 12 O clock the temperature is reached at maximum temperature (40deg).

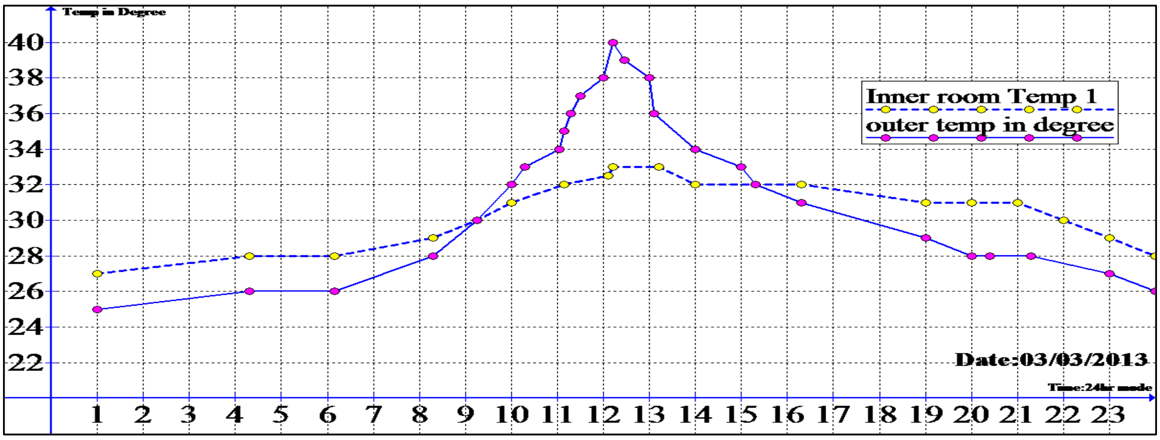

Figure 8: temperature inside and outside layer in a brick wall house- proposed integrated night cooling system

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At the same time the inner room temperature also reached at maximum temperature (33deg).But it reduced considerable amount of tem fall. But that temperature not reflected to the inner temperature due to the block body effect and not proper air circulation.

Fig 8 shows the graph plotted after the proposed system implemented. The proposed system is effectively transfer the outer temperature to the inside room. Based on the graph result this temperature is sufficient and comfort for night.

VI. Conclusion

In this paper low power integrated night cooling system was investigated. Based on the experimental result the proposed cooling system cooled a room efficiently evening to morning. The advantage of this proposed system injects the fresh air efficiently into the room. So we avoided the low oxygen problems over the exiting air conditioners. In this proposed technology the atmospheric air is directly forced and inject to the room. So the atmosphere moisture is not removed. This will help to maintain the moist of skin. The proposed system consist if the movable head that will automatically direct the wind direction. So large amount of air is forced to flow without an external power. Hence this fresh air removes odour, smoke, heat and airborne bacteria. Indoor air quality can be improved.

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