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Experimental and theoretical study to improve the performance of splits in Iraq

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Abstract: In air conditioning cooling systems, especially in regions with extremely hot weather, reducing power consumption and improving performance are key concerns. In the summer, the system's efficiency drastically declines and its use of electricity significantly rises. This article analysis an experimental and theoretical study to improve the performance of evaporative condensers used in air conditioning using evaporative cooled air. The paper mainly focuses on the energy consumption of residential cooling systems and their performance improvement in Iraq. The result shows that when the air entering the condenser is cooled via evaporative cooling, the average compressor work consumption is lowered by 8.2% as a result of the 5% drop in condenser pressure. The highest temperature at the condenser's air outlet surface was lowered by 5 C when evaporative-cooled condensers were utilized, and power consumption was found to be decreased by 13.7 to 58%.

Keywords: Energy, Performance, Air Conditioning, Evaporative, Condenser.

دراسة تجريبية ونظرية لتحسين أداء المكيف في العراق

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المعهد التقني حويجة || الجامعة التقنية الشمالية || العراق

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المستخلص: يعد تقليل استهلاك الطاقة وتحسين الأداء مصدر قلق كبير في أنظمة تبريد تكييف الهواء، خاصة في المناطق ذات الظروف الجوية شديدة الحرارة. في فصل الصيف، ينخفض أداء هذه الأنظمة بشكل حاد ويزداد استهلاك الطاقة الكهربائية بشكل كبير. يقدم هذا البحث دراسة تجريبية ونظرية لتحسين أداء المكثفات التبخرية المستخدمة في تكييف الهواء باستخدام الهواء المبرد بالتبخير. تركز الورقة بشكل أساسي على استهلاك الطاقة لأنظمة التبريد السكنية وتحسين أدائها في العراق. تظهر النتيجة أنه عندما يتم تبريد الهواء الداخل إلى المكثف عن طريق التبريد التبخيري ، ينخفض متوسط استهلاك عمل الضاغط بنسبة 8.2٪ نتيجة لانخفاض ضغط المكثف بنسبة 5٪. تم تخفيض أعلى درجة حرارة عند سطح مخرج الهواء للمكثف بمقدار 5 درجات مئوية عند استخدام مكثفات التبريد التبخيري ، ووجد أن استهلاك الطاقة انخفض بنسبة 13.7 إلى 58٪.

الكلمات المفتاحية: طاقة، أداء، تكييف، تبخيري، مكثف

1. NTRODUCTION.

In the hot weather in the summer, the pressure increases on the use of home air conditioners, in order to obtain the cold air necessary to cool rooms in homes. And home air conditioners need periodic maintenance periodically, as most of the problems and malfunctions associated with them vanish if it is done correctly. Among these common problems is the weakness or lack of cooling of home air conditioners, which is caused by many causes such as air filter not cleaned, the evaporator coil is grimy and dusty and The condenser coil is caked with dirt and debris. In order to increase comfort levels in buildings, air conditioners are typically utilized. Therefore, improving the COP of AC and reducing power usage will help to lower world energy consumption. The key improvement factor for an air-cooled condenser is to lower the ambient temperature. Therefore, cooling systems will continue to try to use less energy, which will increase overall energy efficiency [1]. By lowering the condenser and evaporator pressure differential, boosting condenser heat rejection capability, and decreasing compressor power consumption, air conditioning machines can consume less energy [2–5]. It is also thought that experiments are used to study the performance of split-unit air conditioning systems. Yau, Y.H., and Pean, H.L. [6]. Tianwei et al. [7] provided an experimental investigation to compare the air cooling in traditional and evaporative air cooling condensers. To cut down on energy use and humidity in extremely hot weather, Nikhil Sharma1 and Jujhar Singh [8] incorporated water-cooler wastewater into window air conditioning systems using evaporative cooling. Using pads of various thicknesses to accomplish pre-cooling in an air conditioning system can reduce electricity usage [9]. This work focuses on the improvement of energy saving, and coefficient of performance using an evaporative cooling system.

2. METHODOLOGY.

2.1 Coolselector®2 Software.

This software is in English and has very powerful functions. It can do refrigerant physical properties, pressure enthalpy diagrams, refrigeration system cycle calculations, compressors, two devices, throttling, etc. Any HVACR system can benefit from using Coolselector®2 to reduce energy use and enhance performance. Run objective calculations based on a range of operating conditions, including cooling capacity, refrigerant, evaporation temperature, and condensation temperature, and then choose the optimum components for your design. The aim of this program is to assist engineers to design HVAC systems for commercial buildings. See Fig1. Utilizing the program Coolselector®2, Rima [10] is used to construct and evaluate the effectiveness of cold storage for the freezing of fish.

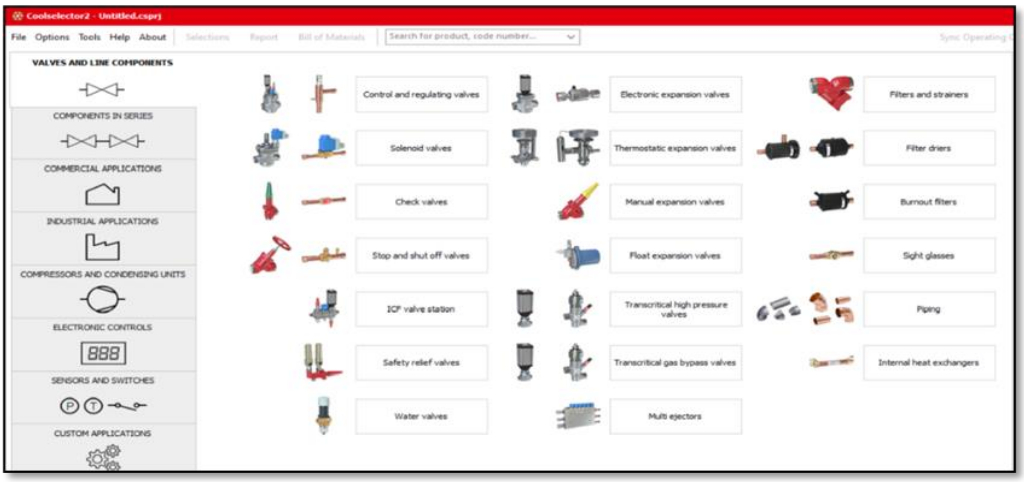

Fig. (1) Interface of Coolselector®2 Software.

2.2 EXPERIMENT SETUP DETAILS.

A schematic diagram and photograph of the experiment setup and are displayed in Figs. 2 and 3, respectively. A split-type air conditioner that used R22 refrigerant as its operating fluid was used for the studies. 99.7% of the refrigerant was propane, 0.15 percent butane, and 0.15 percent isobutene [6]. The AC system was extended with an evaporative cooling system.

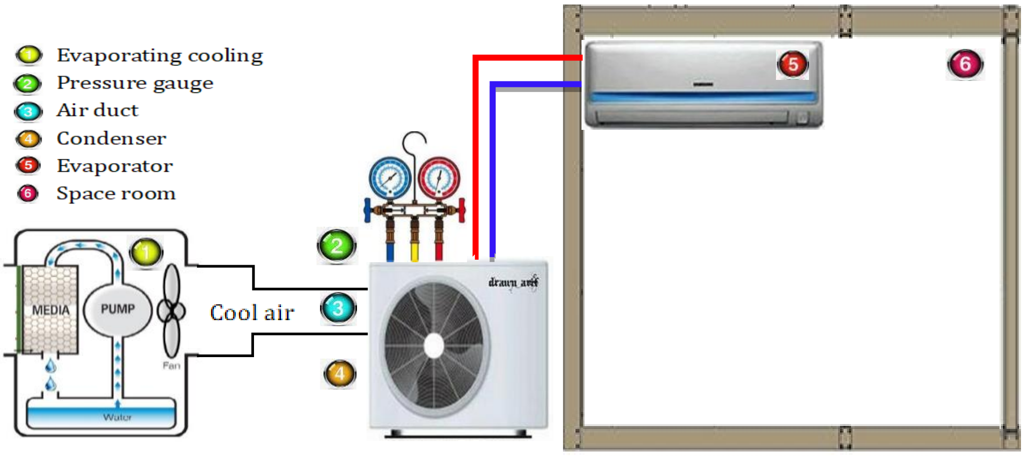

Fig. (2) Schematic Diagram for The Experiment.

Fig. (3) The Experimental Rig.

The compressor power consumption is determined using equation (1).

$$W_{net} = V.I.COS\beta \qquad (1)$$

Where W_{net} represents how much energy a compressor uses, V is voltage, I is current, and $Cos\beta$ is the power factor of electricity which is 0.83. The mass flow rate of HCR-22 refrigerant is calculation by Eq. (2).

$$m = \frac{W_{net}}{h2-h1} \qquad (2)$$

where $\dot{m}$ is the mass flowrate of refrigerants, h_2 is enthalpy of refrigerant at compressor exit, and h_1 is enthalpy of refrigerant at evaporator outlet. The cooling capacity was obtained by Eq. (3).

$$Q_r = \dot{m} \cdot (h_1 - h_4) \qquad (3)$$

To measure (COP), the Eq. (4) is employed.

$$Cop = \frac{Q_r}{W_{net}} \qquad (4)$$

Improvement of cop and work can be calculated as:

$$\epsilon_{COP} = \frac{cop_{evp} - cop_{dry}}{cop_{evp}} \qquad (5)$$

$$\epsilon_{W_{net}} = \frac{W_{net_{evp}} - W_{net_{dry}}}{W_{net_{evp}}} \qquad (6)$$

3. RESULTS AND DISCUSSION.

Experimental data such as the pressure of the condenser and the evaporator and the temperature of the outlet of the condenser were taken and recorded during the summer season from the sixth to the tenth month in Iraq and for different days of each month, then drawing the relationships between the cop, the pressure of the evaporator and the condenser, and the temperature of the condenser before and after cooling, and this is shown in figures 4 to 6. The obtained data were practically entered into the

Coolselector®2 program to obtain results showing the effect of some parameters on the performance of the splits, and this is shown in Figures 8 and 9. Finally, the results of the current work were compared with previous research, which is shown in Figures 10 and 11.

3.1 Effect of A/C COP Enhancement on Overall System:

The coefficient of the refrigeration system (COP) of the air conditioner was improved throughout the hot season by 16.9%, which suggests that it was possible to maximize the refrigerant effect while minimizing compressor work. The average COP value for the entire season and the level of improvement in the current work are shown in Figure 4. Even though it is below the nominal COP of 2.83, the COP has a concave shape and maintains its lowest values in the hottest months of July and August, 2.32 and 2.27, respectively. This behavior is explained by the extremely high ambient temperature, which has a direct impact on the heat rejection from the condenser. While the COP increased significantly in the months with lower ambient temperatures, the cause for this increase can be attributed to the water evaporation process, which lowered the ambient temperature and forced it into the condenser.

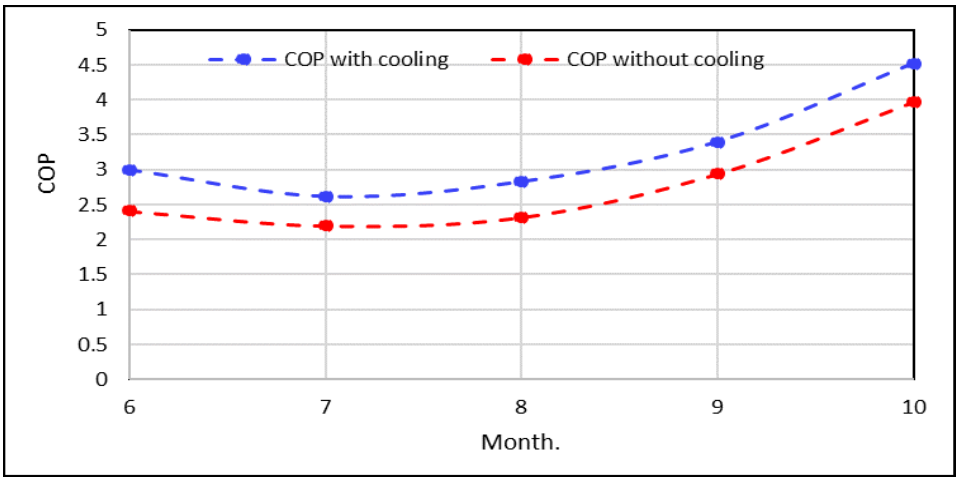

Fig. (4) Coefficient of performance with time.

3.2 Effects of high condenser temperature on split performance:

In Fig. 5, are showing the influence of cold air due to water evaporation on air temperature leaving the condenser where higher the temperature of the condenser means that the gaseous refrigerant compound is higher roasted, which is the degree of its condensation. To the evaporator and part of it is still gas, the cooling of the unit decreases, this case has a more negative impact on the compressor because it pulls a high current to face the increase in the load and the continuation of its work without interruption. Oil clots and disruption of the compressor's cooling system, so the refrigeration compound returns to it from the high-roasting evaporator and the situation moves from bad to worse until it ends within a few months as the compressor malfunctions electrically or mechanically or both together.

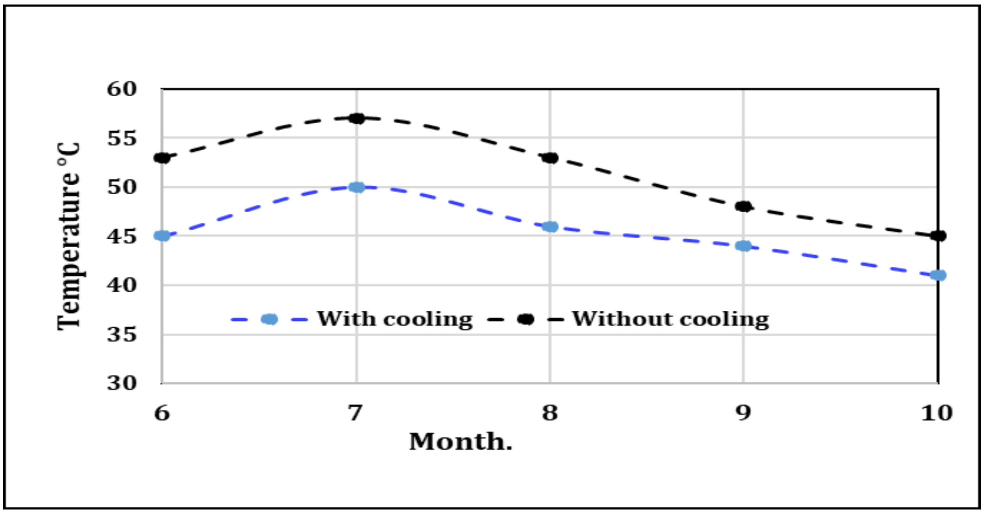

Fig. (5) Average Monthly Temp. of Air Leaving Condenser.

3.3 Effects of high condenser pressure on split performance.

Figures 6 are showing effect on high and low condenser and evaporator pressure respectively, the process showed the condense pressure is directly minimized with cold air within 5.6% but evaporator pressure showed insignificance. Figure 7 is showing the effect of cold air on vapor compression cycles pressure-enthalpy diagram using software Refrigeration Utilities, in October the difference was more clear to appear.

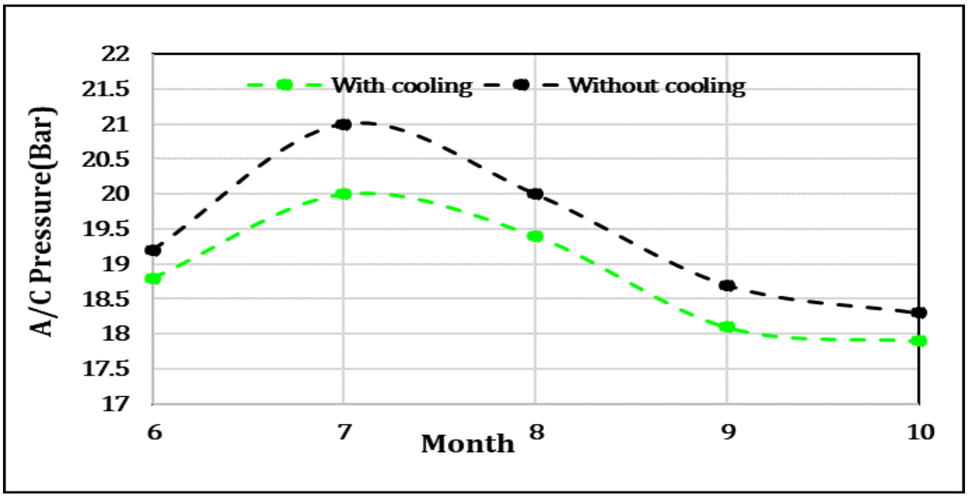

Fig. (6) Variation of Average Pressure with time.

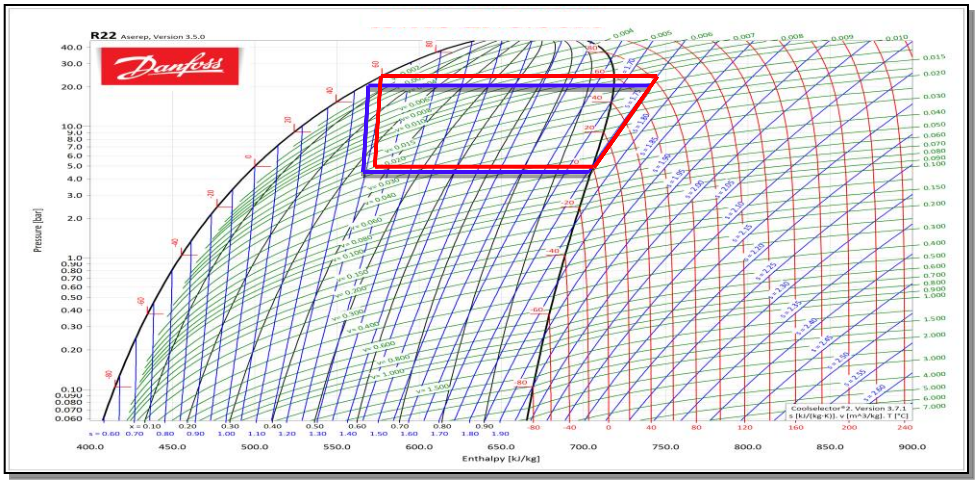

Fig. (7) Effect of Cold Air on A/C Refrigeration Cycle.

3.4 Effects of environmental temperature on the cooling capacity.

Figure 8 shows the relationship of cooling capacity with evaporating dew point temperature at different atmospheric temperatures. We conclude from the above that by decreasing the evaporator temperature, the cooling effect of the evaporator decreases and the rate of passage of the refrigerant medium decreases, while the rate of passage of the refrigerant medium per ton of refrigeration increases, and the cooling capacity of the unit decreases as well as the performance coefficient.

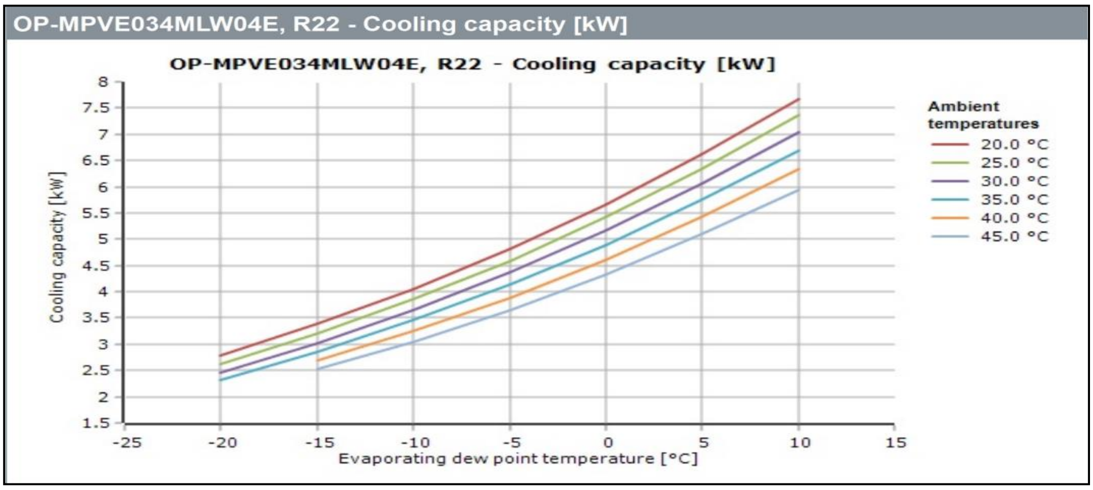

Fig. (8) cooling capacity with evaporating dew point temperature.

3.5 Effects of environmental temperature on the COP.

Figure 9 shows the relationship of the performance factor with the evaporating dew point temperature at different atmospheric temperatures. The evaporator temperature is the saturation temperature corresponding to the evaporator pressure and it is directly affected by the heat load on the evaporator. The evaporator pressure decreases due to the rapid evaporation of the refrigerant and the saturation temperature decreases. If this drop in pressure is not corrected, and of course, the drop in evaporator temperature will result in a bad effect on the performance of the refrigeration cycle in general.

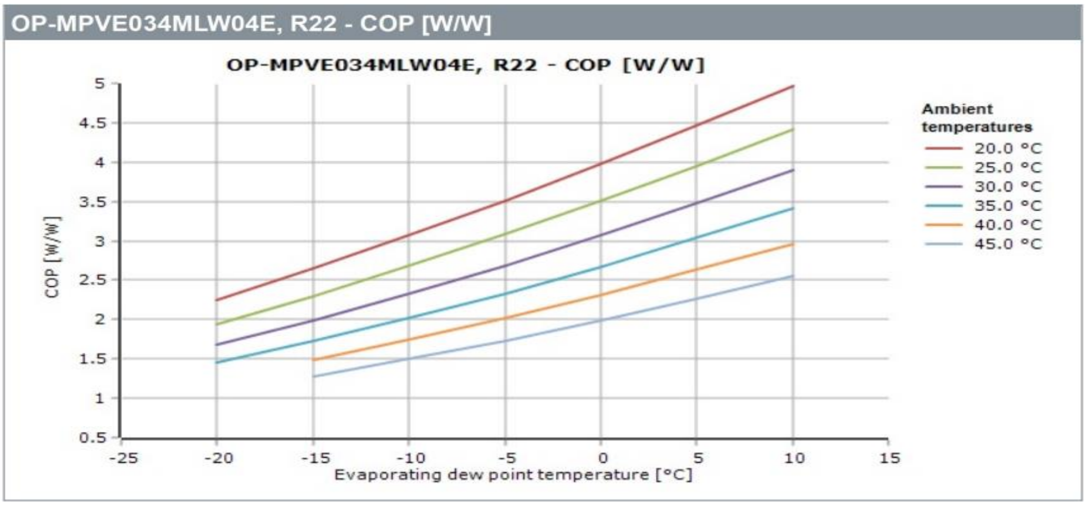

Fig. (9) COP with evaporating dew point temperature.

3.6 COP and Energy Saving.

Figures 10 and 11 compare the results of various research based on energy savings with cooling capacity and the percentage improvement in COP utilizing evaporative cooling (£). It was discovered that by adopting evaporative cooling, the COP could be increased from 14.3 to 55.4% while the existing working COP could be improved by only 23.12%, and the energy consumption could be decreased by 13.7 to 58% while the current work could be improved by 27.34%.

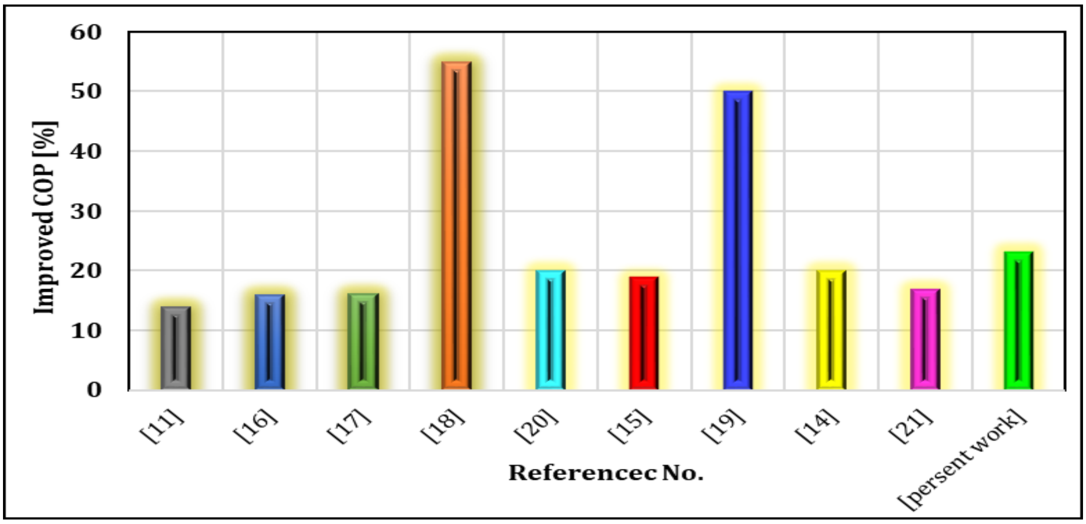

Fig. (10) Comparing different COP improvement studies.

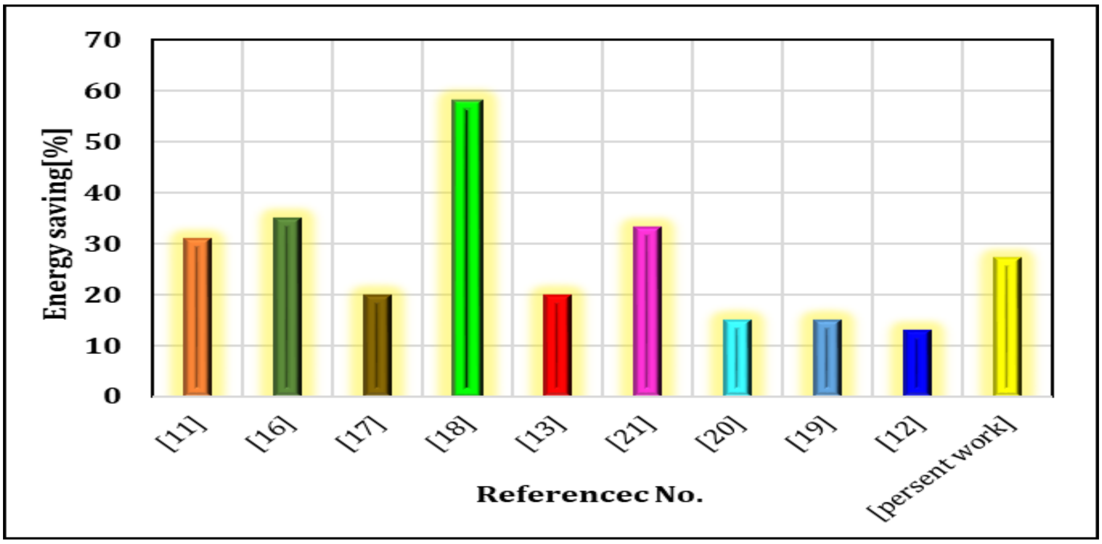

Fig. (11) Results of various energy-saving studies are examined.

4. Conclusions

In the current work effects of the inlet and outlet air temperature and pressures of the condenser on the thermal performance were analyzed. The main conclusions of this study are as follows:

- The experimental findings indicate that employing evaporative cooling can greatly increase the A/C system's performance in terms of cooling capacity and energy savings.
- A/C COP enhances by minimizing average condenser temperature, with air supplied from evaporative cooling can be enhanced by 9.01% during warm and dry summer in Iraq.
- The maximum temperature at the condenser's air output surface was lowered by 5 C by using an evaporative cooler to cool the incoming airflow.
- As the temperature of the surrounding air increased, the split's refrigeration capability dropped.
- With the environment temperature increasing, the coefficient of performance of the split decreased.
- The results indicate that when evaporative cooling is used to lower the air temperature entering the condenser, the average compressor work consumption is reduced by 8.2% as a result of the 5% drop in condenser pressure.
- It was found that by using evaporative-cooled condensers, power consumption can be reduced from 13.7 to 58%.

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