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Experimental Evaluation of an Energy Efficiency Improvement System in Split Air Conditioner

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ABSTRACT: In this study, the effect of using a wet evaporation layer in the inlet air of the condenser on the performance of split air conditioner has been investigated. Also, based on a new contribution, the drained water generated due to the ambient moisture distillation on the evaporator coil, collected and used in the evaporation layer. The temperature of passed air through the surface of the condenser is reduced before entering the condenser due to contact with the evaporation layer. Applied experimental studies and results of prototype test showed that by reducing the temperature of condenser inlet air using proposed evaporative cooling system, the average electrical energy consumption decreases more than 12% and the coefficient of performance increases about 15.1%. Also, despite the desired effects of the proposed mechanism on the coefficient of performance and system energy consumption, the results of parametric studies indicated that effectiveness of the evaporative condenser reduced due to the ambient temperature and relative humidity. So that, the system performance changes decreases with increasing ambient temperature (30.5 to 44.5 Celsius) from 18.22% to 15.05%, and also it declines from 18.14% to 6.4%, as well as reduction of the relative humidity (from 35 to 70 percent).

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1. INTRODUCTION

Split air conditioners use air condensers like many other types of condensing cooling equipment. Using this kind of condenser is more useful than other types of condensers due to its significant advantages in storage, more lifetime and more flexibility in capacity control. The efficiency of these devices is inversely related to the outside temperature, and the ambient temperature rise will lead to an efficiency loss in these systems. Some studies have shown that for every one degree of temperature rise of the condenser surface, the system performance decreases by about 3%. Also, for each degree of reduction in the condenser temperature, the system performance increases between 2 to 4% [1, 2].

One of the effective ways for inlet air cooling of the condenser and consequently reduce the condenser temperature is using a wet evaporating layer in the air entrance or spraying the water directly on the inlet air. In this case, the air temperature decreases in the entrance of the condenser after passing through the wet layer [3, 4].

In all of the previous research, the use of feed water due to persistent evaporation is essential and inevitable. Of course, in a sterner look, it can be seen that this amount of water that leads to lower energy consumption in cooling systems can reduce the water loss that is lost in the thermal power plants during the process of generating electricity. Although there is no accurate information about the average water consumption per kilowatt hour of electrical energy, due to the major part of the country's electricity production by thermal and hydropower plants, this is about 2.5 to 4 liters [5, 6].

The presented approach in this study is using drain water from the distillation of air moisture to reduce the consumption of the same amount of water in a split air conditioner. Generally, since the coil surface temperature is lower than the dew point of the ambient air, the humidity in the air is distilled on the coil surface and is drained by the tubes to the outside. While this water can be collected and used to reduce the temperature of the inlet air by the evaporative layer of the condenser.

2. METHODOLOGY

The processes of a compression cooling cycle can be represented using thermodynamic diagrams. To analyze a compression cycle, usually, the temperature-entropy (*T-s*) and the pressure-enthalpy (*P-h*) graphs are used. Of course, the pressure-enthalpy graph is more conventional and more popular.

In order to experimentally investigate the effect of evaporative layer application on split air conditioner operation, an instance system was designed and implemented. The results were analyzed and the effect of the evaporation layer was evaluated. In this test, drainage water was collected from an air conditioner and used for evaporation. The mechanism for this study is shown in Fig. 1. The system tests

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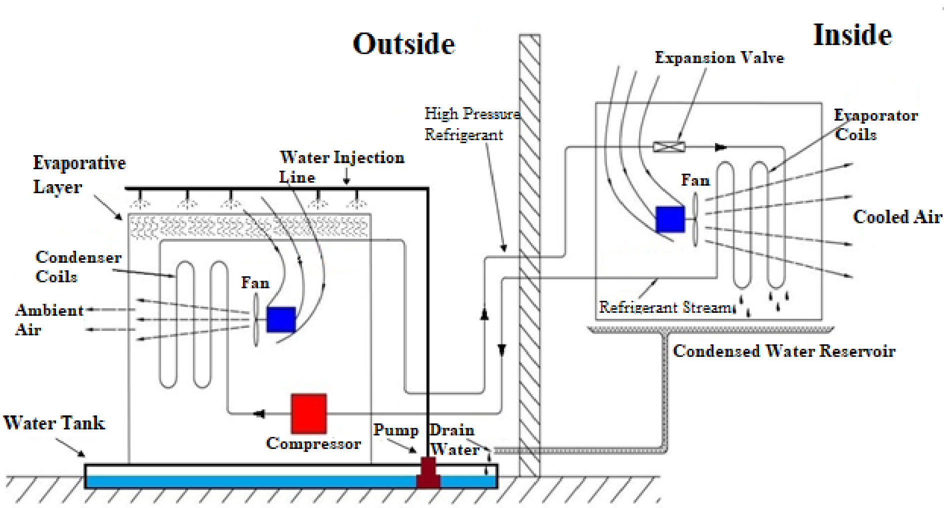

Fig. 1: Configuration of the proposed system

which are proposed in this study have been performed at the site of the center of test and research of cooling systems located in the Iranian research organization for science and technology, which has separate rooms for internal and external investigations. In addition, in order to carry out the test, a split air conditioner was used with a cooling capacity of 27000 Btu/hr. The refrigerant type in the tested device is R22.

3. DISCUSSION AND RESULTS

In order to make the energy model of the proposed system, Engineering Equation Solver (EES) software has been used. The governing equations for the considered cycle were solved in this model. Thus, according to Fig. 2, the P-H diagram as one of the most important characteristics of the system's performance was developed. Table 1 shows the values obtained from the experiment for both cases without/with using the evaporation layer.

In the presented study, the amount of drain water was 1.5 lit/hr and water consumption due to evaporation in the evaporative layer was 8 lit/hr. It should be noted that the amount of drainage water can be affected by different factors, including the number of people in the building, the presence of factors like the humidity of plants or activities such as cooking and etc. On the other hand, the evaporation rate of water can also be related to the ambient air temperature and relative humidity of the environment.

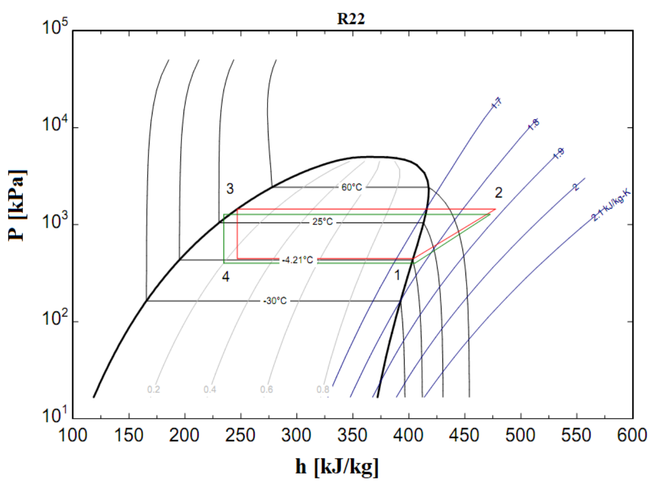

Fig. 2: The P-H diagram of the presented system with and without using the evaporative layer

Table 1: Achieved results from the experimental study

Parameter (unit)	Without the evaporative layer	With the evaporative layer
Power (kW)	2.89	2.47
COP	2.15	2.54
Cooling Capacity (kJ/kg)	6.21	6.28

Regarding the geographical range for using the proposed system, it can be said that the use of evaporative systems in low relative humidity regions is appropriate. In fact, the efficiency of evaporative devices is dependent on the difference between the dry and wet air conditions, and the increase in the difference between these two temperatures increases the equipment efficiency.

In order to consider the feasibility of using the presented system in this study on the air-conditioning equipment, it should be noted that all air conditioning systems can be upgraded with this mechanism. In addition, in larger systems, the amount of drain water is naturally higher and the storage tank, pipeline network, and pump circulation are required in larger scales.

4. CONCLUSIONS

In summary, the results of the present study in the form of a theoretical and experimental study are shown as follows:

- Power consumption of the compressor decreased by an average of 32.12%.
- The heat absorption capacity of the evaporator increased by about14.5%.
- The Coefficient of Performance (COP) of the system increased by more than 15.1%.

Moreover, the results obtained from parametric analyzes in this study have shown the reduction of the effectiveness of the evaporative condenser system with increasing ambient temperature and relative humidity. However, the utilization of this mechanism under all considered conditions has had a positive effect on the rate of performance and energy consumption the split air conditioner.

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