Energy Efficient Solar Regenerated Desiccant Dehumidifier

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Abstract

This paper present solar regenerated desiccant dehumidifier which is energy efficient. The main objective is to reduce the load of air conditioner in humid area and to reduce electricity bills. Desiccant is a substance that absorbs moisture. Here we are using a solar regenerated desiccant as a dehumidifier. The desiccant used here is silica gel. The air from the room is passed through the silica gel using blowers. The silica gel will adsorb the moisture from the air up to the required level. Sensors used to measure the pressure, temperature, humidity are equipped before and after the desiccant. According to the required level the moisture is absorbed. The remaining hot air is then passed through a cooler which will cool the air up to the requirements. The air is then blown in to the room. A solar air heater is used to dry the desiccant. The hot air from the heater is passed or circulate through the desiccant which will in turn dry out the desiccant. The hot air will then blowed outside the room. The main advantage of this system is that we are using solar aided dehumidifier, so apart from the capital cost all other costs are minimum. Solar is renewable energy resource.

Keyword- Adsorption, Silica Gel, Water Vapor

I. INTRODUCTION

Now a day's most of the commercial buildings including banks are spending most of the money on air conditioners. The survey conducted by IESS in 2012 showed that 30% energy consumption is by fans, air coolers and A/C. According to the survey done by World Bank consumption of HVAC is going to increase from 50% to 60% in the coming five years. Also survey conducted by various organisations, like EMC, Prayas etc. shows that, of commercial and industrial electrical energy consumption in Kerala are 50% to 60% are for air conditioners and fans.

The star ratings in appliances don't mean that they will be energy efficient or they will consume less electricity. There is no humidity control or physical dehumidifier in conventional A/Cs.

The percentage of energy consumption in domestic sector alone has increased from 10.11% during 1947 to 24.32% in 2017. The average electricity cost increased by 8% in 2000 and it is estimated that it is likely to increase by 20% by 2020. The increase in electricity charge has already started during 2017.

Thus it is not possible to always rely on electricity or say it is the most viable in considering cost factors. Energy storage is a major problem with renewable energy use and thermal energy storage is one of the method of energy storage. Proposed system comprises of a Solar Air Heater, a container filled with hygroscopic materials like silica gel, zeolite etc. and a cooler. Here the water vapor in the air is absorbed by the hygroscopic material dried with the help of solar air heater until the point where RH reaches below 55% and above 45%.

II. WORKING PRINCIPLE AND EXPLANATIONS

The system works on simple principle of adsorption. In the solar aided dehumidifier, the moist indoor air is dehumidified using adsorbent such as silica gel, and the damped adsorbent is regenerated (dried) by passing heated air through it. Solar thermal energy is used as the heat source for the regeneration of the adsorbent thus leading to energy conservation.
The system can be divided into two parts;
1) Dehumidification
2) Regeneration

A. Dehumidification

The desiccant (here silica gel is selected)* is kept in an aluminium container and the air is passed through it for dehumidification and regeneration. There are two discrete air streams one is for dehumidification and the other is for regeneration.
The figure 1.1 shows the air flow passage and the signal flow in the dehumidification system.

The air to be processed is passed through the desiccant. The air from the room is fed into the desiccant. RH sensor and pressure sensor senses the relative humidity and the pressure of the air from the room the damper and flow meter regulates the amount of air fed to the desiccant

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During each intake of the air from the room a 10% of fresh air is added in order to maintain the oxygen level in the air. The pressure, temperature and the RH of the processed air is measures using sensors and it is then fed back to the room. The weight of the desiccant is measured using a sensor. The weight of the desiccant determines if the desiccant needs to be regenerated or not. All the sensors are connected to a single board computer.

The whole dehumidification process continues until the relative humidity inside the room is between the comfortable humidity level (45% to 55%). Here RH has been set to 48%.

All the corresponding design calculations have been done taking 48% as the standard RH level here. After the dehumidification the processed air can be fed to an air conditioner or a cooler according to the need.

B. Regeneration

The weight of the desiccant triggers the regeneration process i.e. when the desiccant has adsorbed moisture up to its maximum capacity, the desiccant is then regenerated. Air from outside is passed through flat plate solar air heater. The solar air heater raises the dry bulb temperature of the regeneration air, lowering its relative humidity. Figure 1.2 shows the block diagram of regeneration unit.

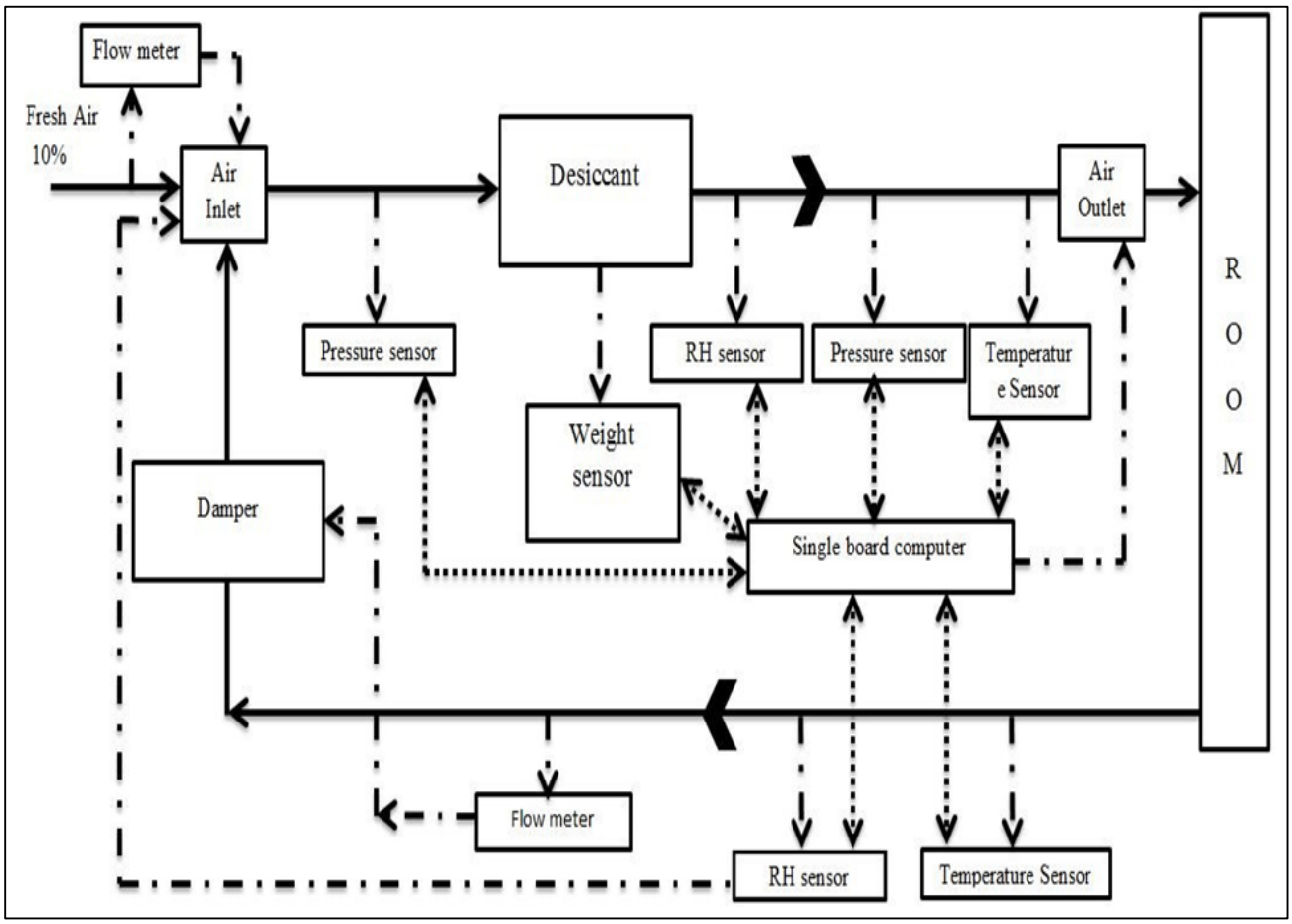

Fig. 1.1: Dehumidification unit

The solar air heater raises the dry bulb temperature of the regeneration air, lowering its relative humidity. This heated air is passed through the desiccant.

As a result water transfers from desiccant to lower RH regeneration air and this air released to atmosphere.There is pressure, RH and temperature sensor to sense the temperature, Rh and pressure of the regeneration air.

All the sensors are connected to a single board computer. The processing air regeneration capacity depends on the temperature of the air.

Depending on the dryness needed, regeneration temperature can be varied from 70^0C to 100^0C. Considering the properties of desiccant here in this project the temperature is set between 80^0C to 90^0C.

A prototype is designed which is an exact replication of the real system that is to be implemented. By implementing the prototype the objective is to prove that the load of the condenser can be reduced by using the dehumidification process which is carried out by the silica gel. Figure 1.3 shows the 2D model of the prototype.

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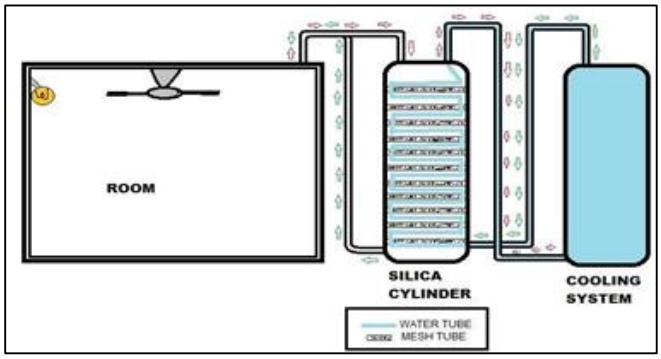

Fig. 1.3: 2D model of prototype

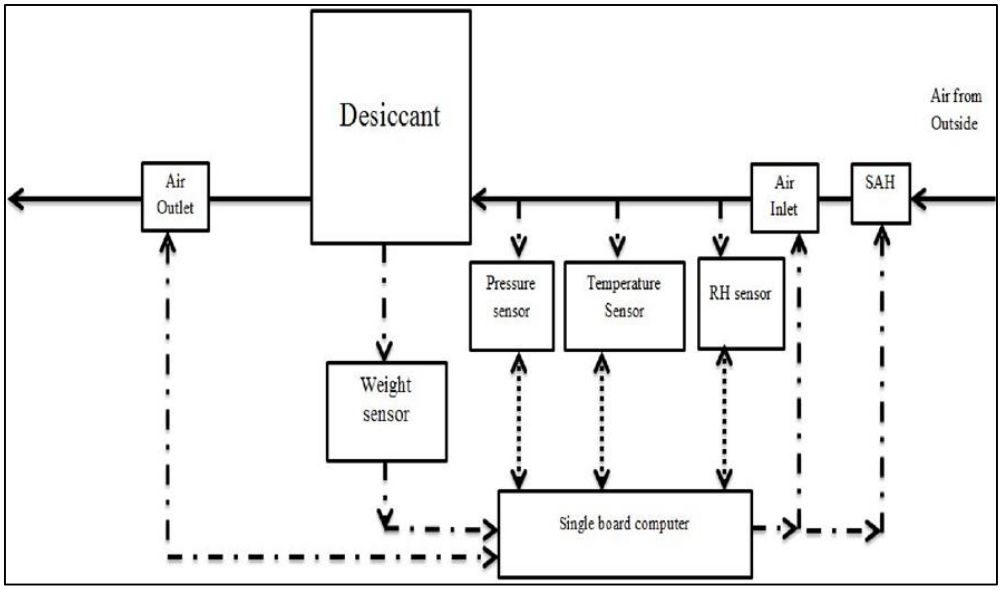

Fig. 4: Regeneration Block Diagram

III. RESULTS AND DISCUSSION

The prototype is designed which is an exact replication of the real system that is to be implemented. By implementing the prototype the objective is to prove that the load of the condenser can be reduced by using the dehumidification process which is carried out by the silica gel.

A non-indicating 5-6mm mesh silica gel is used. The system can even replace air conditioners if the heat generated by silica gel is cooled. This can be done using a water cooling circuit. Studies about silica gel as adsorbent in dehumidifier are not available, hence an experiment needed to be conducted to prove the adsorbing capacity of silica gel and to check its feasibility as an adsorbent in the dehumidifier.

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