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A COMPREHENSIVE REVIEW ON DESICCANT MATERIALS, LIQUID DESICCANT DEHUMIDIFICATION AND ITS SIMULATION TOOLS

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Abstract:
Conventional VCR air conditioner needs a cooling coil temperature below the dew point temperature to condense water in hot and humid climates for maintaining comfort conditions. The additional vapour results, in more consumption of electrical energy relatively due to lower dew point and reheating of air. Desiccant cooling systems can run on low-grade energy which can easily be drawn from solar energy so that it is an alternative to conventional vapor compression systems having high humidity control and high energy efficiency. The main components of the liquid desiccant cooling system are the dehumidifier and regenerator. This paper reports the research and development in liquid desiccant material, liquid desiccant dehumidifier mechanism assisted with indirect-direct evaporative cooling technologies. First, a basic description of the principle of operation for desiccant cooling systems and its classification with hybrid systems is reported. Next, liquid desiccant dehumidification systems are included and discussed with direct evaporative and indirect evaporative cooling systems. The papers also review the correlations for mass transfer coefficient and moisture effectiveness of dehumidifier/regenerator to enhance their mass transfer performance and the Simulation of desiccant cooling-based air conditioning systems using different simulation software technology so that it can be used for estimation the Building Energy Performance. However, the simulation and analysis of desiccant cooling systems remained complex and demanding due to the limited resources of Liquid desiccant cooling system simulation tools.

Nomenclature

CFD	Computation Fluid Dynamics	m_a	Mass flow rate of air
VCR	Vapor Compression Refrigeration	m_s	Mass flow rate of solution
TEG	Triethylene glycol	h_a	Enthalpy of air and
HVAC	Heating Ventilation and Air conditioning	h_s	Enthalpy of solution
LiBr	Lithium Bromide	Q_{cm}	Heat capacity of cooling medium
LiCl	Lithium Chloride	ω_a	Specific humidity of air
Cacl₂	Calcium Chloride	X	Solution mass concentration.
HEx	Heat Exchanger	w	Humidity Ratio
TRNSYS	Software tool name	a	Denotes the air
MATLAB	Software tool name	i and o	The inlet and outlet
d_e	The equivalent diameter of the Dehumidifier/Regenerator	D_a	Air diffusion coefficient
ρ_a	Air density coefficient		

1. Introduction

Statics have shown that the energy consummated globally is most likely to rise by 50.0%, from 2010 to 2050. It can be seen that the building sector consumes more than one-third of the predicted global energy consumption [1]. Moreover, its demands are increasing by more than 0.55% annually since

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2017. This is higher than the demands of the other end-use sectors. The worldwide energy utilization is relied upon to increment by half, inside the period of 2010 to 2050, as shown in Fig. 1. The carbon-di-oxide (CO2) discharges coming about because of such increment in the worldwide energy utilization are additionally expected to increment by 10% from 2017 to 2050 [1]. Due to the increasing lifestyle of humankind, urbanization has been increasing day by day so that peoples are likely to live inside buildings. It was seen by the survey that Individuals spend 70.0–90.0% of their lives with inside structures [2]. This is because of the increment in

(i) Degree of cooling days (ii) Financial development (iii) Reasonableness (IV) Population (v) Urbanization (VI) Maturing (viii) Disease

The impact of cooling degree days (environmental change because of an Earth-wide temperature boost) is more in India when contrasted with different nations. Accordingly, the energy interest in space cooling in India is relied upon to increment fundamentally, as portrayed in Fig. 1 [3]. The desiccant dehumidification method is an energy-efficient and environment-friendly system that can meet the aforementioned dual challenge. More than 90.0% of the current demand is fulfilled by (VCR) Vapor compression refrigeration systems for space cooling but this technology is energy inefficient in controlling the humidity [4-5].

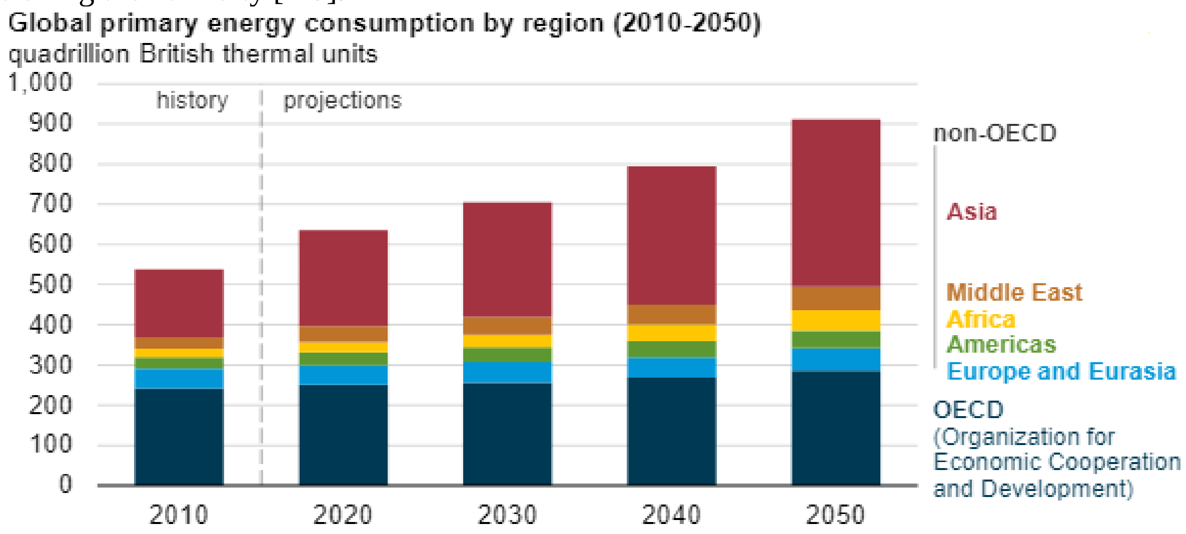

Fig: 1. Global energy consumption by different source [1]

With the improvement of individuals' expectations for everyday comforts, the popularity of thermal comfort in indoor conditions has gotten dire and exact. The thermal comfort of the body is influenced by components, for example, indoor temperature, metabolic rate, relative humidity, and air velocity [6]. In a Vapour compression system, the outside air is first cooled up to the dew point temperature for dehumidification and afterward heated before being conveyed into the cooling space, which is a misuse of energy. To maintain a strategic distance from the heating procedure and improve the vitality of energy efficiency of the entire HVAC system, it has been recommended that the sensible and latent load can be managed independently [7-8]. Solar-assisted desiccant cooling is a promising technology which mainly based on absorption and adsorption phenomena, currently in practice Utilizes low-grade energy, less dependence on non-natural working fluids, and low to medium regeneration temperature. The solar-assisted liquid desiccant cooling system is a unique technique for the accommodation of latent and sensible loads separately compared to other air conditioning technologies. Desiccant material plays a vital role in the accommodation of latent load. Solid or liquid desiccants are used to absorb or adsorb the water vapors from the air due to the difference between the vapor pressure of water on the desiccant surface [9].

The desiccant materials are used to absorb water vapour from air; subsequently, it very well may be named as solid and liquid desiccants. Solid desiccant materials can hold water vapour, e.g., silica, polymers, zeolites, alumina, hydra table salts, and combinations. A few kind of liquid desiccants are solution of calcium chloride, lithium chloride, lithium bromide, tri-ethylene glycol, and a combination of half calcium chloride and half lithium chloride. These liquid desiccants have regular general properties; however their necessities can't be completely tended to by any single desiccant. These prerequisites incorporate low vapour pressure, low viscosity, high density, low regeneration temperature, low crystallization point, and low cost. The water vapour of outside air is removed due to vapour pressure difference of outside air and desiccant material which is generated by making contact of outside air with liquid or solid desiccant, after this to give reasonable cooling to dehumidification measure, conventional vapour compression system, what's more, vapour retention, immediate or circuitous evaporative cooler units utilized. At the point when the arrangement is debilitated by retention of dampness, it sends direct to recovery cycle to deliver the dampness by utilizing an outer warmth assets. This is classified "reactivating" the desiccant [10]. Heat energy, at a temperature as low as 40–50 ◦C needed for recovering of the fluid desiccant can productively acquire utilizing a level plate gatherer [11] The desiccant materials are used to absorb water vapor from the air; subsequently, they very well may be named solid and liquid desiccants. Solid desiccant materials can hold water vapor, e.g., silica, polymers, zeolites, alumina, hydra table salts, and combinations. A few kinds of liquid desiccants are the solution of calcium chloride, lithium chloride, lithium bromide, tri-ethylene glycol, and a combination of half calcium chloride and half lithium chloride. These liquid desiccants have regular general properties; however, their necessities can't be completely tended to by any single desiccant. These prerequisites incorporate low vapor pressure, low viscosity, high density, low regeneration temperature, low crystallization point, and low cost. The water vapor of outside air is removed due to the vapor pressure difference between outside air and desiccant material which is generated by making contact of outside air with liquid or solid desiccant, after this to give reasonable cooling to dehumidification measure, a conventional vapour compression system, what's more, vapour retention, immediate or circuitous evaporative cooler units utilized. At the point when the arrangement is debilitated by retention of dampness, it sends directly to the recovery cycle to deliver the dampness by utilizing outer warmth assets. This is classified as "reactivating" the desiccant [10]. Heat energy, at a temperature as low as 40–50 ◦C needed for recovering the fluid desiccant can productively acquire utilizing a level plate gatherer [11]

1.1 Liquid desiccant materials

Liquid desiccant materials assume significant jobs in the general execution of the desiccant cooling system. Along these lines, it becomes very important to check the performance-based quality of the liquid desiccants to choose the best desiccant solution for the dehumidification process. Natural dissolvable aqueous salts solution and inorganic liquid salt solutions are two types of liquid desiccant materials, The Natural dissolvable aqueous salts solutions are ethylene glycol, diethylene glycol, triethylene glycol (TEG), and inorganic liquid salt solutions, for example, calcium chloride, calcium bromide, lithium chloride, and lithium bromide, are broadly utilized [13].

Triethylene glycol arrangement was used in a solar energy-assisted liquid desiccant cooling system's results showed that Triethylene glycol is a good desiccant solution for the cooling system, due to having a boiling temperature very close to water. It was observed in experimental work that Triethylene glycol can easily evaporate into the processed air and liquid desiccant carryover is taken place hence Triethylene glycol is not suitable for liquid desiccant cooling applications [14-15].

An inorganic salt solution including lithium chloride, lithium bromide, calcium chloride, and potassium formate is broadly examined and applied in different liquid desiccant dehumidification systems. The performance of a liquid desiccant dehumidification process relies significantly upon its vapor pressure. The major driving force for the moisture desorption process in the regenerator or moisture absorption process in the dehumidifier is the difference in the partial pressure of water vapour in the air and the vapour pressure of water above the desiccant solution [16]. Even though the test results demonstrated Triethylene glycol is a decent desiccant for the cooling system because Triethylene glycol has a boiling temperature near water boiling temperature. Triethylene glycol can evaporate the water vapour easily without much stretch and vanishes into the processed air. Therefore there is a carryover of liquid desiccant solution with the humidified air in a conditioned space. This liquid desiccant carryover makes Triethylene glycol unsatisfactory for liquid desiccant cooling applications. The lower vapor pressure dehumidified the outlet air effectively and along this, the desiccant performs better. Table 1 shows the tentatively acquired vapor pressure under different temperature conditions for LiCl, LiBr, and CaCl2.

1.2 Liquid desiccant (Aqueous Salt) vapour pressure [17, 18, 19]

Material	Concentration	Vapour pressure			
		298.15K	303.15K	308.15K	313.15K
$Cacl_2$	35		2.78		3.63
	40		2.55		3.13
	40	2.1	2.53	2.86	3.14
	43		2.2		2.8
LiBr	31		3.11		3.67
	38		2.9		3.47
	40	2.45	2.82	3.08	3.35
	44		2.57		3.14
LiCl	30		2.2		2.79
	40		1.79		2.41
	40	1.48	1.74	2.3	2.41
	44		1.47		2.1

Triethylene glycol was the earliest utilized halide salt solution. Anyway, its application is restricted by its high viscosity, which could bring the issue of unstable working results liquid residence. It was uncovered in [20] that glycol is unstable because of its low surface vapor pressure. As an outcome, glycol isn't reasonable for cooling applications as the system cost could be raised drastically because of glycol being volatilized into the adapted space. Moreover, [12] called attention to that the dehumidification of air came to by utilizing 96% triethylene glycol can be accomplished by applying 42% LiCl, which means the molar grouping of glycol noticeable all around would be 1% that of the water vapor. As an outcome, the yearly loss of triethylene would be fundamentally high. Lithium chloride (LiCl), Calcium chloride (CaCl2), and Lithium bromide (LiBr) are three of the most generally utilized halide salt desiccant arrangements as of late. Sun et al [21] and Ahmed et al [22] estimated the thermodynamic properties of these desiccants, and they found that among these halide salts, lithium chloride (LiCl) arrangement is the most steady fluid desiccant, which offers the least water fume weight and parchedness fixation 30-40%. Anyway, the expense of LiCl is generally high.

2. Desiccant Dehumidification

In hot and humid climate conditions, the sensible load can be accommodated by a cooling coil and the latent load (as additional water vapour in the outside air) can be managed by utilizing different methodologies, for example, strong desiccant dehumidification, electrochemical dehumidification, and liquid desiccant dehumidification [23]. Among these techniques, liquid desiccant dehumidification has attracted consideration in late years on account of its capacity to control moisture precisely and its incredible energy-saving potential. Not at all unlike VCRs, which depended vigorously on electric energy utilization. The liquid desiccant cooling system can work with low-grade renewable energy sources. A few examples of such energy are solar energy, geothermal energy, and waste heat in power plants [24], Results show that Liquid desiccant cooling technology improves the system's energy efficiency. The liquid desiccant cooling system has the capability of energy saving up to 30%–50% as compared to conventional vapour compression refrigeration systems [25].

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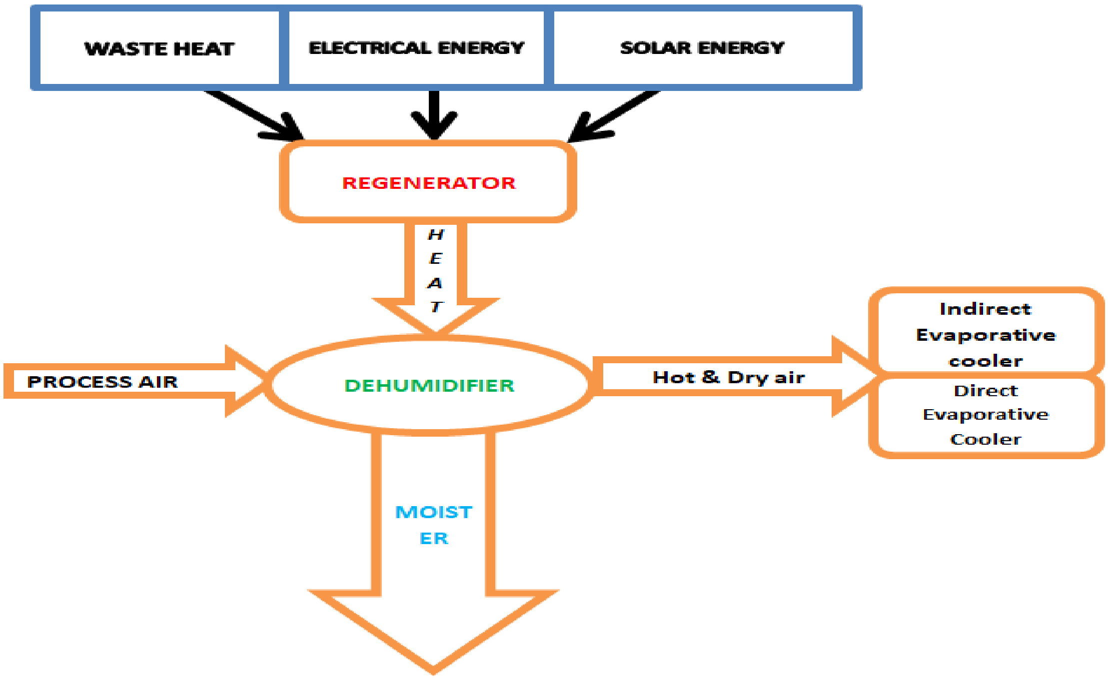

Fig: 2. Principle of desiccant cooling system

In recent decades, immense work has been carried out on the thermal properties of liquid desiccants, heat, and mass transfer characteristics in dehumidifiers/regenerators and system energy efficiency analysis. The liquid desiccant dehumidification approach has become a research hotspot due to its various merits and promising application prospects [26]. Research work shows many prospects for liquid desiccant cooling systems such as liquid desiccant materials, experimental investigation on heat and mass transfer components of dehumidifier/regenerator, mathematical analysis for dehumidifier/regenerator [27], and regeneration of liquid desiccant using renewable energy [28].

The survey of the literature shows that the liquid desiccant cooling system has procured restored interest in the ongoing past. Nonetheless, one of the significant impediments of such frameworks is the entrainment of the desiccant droplets into the supply air stream generally at a high desiccant stream rate when the exhibition is required to be better, which brings about consumption, genuine medical problems, and monetary misfortunes. This primarily happens on account of direct contact between liquid desiccant and air in the normally utilized setup of dehumidifiers. In a large portion of the endeavors made up until this point, the remainder in direct contactors is confined chiefly by controlling arrangement wind current rates and additionally utilizing mist eliminators.

Liquid desiccant cooling system consists about the following components.

1. Dehumidifier (Direct Contact type, Package Bed type and Indirect Contact type)
2. Regenerator (Parallel flow, Cross Flow and counter flow type)
3. Heat exchangers (Water to liquid vice-versa desiccant heat exchangers)
4. Evaporative cooler (Indirect and direct Evaporative cooler)

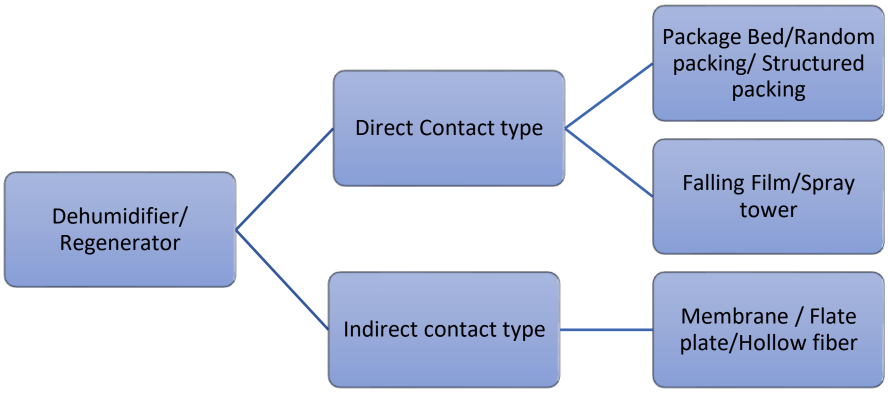

Fig.3 Classification of Dehumidifier and Regenerator

The main component of liquid desiccant dehumidification system is dehumidifier and Regenerator. Dehumidifier is used to absorb the water vapour from atmospheric air because of pressure difference between desiccant and water vapour present in processed air.

The working standard of the dehumidifier is as per the following: When the water vapour pressure in air is higher than the saturation pressure of the desiccant, the vapour diffuses through the air-desiccant interface and gets assimilated in the desiccant, liberating the heat (latent heat of condensation and heat energy of mixing). The working rule of the regenerator is the equivalent aside from the water vapour stream course. The dehumidifiers and regenerators are comprehensively arranged regarding: (I) contact type (ii) number of streams and (iii) number of stages.

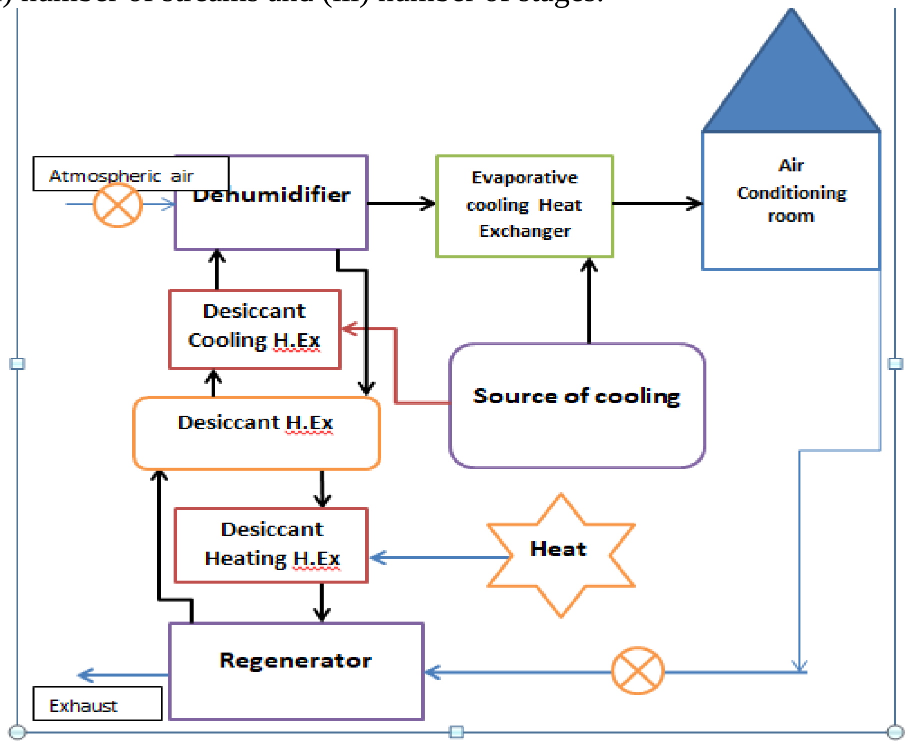

Fig.4 Diagram of Liquid desiccant cooling system

3. Different Dehumidifier Mechanism based on Heat and Mass flow

The dehumidifier and Regenerator are the most important components of liquid desiccant dehumidification and cooling system. The spray type and packed-bed type dehumidifier and regenerator are in shown in Fig. 4 were first adopted and studied. Nonetheless, because the splash type has the intrinsic disadvantages of low efficiency and a significant issue with liquid desiccant carryover with air, it was anything but a reasonable contender for LDCS [30]. Researchers found that the two

sorts of packing materials normally utilized in packed beds are irregular and structured packing. It is observed that Contrasted and the packed bed filled with random packing, the one with structured packing has high efficiency and high capacity of heat and mass flow. It results from the smaller drop in air pressure drop during dehumidification/regeneration [31].
Even though the packed bed type dehumidifier/regenerator is broadly contemplated on account of its basic arrangement and the huge contact area between the air and the solution, a few drawbacks incredibly confine their utilization. Researchers found that the pressure drop on the air side is high when air flows through the packed bed section. Additionally, liquid desiccant carry-over could happen under high air flow rates, which is an extraordinary danger to indoor air quality. Besides, during the dehumidification cycle, latent heat delivered by water vapor absorption is predominantly consumed by the liquid desiccant. Accordingly, the solution temperature increases bit by bit along the flow direction, which diminishes the dehumidification execution. Comparable issues are additionally expected to happen in adiabatic regenerators.
Researchers developed a membrane-based dehumidifier/regenerator to maintain a strategic distance from the liquid carryover as shown in Fig. 4. Researcher utilized the permeable membrane with solid selectivity to isolate the liquid desiccant and air absolutely during the dehumidification or regeneration process. To defeat the deterioration performance, the researcher proposed the internal cooling/heating dehumidifier/regenerator, [33]. Not the same as the stuffed bed type that works under adiabatic conditions, the inside cooling/warming sort is cooled/warmed during the dehumidification/recovery measure, which can enormously improve the warmth and mass exchange execution [34]. The weight drop of the air can likewise be diminished, just as the liquid desiccant vestige.
The random-packed bed was first utilized as a dehumidifier/regenerator in LDCS. Packing materials without customary geometric configurations, for example, pall rings and stepping stool rings are set haphazardly in the random-packed section. The arbitrary placement of packing materials could bring about unwanted and wild dissemination of liquid desiccant on a superficial level. Issues experiences, for example, low solution flow rates may happen under wall flow and channel flow [35]. The flow resistance of air is normally high, which relates to the high power utilization of air fans. To conquer such downsides, structured stuffed beds with higher effectiveness and smaller flow resistance of air were created [35]. Factors, for example, volumetric region, void volume, and space stretch assume significant parts in the assurance of warmth and mass exchange execution [36]. The principle technique to improve the heat and mass exchange execution in a design-packed bed is underlying streamlining. Some new sorts of organized packing materials with high explicit surface territories and unique arrangements, for example, creased cellulose type [37], plant fiber type, and Z-type [38] have been utilized to get attractive dehumidification/recovery execution.
As a result of the idle warmth discharge/ingestion during dehumidification/recovery, the arrangement temperature expanded/diminished bit by bit, and this enormously crumbled the mass exchange execution. Consequently, analysts built up the inner cooling/warming sort to conquer the temperature variety by presenting an additional chilly/heat source. The dehumidifier/regenerator with inside cooling/warming is generally developed as a falling film.

3.1 Governing Equation and Performance evaluation

Based on previous studies, the heat and mass transfer models can be expressed as follows.

(i). The energy and mass conservation equations

$$m_a dh_a + d(m_s h_s) + dQ_{cm} = 0 \quad (1)$$

m_a - Mass flow rate of air, **m_s** - Mass flow rate of solution, **h_a** - Enthalpy of air and, **h_s** -enthalpy of solution.

$$m_a d\omega_a = dm_s \quad (2)$$

$$d(m_s X) = 0 \quad (3)$$

Q_{cm} -Heat capacity of cooling medium, **ω_a** -Specific humidity of air, ***X*** -solution mass concentration.
The heat and mass transfer equations between air and solution can be expressed

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$m_a d\omega_a = K_m F_m(\omega_a - \omega_e)\frac{dx}{H}$

$c_{pa} m_a dt_a = K F_m (t_a - t_s)\frac{dx}{H}$

***(ii).* Absolute moisture Difference Δw:**

$\Delta w = w_{ia} - w_{oa}$ (4)

Here, ***w*** is the Humidity Ratio. ***a*** - denotes the air and ***i*** and ***o*** represents the inlet and outlet respectively.

(iii) Moisture Effectiveness (η_m)

$\eta_m = \frac{w_{ia} - w_{oa}}{w_{ia} - w_{ea}}$ (5)

Here w_{ea} is the equilibrium humidity of the air, the moisture Effectiveness consists about the ratio of actual moisture removal to the maximum possible moisture removal.

(3) The rate of Moisture removal (Δ*m)*:

$\Delta m = m_a (w_{ia} - w_{oa})$ (6)

Here m_a is the air mass flow rate,

Moisture removal rate consist about the amount of moisture absorbed from the air per unit time.

(4) Enthalpy Effectiveness (η_h):

$\eta_h = \frac{h_{ia} - h_{oa}}{h_{ia} - h_{ea}}$ (7)

Where h is the enthalpy and h_e represent the enthalpy of the air under equilibrium with the inlet desiccant solution at its temperature and density.

(5) Mass transfer coefficient h_m

$h_m = \frac{m_a}{A}\left(\frac{w_{ia} - w_{oa}}{w_{ia} - w_{ea}}\right)$ (8)

Here ***A*** is area of contact of air and solution. The heat transfer coefficient h_m means the moisture absorption rate per unit area and time.

(6) Dimensionless Sherwood number **(S_h):**

$S_h = \frac{h_m d_e}{\rho_a D_a}$ (9)

Here d_e- the equivalent diameter of the Dehumidifier/Regenerator, ρ_a - Air density coefficient and D_a - Air diffusion coefficient.

4. Simulation desiccant cooling system

4.1 TRNSYS Software

As per the literature review both TRN-SYS and MAT-LAB can be utilized to demonstrate and analyze a solar energy-assisted desiccant cooling system. TRN-SYS has a module system having a huge component in its library that can model its system. TRN-SYS is used to model and simulate the performance of buildings and transient systems. Each component is demonstrated as a secret element with the sources of info being changed into yields utilizing conditions taken from trial estimations and system distinguishing proof [39]. The product TRN-SYS has been utilized to contemplate the viability of the solar-based cooling system in a wide range of areas and setups. In Egypt, a solar energy-assisted liquid desiccant cooling system was researched utilizing a TRN-SYS for the progressions that happen with the different solar energy collector's areas. The research shows that as the solar energy collector's area increases both the performance of the regenerator and the flow rate of water increase simultaneously [40]. Baniyounes et al. [41] used TRN-SYS technology to simulate a solar energy-assisted desiccant cooling system to show its potential application in the Australian Climate. It was discovered that the solar energy-assisted liquid desiccant cooling system could maintain comfort conditions using lower energy consumption and emissions [41]. An investigation of a solar-powered assisted cooling system in Pakistan utilizing an absorption chiller was conducted by adopting the TRN-SYS facility and it was discovered that the temperature of the normal house could be kept up inside comfortable condition with a hot water storage tank and cylindrical evacuated tube collector's area of (12.02m2)[80]. A study by Fong et al. was done on a solar power-assisted desiccant cooling system in a common room to show its feasibility in Hong Kong. The system created a greener answer for conventional refrigeration systems depending on the performance of solar fraction and the coefficient of performance of the system [42]. Zendehboudi et al. contemplated a solar power-assisted desiccant system in various territories of Iran utilizing the TRN-SYS tool of simulation. They found that the performance of a desiccant system depends on the surrounding air humidity as the higher the ambient air humidity ratio the lower the COP [43]. Utilizing the TRN-SYS software tool the impact of dehumidification limit on the adequacy of a solar energy-assisted desiccant system in Malaysia was considered. Four arrangements were simulated it was presumed that a high dehumidification limit prompts an expansion in the presentation of a solar energy-assisted desiccant system and increases its capacity to give thermal comfort conditions in buildings [44]. The utilization of TRN-SYS as a simulator tool to evaluate the performance of the desiccant cooling system has been generally explored and reported as appeared above with various investigations in many climate conditions. The software has additionally been approved by correlation with exploratory arrangements for instance Martinez et al. displayed a committed open-air system with a desiccant wheel in TRN-SYS and afterward planned a test setup to approve the same model utilizing the root mean square method [45].

4.2 MATLAB Software

MATLAB is an elite register language just as a numerical investigation condition and is regularly utilized to show the solar-powered desiccant cooling system or simply individual segments of it [46]. MATLAB Simulink is a graphical instrument that was initially produced for controlling systems and is one of its numerous current applications [47]. The utilization of MATLAB in the displaying and recreation of the desiccant system are discussed beneath. Aly et al. utilized MATLAB to demonstrate a solar power-assisted desiccant regenerator to explore the impact of various conditions remembering working boundaries and surrounding conditions for the exhibition of the system. A limited diverse methodology was utilized for improvement and desiccant materials were seen during the analysis [48]. Parmar and Hindoliya built up a model utilizing a neural system, MATLAB test system, and trial information to assess a desiccant wheel from the cooling system. The model would then be able to be utilized to foresee explicit dampness and the temperature at the outlet of the framework [49].

Li et al. led an investigation on a cross-flow liquid desiccant regenerator utilizing MATLAB to illuminate the control conditions. The limited contrast strategy was utilized, exploratory outcomes were acquainted with the model and it was discovered that an ideal number of mass exchange units relied upon the working conditions [50]. The displaying of a desiccant wheel was done utilizing MATLAB by Nia et al. Test results from distributed works were utilized to approve the model and the model was utilized to create connections between outlet conditions and inlet parameters [51]. MATLAB is additionally consistently used for the computation of conditions from numerical models as Islam et al. [52] used to unravel customary differential conditions when examining mass and warmth move in fluid desiccants corresponding to cooling and dehumidification. TRN-SYS MAT-LAB co-test system can be utilized largely to permit control systems to be mimicked for the system as a rule in MATLAB. In a solid desiccant system with a desiccant wheel, the angular speed can be controlled for a comparable impact [53].

Conclusion

The liquid desiccant air conditioning system is considered a promising energy-efficient and environmental-friendly alternative to the conventional vapor compression refrigeration system (VCR). A liquid desiccant air conditioning system with VCR is mostly studied as a hybrid air conditioning system due to its efficient control of indoor conditions. This paper presents a review of the research and development in liquid desiccant material, and different dehumidification mechanisms assisted by indirect-direct evaporative cooling technologies. Salt-based desiccant materials have higher water vapor absorption capacity than organic compounds such as LiCl, LiBr, and CaCl2. The liquid desiccants materials, most commonly adopted so far are LiCl, LiBr, and CaCl2. Ionic liquids are assumed as a good alternative due to their most liked properties as no corrosion, low pressure of vapor, and low temperature of regeneration. The packed bed type dehumidifier has a higher mass transfer potential rate than that of the other types of dehumidifier, but the packed bed dehumidifier has a liquid desiccant carry over the problem. Membrane-based dehumidifiers overcome the problem of desiccant carryover by introducing a microporous or corrugated membrane between the air and the desiccant. The mass transfer performances of the internally cooled dehumidifier and heated regenerator are higher than that of the respective adiabatic one. The energy-saving potential of LDAS is significantly better in humid areas.

Both TRN-SYS and MAT-LAB are used widely to analysis the performance of desiccant cooling systems as co-simulator in different climate condition and in the research field of desiccant dehumidification. It was observed that use of MAT-LAB to analyze desiccant dehumidification process has been documented and researched widely. But The TRN-SYS and MAT-LAB as co-simulator has observed very less in research and analysis the performance of Desiccant cooling system.

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