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IMPROVING THE PERFORMANCE OF HOME AIR CONDITIONERS: A REVIEW

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Abstract:

In this study, improvements were made to the air conditioning system in major areas, especially the most important temperature centres in Iraq, where the valid room temperature (DBT) reaches approximately 55 degrees Celsius. This temperature corresponds to the highest climatic temperatures observed in Middle Eastern countries, such as Iraq, during the summer, which often leads to substantial impacts on cooling systems. The proposed solution involves integrating a cooling circuit into the air conditioning system. Many enhancements were tested to increase the efficiency of air conditioning by increasing the coefficient of performance (COP) and reducing power consumption, particularly under extreme climatic conditions experienced in the region.

Keywords: *Enhancement of air conditioning, hot climate, thermal performance, air conditioning system, Energy saving.*

1 INTRODUCTION

The enhancement of cooling system efficiency has been a highly debated subject in recent decades. Many scientists have presented diverse research to investigate different air conditioning methods in residential and business buildings. Nevertheless, Modern air conditioning systems show great efficiency and dependability in functionality and satisfying air conditioning needs. Therefore, the issue of excessive energy use in these air conditioning systems is still the subject of current research. There is a continuing global need for energy, necessitating urgent measures to prevent energy shortages in the future. Approximately thirty per cent of the global energy supply uses air-conditioning systems. In Iraq and several countries in the region, air conditioning is indispensable for providing summer cooling in residential, commercial, and public buildings. The summer season in Iraq spans from April to October. The current ambient temperature is elevated. Average daily temperatures frequently exceed 55°C. These extreme weather conditions require a significant amount of cooling to maintain comfort. The efficiency of commonly utilised air conditioning systems significantly declines in high ambient temperatures; consequently, electricity consumption increases. As a result of these factors, yearly electricity usage required to cool a specific building space is potentially higher in Iraq than in any other country globally. Accordingly, the surrounding wet bulb temperature is the deciding factor here. During the summer, there is a temperature differential of around 25 degrees Celsius between the highest possible DBT and the WBT. Even though the water-cooled cycle consumes a modest quantity of energy, higher efficiency is anticipated from air-conditioning systems that utilise a water-cooled cycle. While there are advantages in terms of peak power demand and annual electricity consumption, the bulk of air-conditioning systems now used in Iraq are of the air-cooled type. In general, higher outside temperatures lead to higher temperatures in the air-conditioned space. Compressors inherently produce a large amount of heat; Therefore, overheating occurs frequently when exposed to high temperatures. If the compressor gets too hot, it often activates an Automatic shut-off mechanism to protect its internal parts and facilitate the space cooling process. This can extend the air conditioner's cooling cycle and restore its efficiency.
Reducing the overall efficiency of the entire station until the system can be restarted. A condenser cooling cycle can be used for optimal performance. Several kinds of air cooling are used in this study and

focus on maintaining specific properties, such as maintaining optimum pressure levels and utilising a p-v diagram to ensure the operation efficiency of the expansion tube. In addition, it aims to achieve a controlled decrease in gas temperature within specified limits.

2 PRINCIPLES of AIR CONDITIONING

The principle behind air conditioning revolves around the fundamental principles of thermodynamics, involving compression, condensation, expansion, and evaporation. Here's a concise explanation:

Air conditioning systems operate based on the principles of thermodynamics. The process begins with the compressor, which compresses a gas with low pressure and low temperature. This compression process elevates both the gas's temperature and pressure. Subsequently, the gas under high pressure is directed towards the condenser coil in the outside unit, dissipating thermal energy into the surrounding atmosphere. Consequently, the refrigerant undergoes condensation, transforming into a high-pressure liquid. Next, the pressurized liquid refrigerant flows via the expansion valve, where its pressure and temperature drop rapidly. This transition turns it into a low-pressure liquid-gas mixture. The mixture flows into the evaporator coil within the evaporator unit, where warm indoor air is circulated across the evaporator's coils. The refrigerant assimilates thermal energy from the air, transforming it into a low-pressure gaseous state by evaporation. This cyclical process continues as the gas at low pressure is directed back to the compressor, restarting the sequence as shown in Figure 1. By manipulating the refrigerant's physical properties through compression, condensation, expansion, and evaporation, an air conditioning system effectively transfers heat from inside a building to the outside environment. This continuous heat exchange results in the cooling of the indoor space. The principles governing this process are rooted in the science of thermodynamics and form the basis for the functionality of various types of air conditioning systems.

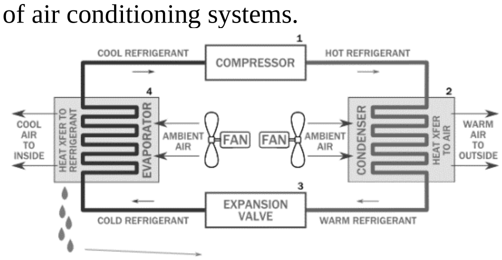

Figure 1. Principle of Air Conditioning and Components

3 TYPES OF ENHANCEMENT

(Hashim, et al., 2023) examines using a direct evaporative cooling system in air conditioning units in hot regions. The study uses both experimental and theoretical approaches. The experimental setup involved a window-type air conditioning unit with varying weather conditions. Results showed a 10% to 20% increase in refrigeration capacity, a significant reduction in outlet temperature, and a 3% decrease in power consumption. The data analysis was conducted using the MATLAB program, and a favourable concordance was found between the experimental and theoretical findings.

(Katekar, 2022) presented that the increase in mean world temperature resulting from heightened energy consumption, industrial development, transportation activities, and global warming has had a substantial detrimental impact on the efficiency of A/C. Researchers examined the effect of integrating condensers with the efficiency of air conditioners when using evaporative cooling pads. The study's findings indicate that the implementation of a honeycomb cellulose cooling pad with a thickness of 2 inches Led to a substantial decrease in power usage by 15% and a remarkable increase in the COP by 45%.

(Atmaca, Şenol and Çağlar, 2022) The efficiency of a (split-type) A/C equipped with a condenser cooled by evaporation pads can be observed in Figure 2 and was analysed compared to a conventional air-cooled condenser. The condenser used evaporative cooling, resulting in a 10.2%–35.3% increase in COP and a 5.8%–18.6% increase in cooling capacity. The study found that external temperature and relative humidity significantly impacted the performance parameters and energy efficiency. The ideal conditions for maximising the system's performance were higher ambient temperature and lower relative humidity.

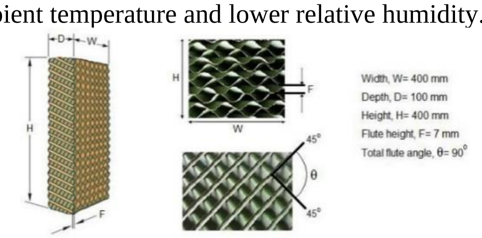

Figure 2: Geometry of the evaporative pad (Hashim, et al., 2023)

(Ameen *et al.*, 2022) studied to develop and assess an Air Conditioning Unit using a magnetic field and several types of tubes. The experimental investigation evaluated the unit's performance by replacing the original tubes with modified finned bent tubes and coil-finned tubes. The performance of electric charging was greatly enhanced, with a 76%

improvement observed in bent tubes and a 177% improvement observed in coil tubes. This approach raises the temperature of the refrigerant and offers a straightforward technical testing technique for Air Conditioning Units equipped with magnetic fields and diverse tubing configurations.

(Thiangchanta *et al.*, 2021) aimed to reduce energy consumption in split-type air conditioners using a pre-cooling system with condensed water to lower ambient air temperature before entering the condenser. Results showed a maximum energy consumption reduction of 26.6% compared to traditional air conditioners. Additionally, the pre-cooling system improved condenser heat rejection consumption by up to 74.3%. Multiple linear regression models were developed, showing high accuracy with R2 values above 0.8 for pre-cooling testing. The study's findings suggest the effectiveness of the pre-cooling system in enhancing energy efficiency and heat rejection in air conditioning systems.

(Yang *et al.*, 2021) explores the impact of external temperatures, nozzle mass flow rates, and spray system operation modes on air conditioner performance. The result shows that using a spray evaporative cooling system significantly improves performance, reducing power consumption by up to 22% and COP by 42.6%. This energy-efficient combination of an air-cooled unit and a spray cooling system can significantly reduce electricity consumption, demonstrating its potential for enhancing performance.

(Watcharajinda *et al.*, 2021) discovered the utilisation of an uncovered reservoir to dissipate heat for a water-cooled condenser, focusing on its application as a cooling tower. The research involved an experiment on (3.5) kW using an R32 A/C system and a 3×3×1.1 (m) open pond in Thailand. A predictive model was constructed to estimate the pond's mean temperature and energy efficiency ratio, with results aligning with experimental observations. The Energy Efficiency Ratio (EER) exhibited a range of 4.2-5.3 during daylight hours, accompanied by an average relative inaccuracy from 0.74-5.23%.

(Eidan *et al.*, 2021) examines the effectiveness of a heat-pipe heat exchanger in a window-type A/C. Implementing the high-pressure heat exchanger decreases the amount of electricity used via the compressor, hence improving the COP of the system. The chosen working fluids are distilled water, acetone, and R-134a. The study's findings indicate that the High-Performance Heat Exchanger system resulted in energy savings of 2.01%, 2.195%, and 1.33% when compared to a conventional system lacking this technology.

(Kang *et al.*, 2020) suggests a method for demand-side management in air conditioning systems by regulating indoor ambient temperature using equivalent thermal parameter models. Four temperature management options are proposed: constant setting, pre-cooling, curtailment, and enhanced curtailment. The study also uses three operational schemes of the chiller. It assesses performance using the five indications, including the average load per hour, the ratio of average load per hour, a 32.5% energy saving ratio, The fraction of power outages occurring during periods of high demand, and the efficiency of the system in converting energy input into useful output. The findings offer direction for enhancing the efficiency of water-cooled air conditioning systems and optimising the economic performance of power systems.

(‘A Review on Performance Improvement of Split Air-Conditioning System Using Loop Heat Pipe’, no date) The study examined the effects of loop heat pipes on dehumidification and consumption of energy in a split-system air conditioner. Incorporating three pentane-filled units into the cooling coil boosted the COP by 18-20% and improved the dehumidification capacity. Additionally, the implementation of Loop Heat Pipes resulted in a reduction in energy consumption. Improved moisture extraction capacity. A single installation on an indoor unit reduced load, resulting in a cooling capacity improvement index of 23.5% and latent heat recovery of 482W.

Atif A. Hasan (2019) found Commercial air conditioning units intended for varying climates in Iraq may experience a reduction in cooling capacity and an increase in energy consumption during the summer due to their inability to adequately chill the air to the condenser. The utilisation of an evaporative cooling pad can be advantageous in this situation. When implementing this particular solution on a refrigeration unit with a capacity of 2 tons in July 2017, there was a notable decrease in electrical energy consumption by 533 kilowatt-hours per month. Additionally, the condensing temperature experienced a reduction of 49 degrees Celsius.

(Q. Shaheen and H. Hmmadi, 2019) An investigation was conducted on a hybrid system that combines an evaporative air cooler with a refrigerated unit as shown in Figure 3. To improve efficiency, reduce moisture, and produce potable water. It analyses heat and mass transfer phenomena in the wetted pads and evaporator, focusing on environmental variables in the Basra region. The experimental setup includes an evaporative air cooler, compressor, and evaporator coil. The results show increased humidity ratio and coil temperature, decreased output temperature, and increased freshwater production.

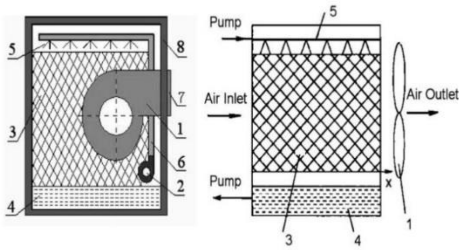

Figure 3: Sketches of the inner configuration and the working principle of the direct evaporative cooler. (Q. Shaheen and H. Hmmadi, 2019)

(Siricharoenpanich *et al.*, 2019) This study aims to show that a water-cooling loop can be built to increase the air conditioning system's thermal efficiency. Between the compressor and condenser units, the experiment makes use of a heat exchanger with concentric helical coiled tubes. The COP is determined to be 31.02% greater than the standard reference system. The system also includes a hot water reservoir for multiple purposes. The results could provide valuable insights for improving the thermal efficiency of air conditioning and hot water storage systems.

(Hammadi *et al*, 2018) Shows the impact of summer temperatures on A/C systems energy consumption, leading to increased peak electrical demand. The work employs theoretical and experimental approaches to investigate a hybrid system integrating an evaporative air cooler with a refrigeration unit. Factors like the temperature of water, air mass flow and water rates, and wetted pad thickness were considered. The findings indicate that adjusting the water temperature before a process can improve efficiency by 5-10%.

(Dhamneya *et al*, 2018) This study examines improving the direct evaporative cooling system's thermodynamic performance by expanding the cooling media's size. Examining the effects of inlet air temperature, humidity, and mass flow rate on the cooling medium, it utilizes Aspen fibers media to study the system's behavior pattern. Except for the triangle top flow configuration, the findings indicate that the saturation efficiency is similar for both the newly designed top flow and conventional lateral flow configurations. When contrasted with regular and alternative top flow DECs, the triangle form attained a saturation efficiency of 97% in case I, 88% in case II, 0% in case III, and 89% in case IV.

(Hamed Alhamdo*et al*, 2018) This study investigates the impact of air-conditioning system temperature and pressure on cooling efficiency in hot climates. It uses experimental and theoretical analyses to improve the temperature of the fluid exiting the evaporator. The results show that increasing the water flow rate from 160 to 190 L/h causes an 11.1% increase in COP and a reduction in the temperature of the outlet cooling by 11.3%. However, the optimal rate for enhancing evaporator temperature is determined to be 170 liters per hour. The study uses the Engineering Equation Solver software to analyse experimental data and adjust the water flow rate accordingly.

(Jawale and Keche, 2018) The study compared the performance of R22 and R290 refrigerants in a 1-ton window air conditioner. Results showed that R290 reduced the coefficient of performance by 6.91%, 6.28%, and 1.38% at different temperatures. Using an evaporative cooling condenser with R290 refrigerant optimised the system, increasing the coefficient of performance by 15.84%, 18.23%, and 22.92%. Power consumption was also significantly reduced, reaching almost 50%. Compared to R22, utilising a condenser that cools air through evaporation with R290 refrigerant substantially improves the operational efficiency of the A/C system, resulting in a 70% reduction in the R290 refrigerant charge

(Najim Abid Jassim, 2017) The study investigates the efficiency of a split-system A/C that uses evaporative water mist pre-cooling to increase cooling capacity while decreasing electricity consumption in high-temperature and low-humidity regions. Using water mist in pre-cooling ambient air reduces condensing temperature and pressure, resulting in superior performance to the air conditioner's adiabatic cooling process. The ECAC, which uses water mist pre-cooling, achieved an Energy Efficiency Ratio (EER) of 47% higher than the ACAC in hot and arid environments with 10% relative humidity.

(Ling *et al.*, 2016) An MSHPS was suggested for use in space-saving modular data centres. The system's use of heat pipe technology and an excellent aisle confinement design effectively eliminates heat and prevents hot air passage. The impact of the entrance air and cooling temperature of the water, in addition to the ideal ratio of refrigerant filling, were investigated experimentally. If you want your cooling capacity to be between 6100W and 6200W, the appropriate refrigerant filling ratio is 33% to 42%. During the evaporation process, the system's thermal resistance falls within the range of (0.0028 to 0.0030) k/w. These findings are crucial for developing and managing MSHPS for modular data centres.

(Martínez *et al.*, 2016) The researcher strategically positioned pads of varying thickness within the evaporator to assess the comprehensive efficiency of the A/C. This assessment involved the determination of the overall airflow and energy consumption and identifying the maximum (COP) value. Employing pads with a 100 mm thickness in the evaporator achieved the optimal coefficient of performance (COP). The compressor's energy consumption experienced a reduction of 11.4 %, while the cooling capacity witnessed an improvement of 1.8 %. Additionally, there was a 10.6% increase in (COP).

(Harby *et al.*, 2016) The study examines home cooling systems that use evaporative condensers, emphasising the difficulties and energy requirements. It reveals that evaporative-cooled condensers can reduce power consumption by up to 58% compared to air-cooled ones and improve performance by around 113.4% in cooling systems with capacities (3 to 3000) kW. The study underscores the importance of minimising energy use in vapour compression cooling systems.

(Zhu *et al.*, 2015) Modern buildings are recycling condensate water to save energy and be environmentally friendly. A unique spray system uses cold water to cool the condenser, maximising waste cold use. Small droplets are formed by crushing the thin liquid coating, and they are deposited on the condenser exchanger surface by condensing air. This uniform evaporation across the heated surface allows for efficient recycling of condensate water, shielding it from environmental contamination. This facility also has a positive economic return, reducing CO2 emissions and energy use.

(Liu *et al.*, 2015) The study investigates the cooling performance of a dual-independent evaporative condenser air conditioning system. Variables such as water spray rate, air velocity, compressor frequency, inlet temperature of evaporator water, and air (DBT) affect the cooling capabilities. In Figure 4 the results show that COP decreases with increased compressor and ambient air DBT frequency. When air velocity rose from (2.05 to 3.97) m/s, COP increased by 13.1%, and when the spray rate increased from 0.03 to 0.05 kg/m.s, COP increased by 6.1%.

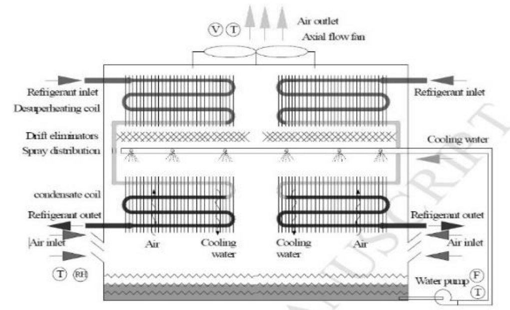

Figure 4: Illustration of the dual-independent experimental evaporative condenser. (Liu *et al.*, 2015)

(Alotaibi, et al , 2015) This study investigates an evaporative cooling design for condensers of air-cooled A/C systems, aiming to reduce energy use in hot countries' weather (exceeding 50° C). The innovation uses a mist system to chill the surrounding air before it passes over the condenser. Two identically sized rooms were built using the same materials and equipped with a new micro split air conditioner from the same manufacturer. The experiment was conducted nine times under various weather conditions. The results showed a 13% increase in the coefficient of performance and an 11% decrease in power usage.

(Islam *et al*, 2015) The operational efficiency of an A/C system utilising a condenser coil cooled by evaporation is investigated in the study. The system improved by 28% compared to traditional units by incorporating sensors and controllers. To investigate the condenser's heat and mass transmission, a theoretical framework was established. The simulated results align with empirical observations; the numerical model offers valuable information regarding the correlation Amidst operational parameters and water film heat transfer properties. The overall heat transfer coefficient is calculated using dimensionless variables.

(Sharma *et al*, 2008) The objective of this study is to reduce energy consumption usage and enhance the efficiency of A/C systems in hot climates, particularly in Middle Eastern countries. By integrating air conditioners with water coolers, the study aims to extract energy from wastewater. The experiment considers factors like Drip Rate, Drip Position, Fan Speed, Amperage, Sucking Temperature, and Humidity. The Results show that running amperage significantly influences performance, suggesting a lower value for optimal performance.

(Yau and Pean, 2014) Investigates the impact of weather variations on the efficiency of an ADB of an A/C system installed in a Malaysian office building.

The study revealed that for each one-degree Celsius rise in outdoor temperature, there is a corresponding decrease of 2% in COP and the overall cooling capacity. However, the SHF experiences a decrease of less than 2%. This study suggests utilising the SLHX technology for cooling machine applications primarily because of its more significant Sensible Heat Factor (SHF).

(Vakiloroaya *et al*, 2014) This research examines the possibility of saving energy by using AC systems that use air cooling to compress vapour, which can be enhanced by incorporating LPA and ECC technologies and a combination of LPA and ECC techniques. Data is collected from a commercial building's direct expansion rooftop package, and performance is predicted using numerical algorithms, observed data, and a mathematical model. The LPA method is more effective at temperatures below (27◦C), while the ECC system is more successful at temperatures over 27◦C. It shows the average saving of energy at 25.3% for LPA, 18.3% for ECC, and 44.2% for combined LPA and ECC approaches.

(Wang *et al*, 2014) Investigate the cooling process that involves using an evaporative condenser To enhance or optimise the COP of an A/C system. It found a negative correlation between DBT and COP. The use of an evaporative cooling condenser led to a drop in saturation temperature, increased refrigerant mass flow rate, and improved COP by 6.1% to 18%. Additionally, the compressor reduced power consumption by 14.3%.

(Dixit *et al*, 2013) This publication presents an experimental study on cellulose pads placed before the condenser to increase the efficiency of the air conditioner. The pad's excellent water wettability and ideal water-to-cooling air contact enhance performance. The design was based on initial studies on cellulose pads' mass transport and heat properties. A 1.5-ton air conditioner was built and tested, with a higher coefficient of performance (COP) than traditional home split air conditioners, which have a standard value of 5.98 but a COP of 8.03 is greater.

(Sarntichartsak and Thepa, 2013) The R-410A inverter air conditioner system was improved through experimental testing and computer research. The system was expanded to 30 to 90 Hz, and a longer capillary tube length was chosen for water temperature. For the purpose of making performance and optimal charge predictions, a leaky inventory model and an integrated model were created. The lowest frequency resulted in an 18.32% increase in COP, while an increased frequency range led to an enhanced COP at 100 l/h, resulting in an efficiency range of 31% to 35%.

(Hao *et al.*, 2013) Evaporative air-cooled chillers (EACCs) combine an Evaporative air cooler equipped with a traditional air-cooled chiller to assess their ability to save energy. The ISEER index is used for this purpose. To optimise the EACC's energy-saving potential, a mathematical model was developed, utilising hourly weather data from four representative Chinese cities. The study found that the ideal pad thickness maximises energy savings, depending on face velocity and climate. The highest saving in energy in China ranges from (2.4% to 14.0%), and the ideal design parameters must be determined based on various climatic conditions. It appears that enhancing the energy efficiency of EACC can be achieved by integrating an air-cooled condenser with a direct evaporative cooler.

(Sawant *et al*, 2012) The rise in the refrigeration and A/C industries has greatly affected the amount of energy that is used. Condenser pressure is crucial for energy-efficient operation. A unique technique, evaporative cooling, uses condensate from the cooling coil for window air conditioner units. Performance testing shows up to 18% improvement in coefficient of performance and 13% energy savings. Locations with mild climate conditions benefit more from the evaporative cooling cycle.

(Jahangeer *et al*, 2011) This study presents a numerical analysis of an evaporatively-cooled condenser's heat transfer properties, focusing on the potential solution of adding water sprays or droplets to air-cooled condensers. The study uses finite difference methods to simulate the condenser's heat transfer properties, with air flowing over the tube and fine sprays applied to produce the thickness of films (0.075, 0.1, 0.15) mm. It is thought that the refrigerant condensation keeps the tube wall temperature constant at the saturation temperature of the refrigerant. When evaporative cooling is used, We find U values up to 2000 $W/m^2.K$ for the total heat transfer from walls to air. There is a good fit between the numerical results and the theoretical and experimental studies.

(Elsayed and Hariri, 2011) A study has investigated the efficiency of a variable-speed condenser fan in a direct-expansion air conditioner as shown in Figure 5. The algorithm controls the flow of air used for heat rejection according to the temperature of the air outside, allowing the fan to run faster when the temperature rises. At 42ºC, the fan can only provide airflow up to (0.43) m^3/s. Depending on the load on the evaporator, the refrigerant flow rate was adjusted using a thermostatic expansion valve and a liquid refrigerant reserve. Researchers found that increasing condenser air flow by 50% reduces compressor power usage by 10%.

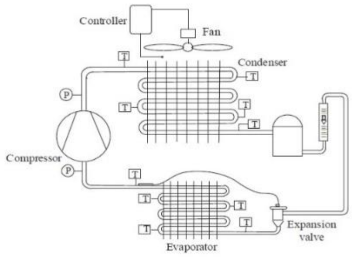

Figure 5: Diagram illustrating the experimental equipment.
(Elsayed and Hariri, 2011)

(Naphon, 2010) The study demonstrates the use of a heat pipe to improve A/C system performance. The copper tube, with three rows, is used to chill air before entering the condenser. The system, with three heat pipe rows, achieves increases in COP and EER of 6.4% and 17.5%, respectively, compared to traditional systems. This study aims to improve air conditioning system performance, reduce energy consumption, and address global warming and environmental concerns.

(Hajidavalloo and Eghtedari, 2010) The study suggests using an evaporatively cooled air condenser in a split-air-conditioning system to improve operational efficiency in high-temperature environments. A new evaporative cooler was integrated with the existing air-cooled condenser, significantly improving performance. The pace of development is positively correlated with an increase in atmospheric temperature. The use of an evaporatively cooled air condenser could decrease power consumption by 20% and increase performance by 50%.

(Elsherbini and Maheshwari, 2010) This study explores the use of shading air conditioning (A/C) equipment's condensers to reduce electrical demand and energy consumption. It evaluates the efficiency of different systems under ideal shading conditions and optimal solar heat gain conditions. Shading theoretically enhances the COP by 2.5%. However, this improvement decreases as temperatures rise. The study also found that condenser shading alone, without evapotranspiration, is ineffective in increasing efficiency or conserving energy.

(Xiaowen and Lee, 2009) A study evaluated the efficiency of a residential water-cooled air-conditioner using a tube-in-tube helical heat exchanger to warm domestic hot water. The study aimed to determine energy efficiency and optimise the design of the helical heat exchanger. The findings demonstrated that the cooling COP increased by at least 12.3% when heat recovery was included, and the comprehensive coefficient of performance reached (4.92L/m) When the flow rate of the tap water was modified to (7.7L/m) liters per minute.

(Chen, Lee and Yik, 2008) This research aims to find out how much energy homes in Hong Kong can save by using air conditioning that uses water-cooled systems. A split type of A/C with water cooling (WAC) and air cooling (AAC) options was tested under various indoor and outdoor conditions. The findings indicated that WACs had a 17.4% higher COP than AACs. The research validated mathematical models for WACs and predicted potential energy savings. An 8.7% reduction in total electricity usage was calculated based on actual construction developments and practical functioning features. The study recommends greater adoption of WACs in subtropical cities.

(Hu and Huang, 2005) This research examines the effectiveness of a Highly efficient residential WCAC that uses cellulose pads as the primary material for its cooling tower. The cellulose pad's favorable water wettability improves the cooling tower's performance, resulting in a consistent water layer and optimal interaction Amid the interaction of cooling air and water. The cooling tower's integration with a Rankine-cycle condensing unit creates an integral outdoor unit. The cellulose pads' heat and mass transmission properties were investigated, and a prototype with a thermal dissipation capability of (3.52kW) was tested. The COP was seen to attain a value of 3.45 across different temperature and air velocity conditions.

(Yu and Chan, 2005) Explore utilising evaporative coolers directly in air-cooled chillers to improve performance. Prior to entering condensers, the coolers chill the air outside, allowing the temperature of condensing to drop (2.1 to 6.2)°C. This results in a (1.4%-to-14.4%) decrease in the power of the chiller and a (1.3%-to-4.6%) Augment in cooling impact. Simulation analysis showed a chiller power savings of 1.3-4.3% when the chiller operates under condensing temperature control, enhancing condenser effectiveness. However, in some conditions, the decrease in power of the compressor exceeds the increase in power of the additional condenser fan, a situation caused by the pressure drop across the cooler.

(Hajidavalloo, 2007) showed that The preservation of energy is a vital consideration in the vapor compression refrigeration cycle, especially in areas with exceedingly high temperatures (almost 50°C). Window air conditioners with air condensers perform poorly in these conditions, leading to increased electricity usage. This article introduces a novel design integrating evaporative cooling into the

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window air conditioner condenser with commercial potential. Two cooling pads saturated with water are inserted into an air conditioner to test the concept presented in Figure 6. The experimental results demonstrate that the thermodynamic properties of the new system have been significantly enhanced, with a 16% decrease in consumption of power and a 55% increase in COP.

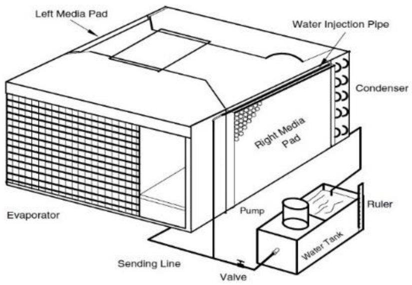

Figure 6: Illustration depicting the modified air conditioning system. (Hajidavalloo, 2007)

4 CONCLUSION

This review highlights the potential for improving cooling system air conditioning arrangements, particularly in regions with extreme temperatures like the Middle East. By focusing on reducing heat effects on the condenser through enhancements aimed at increasing the Coefficient of Performance (COP), our analysis suggests significant improvements in system efficiency and energy consumption. Utilizing a water-cooled cycle emerges as a promising strategy to achieve these goals, offering both technical and economic benefits. Overall, our findings underscore the importance of ongoing innovation to develop more resilient and sustainable cooling systems capable of meeting the challenges of extreme climates.

Abbreviations

DBT	Dry-Bulb-Temperature
A/C	Air Conditioning
MSHP	Multi-Split-Heat-Pipe-system
ADB	Air Cooled Duct Blower
SHF	Sensible Heat Factor
SLHX	Suction Line Heat Exchanger
LPA	Liquid Pressure Amplification
ECC	Evaporative Cooled-Condenser
ISEER	Increase Seasonal Energy Efficiency Ratio
EER	Energy Efficiency Ratio
WBT	Wet-Bulb-Temperature
WCAC	Water-Cooled-Air-Conditioning

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