Humidification Applications Part 2: Adiabatic Humidification

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Introduction

In adiabatic humidification, water is provided to air in liquid form and must still achieve a gaseous state. Energy is required for this purpose and is drawn from the surrounding air in the form of heat. Since a decrease in air temperature also takes place in this case, the process is also called adiabatic cooling. However, the degree of humidification or cooling is entirely dependent on ambient conditions – that is, the difference between dry bulb and wet bulb temperatures. Larger the difference, more effective is the humidification and cooling.

Evaporation

In the case of evaporation, water is guided over evaporator pads while the air to be humidified is applied over the pads at the same time, thus providing the air with humidity. The advantage of humidification by means of evaporation is that not only operating costs, but investment costs as well, are low for a humidification system of this type. And in addition to humidification, evaporative humidifiers or coolers can also be used to cool buildings.

Cellulose paper pads are used often in evaporative cooling or humidification. However, decomposition and rotting of pads over time has been an issue and other alternatives such as PVC pads have been used by some manufacturers and contractors. Pads with glass fibre media are also available. Bacteria do not grow on glass fibre due to its inorganic composition, resulting in longer service life. But these pads are seldom offered by contractors due to high first cost.

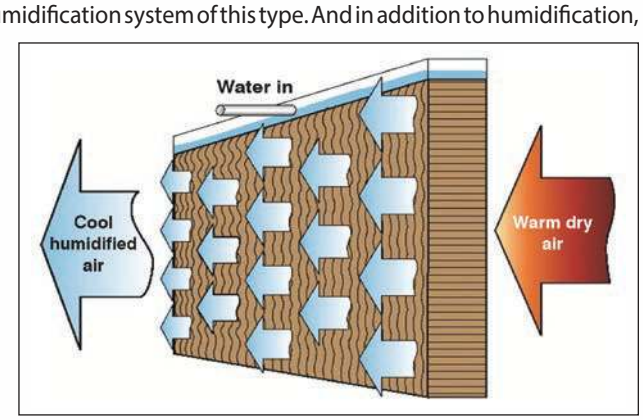

Figure 1: Cellulose paper pads are used often in evaporative cooling or humidification

Atomization

In humidification through atomization, water is provided to the air to be humidified in tiny droplets via mechanical atomizers or with the help of nozzles. This method causes the

About the Author

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state of water to change and requires heat from the surrounding air as well as some external energy such as a pump or compressed air to atomize water. Adiabatic humidification systems in environments with high heat generation can also contribute to cooling in addition to their basic function of humidification. In cases where very high sensible loads mandate excessive supply air quantity in-room cooling with atmomization enables the system designer to reduce the air handling equipment to a manageable size.

Air washers are popular in textile air conditioning as well as air cooling applications in India. However, air washers are not efficient as humidifiers as typically only 2 to 2.5 per cent of the water sprayed evaporates while the balance provides sensible cooling of the air. The pumping power requirements are high. Air washers spraying chilled water have been installed in many textile units requiring air conditioning with humidification. In such cases, the air washers serve the dual purpose of cooling as well as humidification.

In spray humidifiers, the amount of water sprayed is evaporated. These type of spray humidifiers are an addition to air conditioning and cannot replace the air conditioning even if chilled water is sprayed.

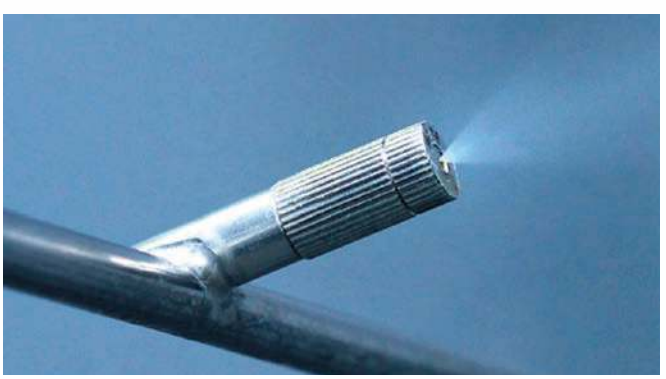

Figure 2: Spray nozzle for atomization using compressed air

Figure 3: Spray nozzle for atomization using high pressure pumps

A disadvantage with adiabatic humidifiers is that they work well in summer when the difference in ambient dry and wet bulb temperatures is high but in winter these type of humidifiers are not very effective unless air is preheated adequately.

Applications of Adiabatic Humidification

Usually, pharmaceutical and healthcare sector requires smaller air handling systems and isothermal humidification is a simpler and practical solution. It has the added benefit of meeting health and safety requirements – as risk of microbial contamination is eliminated. The guidelines on humidification by World Health Organization also mandate the use of isothermal (steam) humidification.

However, many industries such as automotive, electronics, explosives manufacturing and textiles require high air volumes in air conditioning or air cooling. In such cases, adiabatic humidification is a more acceptable option. In new type of humidifiers / coolers the risk of microbial contamination is mitigated through different treatments such as silver ion impregnation, in-line or submerged UV.

Humidification in Automotive Industry

Paint Booths

Water Based Paints

Water based coatings are widely used in the automobile industry. For water based paints, RH as high as 65% - 75% is recommended to deliver consistent paint quality and restrict aerosol evaporation. It also ensures consistent deposition of coat and prevents premature drying. As the air from a paint booth is not recirculated, the humidification loads are very high in peak summer as well as winter.

Electrostatic Paints

Economic and environmental imperatives such as waste reduction, overspray control, particulate recovery and solvent reduction, mean that electrostatic paint and powder coating are now very widely used, particularly, in large industrial applications like robotic, manual and conveyor booths. The process is dependent on maintaining differential charge between the powder and earthing medium, giving good coat uniformity with minimal overspray and waste reduction. However, if the RH is too high, the effects of electrostatic charge are disrupted and coat adhesion is affected. In low relative humidity, the charging characteristics are affected and the powder does not become properly charged. There is lower transfer efficiency between the powder and items being coated, leading to inadequate film thickness. Costs and waste increase. Low RH also provides the potential for arcing.

For electrostatic paint and powder coating, a relative humidity between 45%-60% RH is ideal at 20-25°C.

Dipping & Electroplating

In multi-stage coating and surface treatment process, metal items are moved from tank to tank. In hot and dry climate, the lack of moisture in the atmosphere can cause a job to dry prematurely and unevenly, particularly if there is a delay and work cannot be moved on to the next stage. This leads to uneven drying at the surface, causing staining and affecting the surface treatment in subsequent process tanks. Stripping and reworking the piece is time consuming and wasteful. Maintaining a relative humidity in the air of 50%-60% RH prevents rapid surface drying.

Sanding Decks

By maintaining 55%-60% RH in sanding decks, the dust is suppressed and static build-up reduced. This prevents the airborne dust from redepositing on the bodywork, improving the quality of finish and also reducing the sanding time.

Engine Testing Cells

Exhaust emmision testing of engines is required to be carried out at specified temperature and humidity levels. For maintaining high level of RH, humidification is a must.

Humidification in Electronics Manufacturing Industry

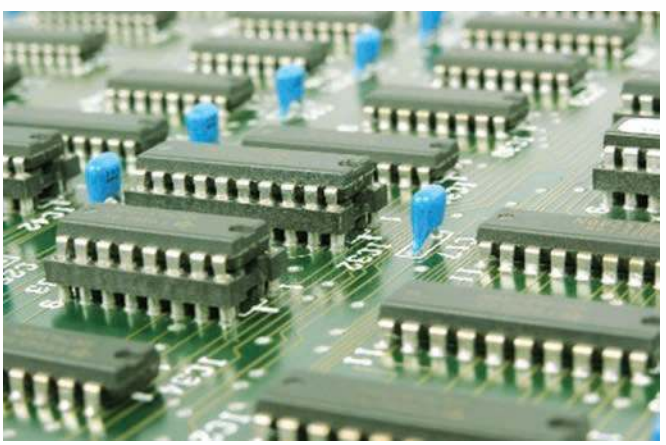

Figure 4: Electronic devices are highly sensitive to electrostatic discharge

Electronic devices, printed circuit boards, components, and data are highly sensitive to electrostatic discharge. Correct humidity levels are essential to minimizing the damage caused by ESD.

What is ESD?

Electrostatic discharge (ESD) is the sudden flow of electricity between two electrically charged objects caused by contact. ESD occurs when differently charged objects are brought close together or when the dielectric between them breaks down, sometimes creating a visible spark.

However, many ESD events occur without a visible or audible spark. A person carrying a relatively small electric charge may not feel a discharge that is sufficient to damage sensitive electronic components.

These invisible forms of ESD can cause outright device failures or may affect the long-term reliability and performance of electronic devices. The effects of ESD on some electronics may not become evident until well into their product life.

Static Electricity

One of the causes of ESD events is static electricity. Static electricity is often generated through turbocharging – the separation of electric charges that occurs when two materials are brought into contact and then separated.

Examples of turbocharging include walking on a rug, rubbing a plastic comb against dry hair or rubbing a balloon against a sweater. The friction between two materials results in turbocharging, thus, it is creating a difference of electrical potential that can lead to ESD. Another cause of ESD damage is through electrostatic induction. This occurs when an electrically charged object is placed near a conductive object isolated from ground. The presence of the charged object creates an electrostatic field that causes electrical charges on the surface of the other object to redistribute.

How to Minimize ESD?

Most electronics manufacturers establish electrostatic protective areas free of static, using measures to:

- Prevent charging – by avoiding highly charging materials
- Remove static – by grounding human workers or providing anti-static devices
- Control humidity

Humidity Control – the Ideal Solution to Eliminate ESD

With a humidity level of 40% RH, surface resistance is lowered on metallic surfaces. Humidifiers add moisture to the air, and the moisture in the air forms a thin protective film on surfaces that serves as a natural conductor to dissipate electric charges. When humidity drops below 40% RH, this protection disappears, and normal employee activities lead to objects being charged with static electricity.

Explosive & Munition Manufacturing

During the manufacturing of explosive devices such as munitions, fireworks or flares, uncontrolled static electrical discharge presents a high risk to the combustible materials being processed. By maintaining a humidity of 55% RH, static build-up is avoided as the moisture acts as a conductor and dissipates any electrical charge generated by friction.

Thermohygrographs are used to record the temperature and humidity in explosive manufacturing facilities so that the environmental conditions under which munitions are produced can be traced back and checked should a defect be identified in the field at a later date.

Both in-room and in-duct humidifiers are used in these environments, but they must be ATEX explosion proof and intrinsically safe.

Figure 5: Thermohygrographs are used to record the temperature and humidity in explosive manufacturing facilities

continued on page 34

continued from page 32

Textile Manufacturing

Humidification in textile manufacturing has many benefits that will enhance profitability.

Product Weight

Humidification prevents moisture loss during a textile's processing and storage, and can reduce weight loss from a typical 4% to just 0.5%.

Yarn Quality

Correct humidification will maintain yarn strength and elasticity, producing a better-quality product with higher margins. Wastage is also reduced through a reduction in shedding.

Static Control

Static can cause reduced productivity and product quality due to lint and fly attraction, machine jams and employee discomfort or even accidents. Higher humidity naturally dissipates static charges alleviating these problems.

Weaving Efficiency

Optimal humidification reduces yarn breakages in weaving, reducing machine downtime as well as loom stop marks and weavers' knots in the finished product.

Employee Comfort

Humidifiers can deliver between 5-12°C of evaporative cooling to a textile production facility, while suppressing dust, fly and lint. This creates a healthier and more productive atmosphere for employees.

The humidity requirements in textile industry are different for different fabrics as well as different processes.

Table 1: Optimal RH levels in textile manufacturing

	Spinning	Twisting	Winding	Weaving
Wool	50-85%	60-65%	55-60%	50-60%
Cotton	35-65%	50-65%	55-65%	70-85%
Man-made fibres	45-65%	45-65%	60-65%	60-70%
Silk	60-65%	60-65%	60-65%	60-65%
Jute	75%	75%	75%	75%
Linen	80%	80%	80%	80%

Paper & Pulp Production

Humidity control in the paper industry is essential to control the moisture loss of the paper after drying. Once produced and reeled, the paper can be exposed to ambient conditions at the end of the paper machine for considerable periods of time. Exposed surfaces of the paper will change in moisture content dependent on the ambient humidity, leading to problems during the slitting and wrapping processes.

Low humidity, below 50%, causes the paper to shrink, curl and lose dimensional stability making the reel of paper unusable and in turn very costly to the manufacturer. To stop this from occurring, the typical humidity level required is 55% RH. When this level is maintained, the moisture in the paper retains not only the flexibility of the product but also its stability during production and packing.

Low humidity in the slitting area will cause moisture losses to occur; these losses will take place very quickly. However, damage to the paper may not be seen at this stage as the tension on the paper prevents any curl or dimensional change being seen. Changes to the paper in the slitting process will show at the sheeting stage because the tension has been taken off the paper and it is now free to change its shape. When humidity is below 45% RH, static electricity will be generated, which can cause packing issues and present a risk to staff from unexpected shocks.

Printing

In the competitive print market where return on investment really matters, humidity control is essential to maintain quality and productivity at all stages of production.

Figure 6: Humidity control is essential to maintain quality at all stages of production in printing

Paper and Ink

Paper is very hygroscopic, which means it loses moisture rapidly when exposed to dry air. Sheet and web roll paper is typically produced and wrapped to stay in equilibrium with air with a relative humidity of 50±5% RH.

When the ambient humidity falls below this level, paper loses water to the environment from exposed surfaces, changing its shape, dimensions and physical properties. Below 40% RH, the movement of paper on paper and other surfaces generates electrostatic charges, attracting dust and making it difficult to handle. The problems are most pronounced in hot summers and cold winters, when the relative humidity can fall below 30% RH even in temperate climates.

A higher relative humidity of 55±5% RH is typically recommended where water based inks are used and some ink manufacturers recommend 60%.

Platemaking

When the protective film or paper is removed from plates, electrostatic charge is generated if the relative humidity drops below a threshold of 40% RH. This attracts dust and grit to an otherwise unblemished surface, makes handling difficult and also generates sparks. Maintaining an environment of 45% RH prevents this.

Sheet Fed Offset

A dry press hall means the edges of unwrapped paper lose moisture rapidly. Tight edges result, making the paper curl that causes misfeed with misregister, dot doubling and creasing as the paper passes between blanket and impression cylinders.

Misfeed also occurs due to electrostatic build up, which also causes stacking difficulties coming out of the press. Printed work awaiting another pass continues to change with misregister being a particular problem. In dry air, work passing to finishing suffers from paper sticking and creasing due to electrostatic and paper cracks on folds.

The impacts of dry air can be so severe that printing stops altogether. Maintaining a relative humidity of 50-55% RH in the press hall and bindery resolves these issues.

Web Printing

If air is too dry in the paper store, laydown area and reel stand, the exposed edges of the paper rolls loose moisture and shrink. On the web press, the paper is under greater tension at its edges than the centre, which causes the edges to tear, leading to web breaks. The result is substantial downtime as the paper is spliced or rethreaded through the press.

In a dry press hall, the rapid passage of paper through the press generates electrostatic charge, which becomes a particular problem as the printed work passes to finishing for cutting, trimming and folding due to sticking paper.

Web printing is highly productive, and any loss of production is costly, but problems relating to dry air can be addressed by maintaining the relative humidity at 50-55% RH. In flexo, with water-based inks, 55-60% RH is recommended.

Tobacco Manufacturing

Tobacco leaves, cut tobacco and paper are all extremely hygroscopic which means that they give up their moisture to the surrounding environment if the air is too dry. Dry air causes tobacco's properties to degrade resulting in shrinkage, weight loss, brittleness, flaking, splitting, and tearing. This causes tobacco to literally fall out of cigarettes, cigarette papers to misfeed on machines and cigar leaves to crack.

Recommended relative humidity levels in tobacco industry

Primary production : 60-68% RH
Tobacco stores : 60-70% RH
Ripping rooms : 65% RH

Maintaining the right level of ambient relative humidity prevents all these problems by ensuring that tobacco, paper and leaves retain moisture at the correct levels, so maintaining their quality and ensuring that production can proceed at full efficiency.

VIEWPOINT *continued from page 27*

breakdowns in a timely manner. The remote operations have enabled uninterrupted operations and minimised operations personnel required for regular operations. More importantly, the smart building systems at Infosys have played a pivotal role in energy savings, and in ensuring that optimum conditions of thermal comfort and indoor air quality are maintained at the workplaces.

Healthier Workplaces

People spend most of their time indoors and therefore it is necessary to ensure good air quality in buildings, more so in the case of centrally air-conditioned buildings, through adequate fresh air supply. In buildings with central air conditioning, about 15 per cent of the total air supplied is fresh air and the remaining 85 per cent is recirculated air from the conditioned space. So, the possibility of transmission of infections in general will be high in case of air-conditioned spaces. An important measure to address this issue is to increase the quantity of fresh air in the air conditioning systems. Guidelines issued by reputed organisations and associations on air conditioning in response to COVID-19 also recommend increasing the fresh air supply in the air conditioning systems so as to reduce recirculation and maintain a better air quality. While this can be possible in some buildings with a penalty on energy consumption, there can be a totally new approach for new buildings. Radiant cooling is a way of cooling in buildings where most of the cooling is achieved through surfaces like ceilings, walls or floors that have pipes embedded in them carrying cold water. Air is supplied to take care of the fresh air requirements and for maintaining the right humidity levels. No recirculation of air is done in a radiant system, thus ensuring healthier indoors in general and reducing the possibility of transmission of infections. Radiant cooling is 30 per cent more efficient than conventional air conditioning, occupies lesser space due to fewer equipment, and costs almost the same as conventional air conditioning systems. Radiant cooling will be a preferred choice of cooling system in future for office buildings.

Infosys was the first company in India to implement radiant cooling system in an office building in 2009 in Hyderabad. Global experts were roped in to help local teams to design and implement the system. The operational data for the building clearly showed a 30 per cent reduced energy consumption by the radiant system as compared to the conventional air conditioning system. From then on, radiant cooling has been the preferred way of cooling for Infosys office buildings. Today, five million square feet of space at Infosys has radiant cooling system, ensuring good indoor air quality, high thermal comfort and reduced energy bills.

Conclusion

There may be other technologies that can help in improving air quality or reduce energy consumption in buildings, but the ones discussed here are based on experience and a large amount of operational data over the past decade. So, green buildings, smart building systems and radiant cooling are among the proven key elements that can be considered for office buildings globally, not only to ensure energy efficiency and remote operations, but more importantly to provide a healthy environment in workplaces, and bring back confidence in people to return to their workplaces.