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Liquid Desiccant Dehumidification and Cooling System: A Review

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Abstract— **Liquid dehumidification was shown to be an efficient way of extracting air moisture with comparatively minimal energy. Draining cooling systems have been given significant attention in recent years because they are capable of using little thermal energy. The potential for hybrid cooling (HCS) as well as simulation results shows the benefits of this system in comparison with traditional vapor compression systems (VCS). When one tone of the compressor is employed in an HCS instead of VCS the cooling impact and COP increase in the HCS by 60 percent and 45 percent correspondingly.**

Keywords—Liquid desiccant, Dehumidification, Cooling, Lithium chloride.

I. Introduction

Conventional cooling and air conditioning systems use significant quantities of power and control more than 25% of China's overall energy usage. Thermal comfort, indoor air quality, energy efficiency and the accompanying environmental impact are key design objectives for air conditioning systems. The Department of Energy of the US states that one of the biggest power customers accounts for 15 percent of total cooling (air conditioning and cooling). Climate control plays a crucial part in both sensitive and latent cooling loads in hot and damp areas. The LDDS is an alternative to mechanical air conditioning. LDDS is the most effective solution. The major benefits of the LDDS are energy savings through the transition from power to renewable or low-quality energy. For human life and societal growth, including agricultural and industrial operations, air conditioning and freshwater are critical. Due to its energy conservation and environmentally benign character, P. Anandalakshmi et al [1] in 2020 noticed in dehumidify modules. Sorption devices that operate on low-grade heat that may be supplied with solar energy [2] are among the most important cooling methods. In this work, a unique external air system is presented for the treatment of air supply using lithium chloride as a liquid desiccant [3]. The results indicate that the DOAS is better suited for hot and wet climates [4]. The air supply may be controlled independently for temperature and humidity and has a large air/drought contact area [5]. The system mainly consists of a dehumidifier, a regenerator, an evaporative cooler and an air-to-air heat exchanger. It is worth noting that the solution concentration ratio plays a considerable role in the system performance [6]. Recent research subjects include mixed solvent drying substances. In this research, a thermodynamic study was performed on dehumidification of the hybrid membrane and a cooling system of the dew-point evaporation [7]. The momentum, continuity, energy and species equations were developed into a complete mathematical model [8]. With a maximum difference of ±5,0% [9], the model was able to predict the experimental results satisfactorily. The supply air might be adjusted in the proposed thermal comfort area of 20.0–28.0 °C with a moisture ratio of under 12.0 g/kg.

It allows separate air humidity and temperature management, thereby carefully decoupling latent and sensitive heat loads. A revolutionary dual product solar-powered cooling and water system based on the absorption cooling cycle. Enhanced energy and performance [10] have been shown by the system.

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P. Mohandes et al. [11] To study the system a simultaneous heat and mass transfer dehumidification process is necessary and dependable transfer coefficients are necessary. Two distinct ways for eliminating the surplus heat are examined in this paper: the addition of a cooled air condenser in the regeneration air pipeline's entry or output and the water condenser system fared the best amongst all the systems examined [12]. Structural enhancements, for example, structural modifications, ultrasonic atomization, cone module modification and liquid dehydration, including adding surfactants and nanoparticles, are included in the approaches [13]. In-house cooled liquid dehumidifier systems in the sector of air-conditioning are considered small and efficient [14]. A unique 3D simulation model to examine the liquid drying performance of a decaying film Dehumidifier [15] was effectively created in this work. The simulation showed that the performance of dehumidifying was directly associated with air moisture, speed, temperature solution, center, temperature and contact angle [16]. To account for the interface dehumidification process [17], the penetration mass transfer model was employed in the simulation. In recent years the development of energy-efficient hybrid air conditioners, especially for tropical climates, has received substantial attention from desiccant-based dehumidification [18]. This study covers the current research on fluid desiccant air from humidifiers [19] in a complete literature review. Emphasis on component, system and material handling methods [20]. The energy consumption for the management of interior humidity, especially in tropical and subtropical countries, is significant [21]. The findings suggest that the range of performance coefficient is between 2.6-2.9, which is 30-40 percent greater than heat pump heating combined with a humidifying electric heater [22]. To provide a greater centrifugal artificial force than gravity, a redesigned liquid dehumidification method was proposed [23]. The system was built, troubleshooting and field tests were performed in the summertime [24]. Two key difficulties, i.e., the performance of the system and an increase in air temperature, have been identified as indicators for assessing the system's performance [25]. A recent article shows that the system is a success, a fresh study and a new set of results are required. In this situation, the system is defined as "the perfect match." It has been described for the first time as "temperature-sensitive" Dehumidification of liquid desiccant is an excellent means of humidity extraction. It uses less energy than standard methods. A good desiccant should better absorb moisture and reduce regeneration temperature [26]. This paper examined a unique internally cooled dehumidifying ultrasonic atomization system (IC-UADS). A model was constructed for performance prediction based on the conversion laws of mass and energy and the sensitive heat balance. A counter-flow HPLD system is the subject of the present study [27]. This research presented a two-story dehumidifying fluid-drying system driven by electricity and low-temperature heat. Calcium chloride solution is used as a desiccant which is dehumidified immediately by external air. Geothermal energy Shallow is clean, renewable energy that is around 3–50 m deep down below the earth's surface. This research discusses and examines existing air conditioning technology for hybrid liquid desiccants. For the prevision of the performance of the adiabatic counter – the liquid dehumidifier/regenerator flow a two-dimensional thermal model is presented. The effect of the air moisture ratio is thoroughly investigated 28]. Modeling and simulation of dehumidifier seem to be essential since they enable the assessment of the operability and performance of a greenhouse. Membranes with holes, such as low weight, corrosion resistance and no liquid gout conveyor are of major benefit. The hollow fiber membranes are lighter, corrosion-resistant, and of low weight compared to conventional porous media or packing towers in dehumidification applications. In this work, the VOF (fragment volume) and RNG (group of renewal) k-verte turbulence models for the counter-current flow from the LDD were developed. In this work, a hybrid approach is devised that combines electrodialysis with a thermal technique of dehumidifying fluid desiccant. Simulations under three distinct weather conditions conducted the feasibility evaluation of the technology proposed [29].

II. PROBLEM IDENTIFICATION

Research outlines the dehumidification procedures with all possible alternatives in a simple and understandable approach today. The revolving wheel, thanks to its high-surface wave design, is the most commonly used for solid desiccant. As a fluid desiccant in the system, calcium chloride solution costs less and is non-toxic. When using an HCS compressor of 1 tonne instead of a traditional vapor compression system, the cooling effect and the COP of HCS improve by 60% and 40% respectively. HCS costs are anticipated at around $400 per TR (Rs 20,000 per TR) The HCS system may be developed between 0.5 TR and more than 100 TR. It's quiet, with no noise sprinkling or spraying. Low usage of electricity.

III. Experimental Performance Of A Liquid Desiccant Dehumidification System Under Tropical Climates.

The US Energy Department says that cooling (air conditioning and cooling) is one of the top consumers of power. This level is bound to burgeon as people improve their living. Current energy crises, climate change and rising needs for air conditioning have produced the need for renewable energy technology. Sorting technologies that function with low-level heat can be supplied by solar energy are the most important cooling technology.

IV. Control Performance Of A Dedicated Outdoor Air System Adopting Liquid Desiccant Dehumidification

The separate temperature, wet and ventilation controls in buildings can be implemented in dedicated external air systems (DOAS). In comparison to typical climate control systems, the system can deliver a healthier and more pleasant interior environment and energy savings. The DOAS comprises largely of a membrane heat exchanger, a dehumidifier, a regenerator and a dry refreshing coil. It is better for hot and humid regions than for energy efficiency systems up to 19.9–34.8 percent. There are various components to the proposed liquid desiccant-based DOAS. On basis of simulation testing, the control performance of the DOAS will be examined. In the open literature, the modeling methodology was not revealed for this novel system. The findings of an investigation of partial energy efficiency are practical and beneficial for applications.

V. Results And Discussion

The calcium chloride and lithium chloride desiccants were used in two sets of studies. Varying heating, desiccant rate and ambient conditions yielded different working conditions. The dehumidifier is connected to the dehumidifier to avoid transferring it to the preconditioned environment. According to the authors, the efficiency value is greater for packaged bed air systems. The findings of partial energy saving analysis are realistic and valuable for applications. Simulation tests demonstrate that the established solutions are possible under changing load circumstances to dehumidify the air supply and regenerate the dry solution. The results reveal that the system incorporated is better suited to hot and wet areas. When air and humidity are higher, the system has a greater COP.

VI. Conclusion

A test setup to test the effectiveness of the dehumidification system for fluid desiccants with calcium chloride and lithium chloride as drying agents has been created. A dehumidifier was employed to avoid the transportation of drying into the airflow through indirect contact air dehumidifier. The dehumidifier's efficiency ranged from 0.25 to 0.44, while the regenerator's efficiency was 0.07 to 0.80. The usage of polymer-based contractors with greater mass transfer coefficients is to be included in future research. The actual mechanism of mass and heat transmission, as the absorption thermal distribution, the desiccant solution's weighting ratio across the dehumidifier pack sheets, is unclear. The introduction of hybrid systems is mainly designed to minimize the instability of the system. In addition, the capability of hybrid systems to handle sensible process air cooling is significantly more than the usual traditional sensitive type coolers. One of the key characteristics of the liquid dehumidification/cooling system is the efficiency of disposing of the significant latent content.

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