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Enhancement the Performance of Condenser of Split type Air Conditioning System by using Evaporative Cooling: A Review

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Abstract

The improvement of coefficient of performance and reduction of energy consumption of a split air conditioning system. When retrofitted with evaporative cooling in the condenser of split air conditioner is reviewed in this paper. The condensing unit is retrofitted with a cellulose corrugated pad. This condenser can exchange heat with the ambient air cooled with evaporative cooling which is much lower in temperature than atmospheric air. By application of evaporative air cooling it is possible to exchange more heat than the unwetted exchanger. In this paper a split air conditioner is introduce by putting cooling pads behind condenser system and injecting water on them in order to cool down the air before it passing over the condenser.

Keywords: Coefficient of performance, Indirect Evaporative cooling, Split air-conditioning system, Energy saving.

Introduction

With impact of energy crisis and global warming many researchers have paid much attention on strategies for saving energy.The improvement of refrigeration cycle performance can be done by lowering the compressor power consumption, increasing the condenser heat rejection capacity or reducing the difference between condenser and evaporator pressures. Due to simplicity and flexibility split air conditioner is generally used in small size in residential and commercial buildings. The condenser used in this system for heat rejection process which is generally air cooled, it seems reasonable as far as the air temperature in summer is moderate and not too high (about 40º C). But when the air temperature increase and approaches 45º C or higher. "Split type" air conditioner that is divided into two parts are fan coil unit and condensing unit where the fan coil unit is located inside the room and another one is located outside the room. The performance of split air conditioner depends on heat transfer between the coils and the airflow. In this regard, by cooling ambient air temperature by evaporative cooling could results in significant energy and demand saving, this small saving could save huge amount of watts unit. In air conditioning system there are three kinds of condensers using air cooled, water cooled, and evaporative cooled. Condenser used in conventionalsmall tonnage residential split air conditioners are mostly air cooled.

Literature review

- The following literature review describes important research results regarding thecooling of condenser of split air-conditioning system.

Ebrahim Hajidavalloo et. Al.(2007)– In this paper with the application of evpoartively cooled condenser is built by using cooling pads in both sides of the air condenser and injected water on them in place of air cooled condenser when the ambient temperature at 40^0C. has significant effect on the performance improvement of the cycle and the rate of improvement is increased as ambient temperature increases and power consumption can be reduced up to 16% and the coefficient of performance can be improved around 55%. Despite the fast growing number of split-air-conditioners with air-cooled condenser in the market, and also regarding to the important potential of using evaporative cooling in reducing power consumption, there is little works in this area to investigate the different advantages of this system. It seems much works are required to address different aspect and advantage of this system. It should be noticed that the results of using evaporative cooler in window air-conditioners may not be simply applied to the spilt-air- conditioner because their design parameters are different. Window-air-conditioners are rapidly being replaced

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by split type air conditioners due to their better performance and lower noise. In this work, experimental investigation was used to evaluate the effect of using an evaporative cooled air condenser on the performance of an air-cooled split-air-conditioner under variable ambient air conditions in order to show how much COP and power consumption could be improved by changing the system**[1].**

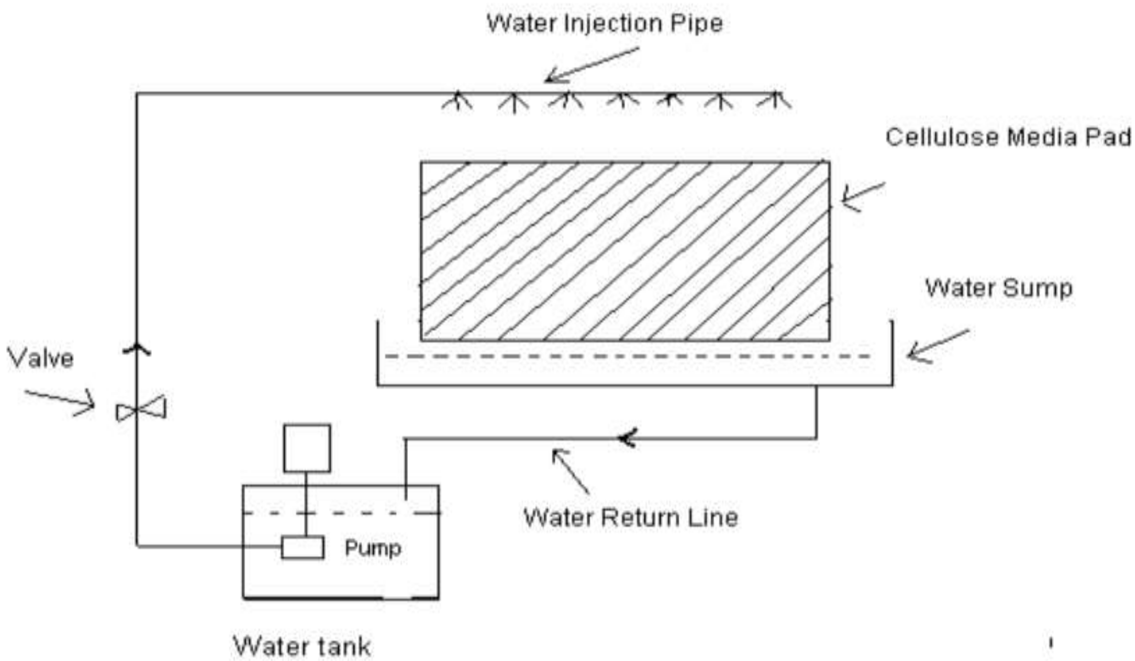

Fig. 2.Water circulation diagram of evaporative media pad.

- **Hu and Huang et. Al.(2005) -**This studies shows by keeping the cellulose pad in water cooled condenser of residential air-condenser of 3.5kw cooling capacity and 98 W pump was used which results the coefficient of Performance is improved from 3.0 to 3.5.Carried out ina 7.4 kW residential split heat pump system utilizing an innovative design of evaporative-cooled condenser. The condenser was 1 m wide, 0.66 m long and 0.66 m high.The heat to be removed from condenser was taken place in a cooling water tank where the condensertubes were immersed. The heated water in the tank was lifted by the rotating disks whichpartly immersed in the water and then cooled by the cooling air flow. The test results showed thatCOP was increased by 11.1–21.6% as compared to the air-cooled condenser. However, the size ofHwangs system was too large, heavy and complicate for residential application.The performance of a water-cooled condenser depends on the heat transfer between the refrigerant tubes and water flow. Evaporative-cooled condensers not only have a higher heat transfer coefficient than air-cooledcondensers but also have a simpler configuration than evaporative cooledcondensers[2].

- **Goswamiet. Al. (1993) –**Employed an evaporative cooling on existing 2.5 ton window air conditioning system by inject water from top by a small water pump on four media pad around the condenser. They reported the electric energy saving of 20% for the retrofitted system when ambient air temperature was 34^0C. They uses a simple and cheapest way for cooling ambient air temperature is employing the evaporative cooling system which results in decrease in ambient air temperature before it passes over the condenser coil [4].

- **R. Armbrusteret. Al.(2005) -**Investigated that the evaporating cooling of air conditioner by

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falling of water freely from one horizontal tubes to the other below horizontal tubes due to which the water flow exposed to upwardly streaming air and change of water temperature in the flow direction and the reduction of water temperature was observed to depend on the humidity, velocity of air and on the tube spacing falling film heat exchangers with horizontal tubes,Arranged one upon the other, thus forming a bundle, have been used for more than one and a half century in chemical engineering and energy conversion processes as evaporators or condensers, for example. A further group of such falling film apparatus are the evaporative coolers, in which a bundle of tubes is sprayed with water that flows around the tubes as a film and falls freely from tube to tube. The film is usually exposed to an air flow; it is heated on tubes, and at the same time, cooled mainly by evaporation at the water-air interface[3].

- **Vrachopouloset. Al.(2005) -** developed an incorporated evaporative condenser, which was installed with a cooling water sprinkle network in the front. In this method water was directly sprayed into air stream. Since the air filled with water droplets was directly induced to the condensing unit corrosion problem possibly occurred on equipment [5].

- **Chow et. Al. (2002)-**reported that if the on-coil temperature of a condensing unit were raised by 1^0C, the coefficient of performance (COP) of the air conditioner would drop by around 3%. In addition, if this temperature remained above 45^0C for an extended period, the air conditioner would trip because of the excessive condenser working pressure[6].

- **W.Leidenfrost and B.Korenic(1979)-**In this wetted the condenser of refrigeration or heat pump system makes it possible to exchange the condenser load at lower temperature. Wetted heat exchangers require less extended surfaces and can operate effectively with bare tubes only[7].

- **Design of Experimentation**

The main concern of applying evaporative cooling in an existing residential split air conditioner with the best performance and minimum side effect. There are two methods for evaporative cooling in condensers namely direct and indirect method. In direct method water is directly injected on the condenser and provides cooling effect. This method has disadvantages of including mineral deposits and corrosion of the condenser coils. Therefore, this method has rarely been used in residential air conditioners. In the indirect method water is injected on the evaporative media pad which is located in the way of air over the condenser and provides cooling effect by evaporation of water. Media pads are corrugated cellulose bound cardboard structures which are cross-fluted to increase the contact area between air and water.

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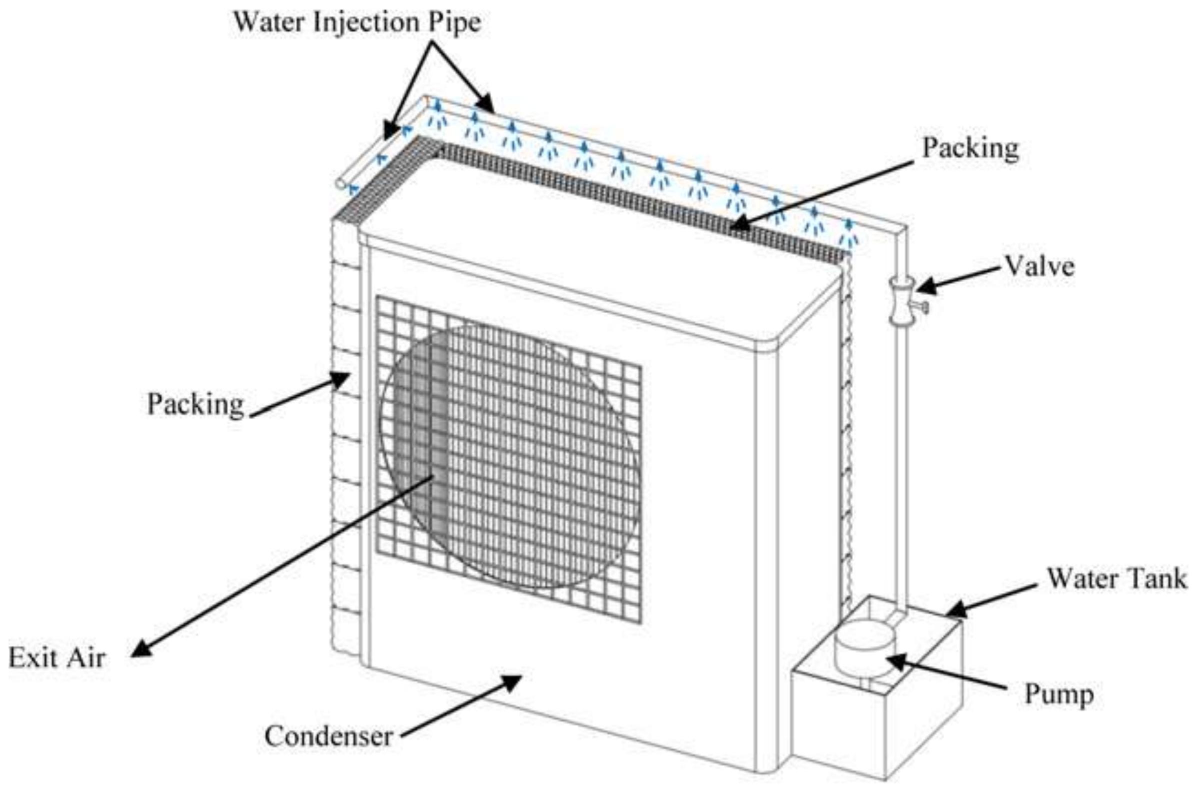

Fig 2: – Schematic view of the retrofitted condenser.

The place of media pad should be installed in a way to give a good cooling effect and also takes minimum space from outside partition of our equipment. The limitation of space is very important in our design consideration. In this work, one evaporative media pad, media pad is cellulose bound structures with height 22”, width of media pad in curve shape with angle 90^0 so the length of long side is 30” and short side 10” and 1.5” thickness, this pad is installed behind the condenser and the distance between them is 2.5cm to give the largest area available for cooling without increasing the total volume of outside partition of our device.A water circulation system was incorporated to spray water on the top of the media pad. It includes a small pump, tank and water spraying pipe. Energy meter will be used to measure the electrical current consumption of the compressor. For air circulation, hot ambient air passes over the evaporative media pad and after cooling down passes over the condenser and finally exits by fan which is located in front of the condenser as is shown in figure2.

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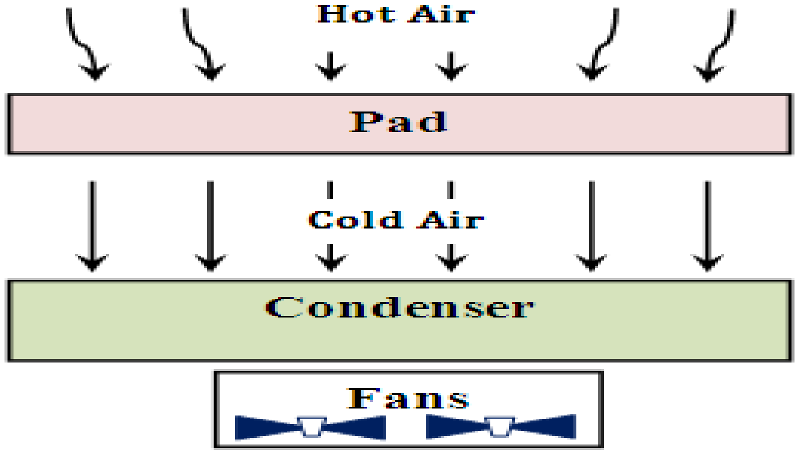

Fig.3. Schematic diagram of air circulation.

Conclusions

1. Byusing anevaporative cooling condenser of split air conditioner the pressure ratio across the cycle reduces, and the reduction of pressure ratio indicates the power reduction in the system.

2.Theexperimental results revealed that with evaporative coolingsystem the power consumption decreased, coolingcapacity and coefficient of performance increased considerably.

3.The cooling-down of water caused by its interactionwith the surrounding air during the free fall betweenadjacent tubes is much more pronounced than
during the flow as a film around the tube.

4. A novel design for employing indirectevaporative cooling system in a window-air-conditionerwas introducedanalysis based on local pricesshows the energy saving can pay for the cost associate withretrofitting the condenser in less than 1 year.

5. The temperature drop of water during the free fall was reasoned to depend on the conditions of air (partial vapour pressure Pv, velocity U, temperature T), the flow rate C and the inlet temperature Ti of the water.

6. The split-type air conditioner with integrated water heater has been developed bymodeling of the system componentsthe heat and mass transfer and pressurelosses occurring and enhancement of heat transfer.

7. The pressure of condenser and evaporator reduces.

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