

A Review of Desiccant Dehumidification Technology

Karrar Al.-AHMEDI*¹

¹Warsaw University of Technology, Warsaw, Poland

Abstract

This study focuses on dehumidification technologies. It identifies the different types of dehumidification technologies and seeks to understand each technology's competitive advantages. On the various technologies, the study concentrates on three standard systems. The systems are the solid desiccant-wheel, solid desiccant air conditioner, and the liquid desiccant dehumidification system. The study establishes the characteristics of each of them and how they can be preferred. The study also looks at the applicability of the technologies to different uses and discusses in details application in hotels, supermarkets, and office blocks. In these application areas, the study focuses on benefits and possible consequences for the non-adoption of such systems. The study establishes reasons to support the relevance of this technology to those essential industries. This study concludes by looking at current developments in dehumidification technology. A focus is made on the drivers for the advancement and a discussion of some of the recent improvements. The study adopts this discussion to help advise on the future of dehumidification technology.

Keywords: dehumidification technologies, solar cooling

1 Introduction

Dehumidification refers to the measures taken to keep humidity at low levels. The technology forms part of the heating processes in modern-day applications. The combined process involves heating, ventilation, and also air conditioning. The complete system is made up of different components to facilitate all of these functions. The functions make rooms more hospitable by controlling extreme conditions and especially coldness, hot and humid weather. The first instance is the heating to reduce coldness and then air conditioning and dehumidification to avoid the adverse effects of moist environments. According to Yin, Qian, and Zhang (2014), the use of this desiccant dehumidification technology has increased in recent times due to its efficiency and ability to control both humidity and temperature independently.

According to Pesaran (1994), air dehumidification is achievable through two methods. The methods identified were, cooling air to temperatures lower than its condensation point and then extracting the moisture through condensation. The other process was through sorption using a desiccant substance, which can either be a solid or a liquid. This chapter will focus on the dehumidification through exposure to a desiccant material [1–6, 9–14].

2 Desiccant dehumidification types

Different desiccant dehumidification technologies have been advanced as technology keeps on changing. The changes are also driven by an endeavour to create a competitive advantage by organisations. With these advancements and variations, it becomes imperative for users to understand the characteristics of the types. Knowledge of the modifications will enable proper choice by the users. This section seeks to establish the underlying components of three types of dehumidifiers. The three main types of dehumidification systems and can be classified according to their operation. They include solid-desiccant-wheel, solid desiccant air conditioner and the liquid-desiccant dehumidification system type. The three types of dehumidification systems will be focused on to understand their operating principles. Understanding how they operate can advise on recommended advancements to make them more efficient.

*corresponding author: E-mail address: engkarrar0@gmail.com (Karrar Al.-AHMEDI)

2.1 Solid-Desiccant-Wheel Dehumidifier

A solid desiccant wheel dehumidifier works through exposing moist air to a dehumidification solid. The solid then absorbs moisture from the air, making it dry. This absorbing of moisture occurs concurrently with the passing of latent heat energy to the already dehumidified air. Consequently, the moist air leaves the system hot and dry. The hot air exiting the system is directed and used in the heating of rooms. The system has a wheel, which ensures that moisturised desiccant solid is exposed to heat to release the moisture to be able to be used again.

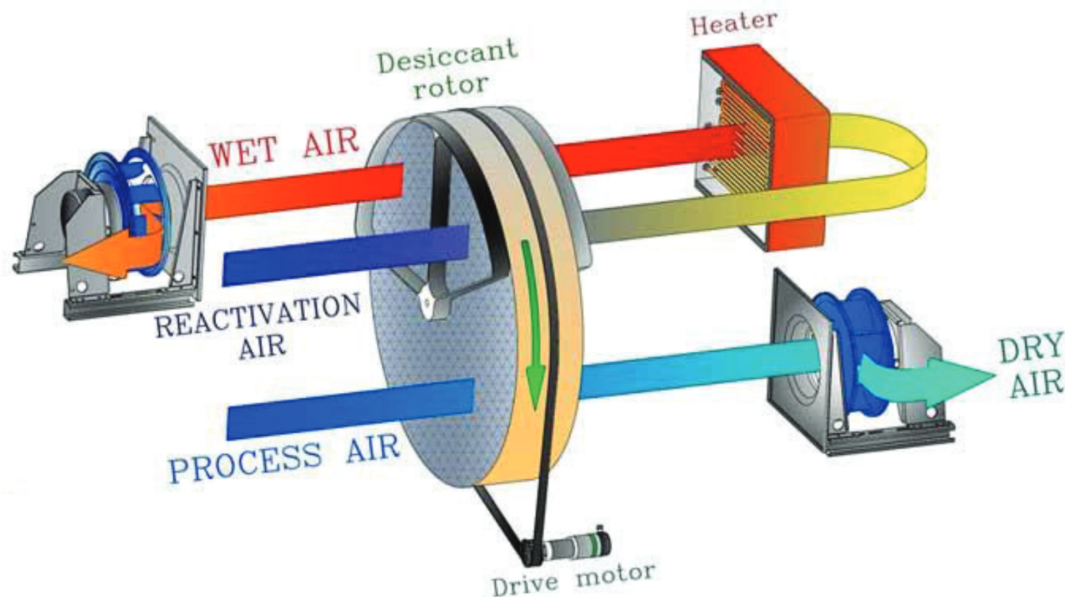


Figure 1. Solid desiccant wheel dehumidifier [7, 8]

2.2 Dehumidifier Schematic of a Solid-Desiccant Air Conditioner

This system is more advanced than the traditional vapour compression refrigeration systems. According to Jani, Mishra and Sahoo (2016), the system is more efficient in humidity control for conditioned air and especially in conditioned air. There are several types which have been developed to cater for differences in climatic conditions and boost efficiency in specific situations. As established by Sultan, El-Sharkawy, Miyazaki, Saha and Koyama (2015), the three types are the stand-alone, single-stage hybrid and the two-stage hybrid desiccant air conditioning systems. According to La, Dai, Li, Wang and Ge (2010), these systems have several advantages over the desiccant wheel dehumidification system. The benefits include environmental friendliness, energy efficiency, being CFCs free, and use of low-grade heat energy.

2.3 Liquid Desiccant Dehumidification System

It has been purported by Rafique, Gandhidasan and Bahaidarah (2016) that this system is a good response to the increased cost of fossil fuels. The scholars have also argued that the liquid desiccants are better as, not only are they environmentally friendly, but can also use alternative sources of energy. Mei et al. (1992) established that this system works by passing humid air through a cooling tower, which has been wetted with a liquid desiccant. As a result, the dehumidification liquid gets more dilute as dehumidification continues. It is then reactivated through heating and spraying through a reactivation airstream. Some of the liquids used in these systems are like the chlorides of both calcium and lithium, lithium bromide, glycols and salt mixtures. The structure below elaborates on the working of this liquid desiccant system.

The numbered processes are as discussed below: 1. Warm, humid air entering the desiccant system through the packed tower base 2. Liquid desiccant sprayed is sprayed over the packed desiccant material. The liquid desiccant absorbs heat and moistness away from air passing over it. 3. Previously hot and humid air leaving the system dry and cool 4. Dilute solution of the liquid desiccant collects at the base of the packed tower where it is then circulated to the generator for reconcentration 5. A heater raises the dilute desiccant solution temperature 6. Moisture is removed

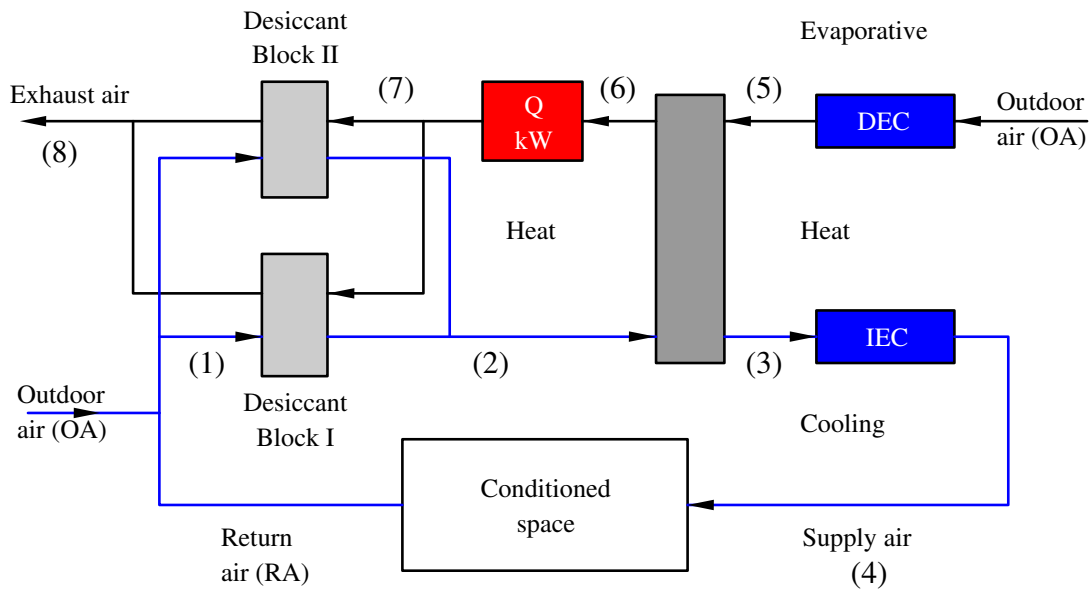


Figure 2. Solid desiccant air conditioner [12]

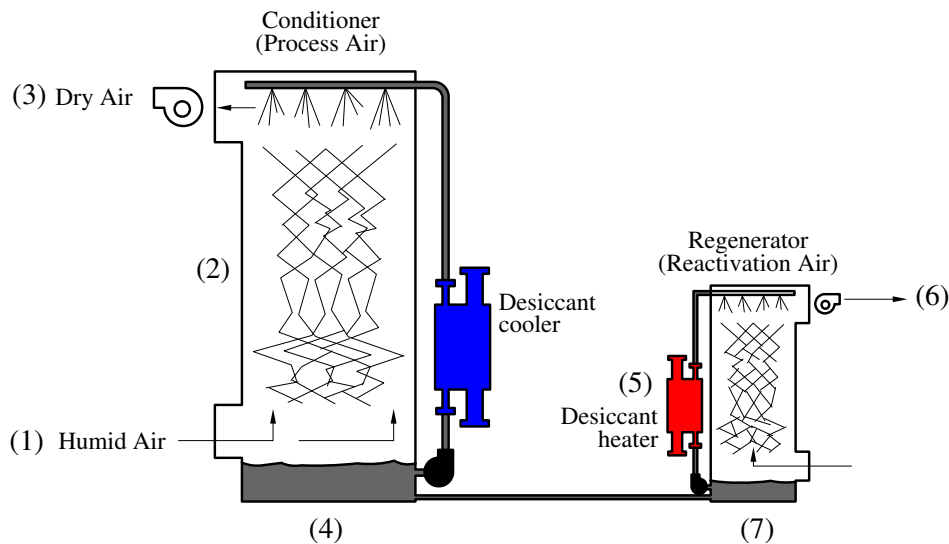


Figure 3. Liquid desiccant dehumidification system [5]

from heated desiccant solution by a small air stream 7. A concentrated desiccant collects at the regenerator and is circulated back to the conditioner for reuse.

3 Desiccant dehumidification applications

Due to the continued need for heating, there is an ever-increasing need for dehumidification systems. Almost all industries need these systems in one way or the other. For this study, a focus will be made to only three areas where the systems are required. The three to be focused on include supermarkets, offices and in the hotel industry. This focus is advised by the need for proper dehumidification and heating services in these areas.

3.1 Application of desiccant dehumidification in supermarkets industry

Supermarkets have many activities going on in their floors. In addition to them, there are many people and products, which require freshness. This situation indicates a necessity for a dehumidification system as moisture can be very

harmful to products and the health of the supermarket users. It is important to note that people have become more concerned about their health and would not hesitate to change tastes, which are not health conscious. With the recent desiccant dehumidification becoming more popular in the current economy, its general application has been used widely. With the supermarkets dealing with almost all kind of products, the technology becomes quite relevant in the context. The issue of controlled humidity to products such as foods could be very appropriate to be introduced to this technology. This appropriateness is due to its biotechnology which has both bactericidal and fungicidal properties. These properties are required to preserve foods and ensure good condition in the supermarket shelves.

According to Khattar (1991), air conditions and dehumidification systems, which are electrically powered, have been successful compared to gas-powered ones and especially in supermarkets. He noted that the methods are very cost-effective in installation and operation, and he posed that this lead to overall cost saving and better profit margins for supermarkets. The greatest challenge that has existed has been of the large-scale operations that take place in the supermarket. Cooling dehumidification systems have become very common in this industry. As a result, the desiccant dehumidification has become more preferred due to its high-efficiency level. The system is more eco-friendly, with the utilisation of even unwanted pressure from rejected heat.

3.2 Application of desiccant dehumidification in the hotel industry

Another critical industry, which is very sensitive to humidity and temperatures, is the hotel industry. As the hotels mostly deal with food, there are chances that humid air would result in the growth of moulds in those foods something hotel owners would not want. The desiccant dehumidification systems are installed in hotels to reduce humidity conditions to acceptable levels while at the same time, cooling the rooms. Proper humidities in hotels is desired to prevent adverse effects of humidity like a fungal growth. Research by Mei et al. (1992) revealed that US hotel industry was losing up to 68 Million dollars in a year because of mildew damage and mould caused by excess moisture. The losses are more adverse in those regions which are inherently hot and humid as these are the best conditions for the growth of moulds (Niu, 2001). Based on this extend in damages, it then becomes evident that dehumidification in the hotel industry is worth it. By avoiding these loses, a hotel can save so much and use the savings to create a competitive edge. The benefits by saving what could have cost the hotel are enough to justify the installation costs.

3.3 Application of desiccant dehumidification in the office building industry

The office building is a crucial area where dehumidification technology is very critical. Office buildings are prone to damages on their walls if high levels of humidity are experienced. Apart from the damage to the walls, humidity decreases the quality of air in the office building, which can have health consequences on the users of the office block. These damages end up costing the office space owners so much in repairs and loss of rent revenue due to non-preference of their office space. The non-preference occurs when tenants learn that the air in a building is not at the acceptable humidity levels and primarily if these artificial technologies have not been used to control it. Based on these possible consequences of humidity to buildings, dehumidification systems have become very important in the office building industry. This increase in demand has also been boosted by the recognition, by building design engineers as argued by Mei et al. (1992), of the fact that excess humidity in indoor air is harmful to the building furnishes and structural elements. Office building owners should, therefore, endeavour to install dehumidification systems to avoid the above-identified losses.

4 Recent desiccant dehumidification technologies

There are aspects, which have brought about continuous advancement in this technology. Among others, the efficiency of the systems and their cost of operation has been vital concerns where current modifications are banked on. Some of the latest technologies involve air desiccants. Isothermal membrane-based air dehumidification technology is one of the latest technologies. This technology has been proposed by Qu, Abdelaziz, Gao, Yin (2018). According to the researchers, this system is very economical in terms of energy consumption than other dehumidification technologies. This property can be attributed to its functioning as it uses a selective membrane, where its only vapour particles that can move from one highly concentrated side to the other depending on their concentration difference between the two opposite sides of the selective membrane.

Another development is the hybrid solar liquid desiccant which is an advancement of the traditional evaporative cooling technology. This advancement has been claimed to be very eco-friendly and energy-saving (Buker and Riffat (2015). There is also another recent technology as purported by Zhang (2011), which involves the use of hollow fibre

membrane contactors. These are used to enhance the liquid desiccant operations by ensuring no liquid droplets are spilling over in the process. This efficiency is achieved by providing there is no contact point between the process air and the liquid desiccant. Rotary desiccant air conditioning system has also been purported by La, Li, Ge, Dai and Wang (2010). It has been designed as a hybrid of the desiccant dehumidification and evaporative cooling. It has been credited with environmental friendliness, energy efficiency, health and comfort compared to other systems and the control of humidity and temperature separately. With these diverse recent developments, it is expected that more are coming and their cost will be less as the firms engage in research to bring about a competing edge.

5 Conclusion

A review in the study indicates that there is a growing need for these dehumidification technologies. More and more uses are being devised in different industries, and it is expected that the technology will remain viable in the future. What businesses investing in the technology need to be aware of is the factors which are considered in choosing a system to use. The key elements are cost-effectiveness, environmental concerns like avoiding CFCs, quality of the output air and such kind of considerations. Manufacturers can also continue researching and developing industry-specific systems and also determine consumer behaviour changes to meet them quickly, even after the change. A focus can also be made to the types of desiccants, the intended source of the reactivation energy, the cooling sources and the storage of the reactivation energy.

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