Humidification

This month's skills workshop explains the nature of humidity and highlights how specific environments can benefit from humidification.

What is humidity?

Humidity is simply the moisture in the air. Relative humidity is the amount of water contained in the air at any given temperature as compared to the maximum amo unt of moisture the air can hold at that temperature when saturated. For example, at 21°C, 1kg of dry air can hold up to 15.8g of moisture. If 1kg of air at 21°C contains 15.8g of moisture, it is said to be at 100% relative humidity. If that same quantity of air contains 7.9g of moisture at 21°C, this is compared to the amount of moisture that the air can hold when saturated at this temperature: 7.9/15.8= 0.50 (50%). Accordingly, this air is at 50% rH (relative Humidity).

The amount of water that air can hold changes with its temperature, increasing as the temperature of the air increases. Accordingly, while 1kg of dry air at 21°C can hold up to 15.8g, the same quantity of air at – 18°C can hold only 0.92g of moisture. Therefore, if you have 1kg of air at 21°C with 50% rH that is 7.9g, as you cool this air toward – 18°C, the air will reach saturation (100%rH) at 9.5°C and begin to rain (or snow). Conversely, if you take 1kg of dry air at – 18°C and 100%rH that is 0.92g and raise its temperature to 21°C without adding any more moisture, you will end up with: 0.92/15.8=0.06 (6%rH). This condition would be drier than the Sahara Desert which averages around 12%rH. This dry air is the cause of many IAQ (Internal Air Quality) problems.

Why is dry air a problem?

When the outside temperatures fall below inside temperatures, as in Winter, the result is that the cold, moist air entering the heated building becomes hot, dry air. In the same way that moisture in the air will be absorbed by materials in a building, this hot, dry air pulls moisture from everything it comes in contact with, trying to reach "equilibrium" (the point at which the material no longer loses or gains moisture). This drying out of the air is what causes the familiar problems of dry nose and throat, cracking of woodwork and materials, and static electricity discharges. This same dry air condition can also be caused by cooling the air below its dew point, thus removing moisture (dehumidifying), and then reheating it. This condition could occur in an air conditioning system or in refrigeration.

As an example of the problem: if you take wood from outdoors that has equalised with the outside air moisture content, into a heated building with a lower moisture content, the wood will begin to give up its moisture to the dry air in the building. As the wood loses moisture from its edges, the edges will shrink and pull apart creating cracks, or warping the wood. This same damage can occur with paper, textiles, some plastics, wax, porcelain, fruits and vegetables and other materials that have the ability to absorb or give up moisture. Such materials are said to be hygroscopic (water absorbing). Hygroscopic materials always seek to reach equilibrium with their environment.

In the case of a museum, where expensive paintings, sculptures and other hygroscopic materials are kept, rapid changes in relative humidity can be devastating and will eventually destroy the artifacts. In a printing operation, paper that is rapidly drying while running through a press, will shrink and curl causing jamming, tearing and even misregistration of printing colours. In a microchip wafer fabrication laboratory, slight changes in the dimension of a silicon wafer can result in chips that are not usable.

The key to protection of hygroscopic materials is stability of the environment. It is detrimental to permit the relative humidity to vary rapidly or widely throughout the year. This is one of the reasons why control (or stabilisation) of the relative humidity is becoming an important part of indoor air quality. This is accomplished by dehumidifying when the air becomes too moist and humidifying when the air becomes too dry.

Why humidify?

There are three basic questions that determine why an environment might need to be humidified.

They are:

1. Are there any hygroscopic (moisture absorbing) materials used either in the process or in the building?
2. Is there any problem with static electricity?
3. Is health and comfort a consideration?

Let's consider these questions one at a time with some specific applications to look at.

1. Is there anything hygroscopic in the environment?

Hygroscopic is any material that absorbs moisture into the cell of the material causing a dimensional change. This is different from hydrophilic absorption which is absorption of moisture between the cells, usually *not* causing a dimensional change. It is the dimensional change of materials due to changing relative humidity that can have a more direct effect on the workability of materials and processes than even the temperature can. Some examples:

Printing

Paper arrives at the print shop in rolls, conditioned at the paper mill to a certain moisture content and wrapped in a vapour barrier paper to help retain this moisture (this is partly because paper is sold by weight, the moisture content then maintains selling price). As soon as this wrapper is removed, the paper begins to lose moisture to the surrounding air if it is drier, or to take in moisture if it is moister. As the paper absorbs moisture its cells expand, and conversely shrink when giving off moisture. A single roll of paper can change dimension by several inches in width and length. When a paper roll is placed on a press and begun to be unwound through the press, it will loose moisture very quickly. If multiple colours are being printed, these colours may print at the wrong places, causing "misregistration of colours" due to the changing dimension of the paper. Many pressmen will adjust the rollers to compensate for this, but if the humidity changes during the day, then the adjustment of the rollers will need to be done quite frequently causing loss of paper, time and production speed.

Suggested humidification for different applications		
APPLICATIONS*	ISOTHERMAL	ADIABATIC
Pure environments		
Sterile/aseptic environments (surgery, etc.)	✓	
Clean environments (clean rooms, etc.)	✓	✓ (1)
Hospitals/laboratories	✓	✓ (1)
Civil environments		
Houses	✓	
Steam baths	✓	
Offices	✓	✓ (2)
Libraries	✓ (3)	✓ (2/3)
Museums	✓ (3)	✓ (2/3)
Fan coils	✓	
Food industry		
Production lines	✓	✓ (4)
Cold rooms		✓
Ripening rooms		✓
Bread leavening	✓	
Cheese maturing	✓	
Display cabinets		
Wine cellars and wine barrels	✓	✓
Other industrial applications		
Wood storage	✓	✓
Paper mills		✓
Printing facilities	✓	✓
Photographic labs	✓	✓ (2)
Textiles		✓
Tobacco ripening and storage	✓	✓
Cigars storage	✓	✓
Amusement parks		✓
Farming applications		
Animal breeding		✓
Hatching		✓
Greenhouses (mushrooms, etc.)		✓

*Always consult suppliers about the regulations for your specific application.
1. Humidity in duct, use demineralised water and do regular maintenance
2. Atomise water inside duct only
3. Uses of steam /water containing treatment chemicals
4. Demineralised water is recommended

The preferred situation is a stable atmosphere. With proper humidity control, the paper will be stabilised, neither giving off or absorbing moisture and therefore not changing dimension. The result is faster speed, less downtime and also a reduction in the use of ink since less of the ink is absorbed by the paper itself.

Woodworking

Again, wood will shrink as it dries, causing cracking, splitting, checking and warping. Dry wood will also absorb the solvent out of finishes, producing a grainy, unglossy appearance. Likewise, glue joints will be unstable since the wood will absorb the solvent from the glue before it can cure properly. Again, the preferred situation is a stable atmosphere, so that the wood retains the same dimension throughout the process.

Textiles

As fibres are run through the looms, if they are dry, they will become brittle causing breakage, down time and reduction of production speed. A second side effect is that breaking fibres put lint into the air, often causing the air quality to deteriorate below OSHA standards. This is particularly important in cotton mills and asbestos brake lining manufacturing. Proper humidification reduces fibre breakage, the dust count in the air, and also results in faster machine speeds.

Offices

In offices, there is often expensive wood furniture, panelling, and carpets to be concerned about. Dry air in the winter will crack and warp desks and panelling. Carpets are made of fibres and as these dry out, they become subject to breakage from foot traffic. This increases the dust count in the air and also leads to premature carpet wear.

Additionally, indoor air quality can be improved with proper humidification. The dust count is lower due to reduced fibre breakage, and because dust particles will agglomerate. Larger particles will be more easily retained by filters which will also become more efficient due to hygroscopic swelling.

Hi-tech micro-chip manufacturing

With chips today becoming smaller and smaller, manufacturers are no longer talking about distances of microns, but rather, distances measured in angstroms! Even a slight change in the dimension of the silicon wafer during photographic masking will result in a relative misregistration of the mask of over 100 mils.

Additionally, normal shedding of human skin in this environment can spell disaster. Relatively speaking, if a micro chip were compared to New York City, a single microscopic flake of human skin would crush Manhattan, The Bronx, Harlem, Queens and half of Long Island.

Humidity control has become critical for **Hi-tech investment casting**. The consideration here is not just the end product, but hygroscopic materials used in a process. In the lost wax investment casting process, a wax mould of the part is first made and then dipped in porcelain.

As the porcelain and wax dry and cure, if the air is too dry, the porcelain will shrink at a greater rate than the wax, causing hairline fissures in the mould. When molten metal is poured into the mould, it will take up these fissures and this results in a non-recoverable casting.

This is the process used to make jet engine parts.

3. Is health and comfort a consideration?

Health and comfort haven't always been the number one consideration of most employers, but with today's litigious society, it is becoming more and more of an issue. Aside from the out-gassing of materials and the reduction of dust by proper humidification, there is the fact that human beings simply feel better when nasal passages are maintained at a stable level.

Due to a reduction of surface evaporation on the skin by proper humidification, people feel warmer when the humidity is raised, often allowing the temperature to be reduced, saving on the heating energy normally required, and decreasing the heat loss gradient between indoors and outdoors.

Another source of problem in modern offices is the advent of soft contact lenses. Since these lenses are hygroscopic, they absorb and evaporate moisture from the surface of the eye. In a very dry atmosphere, these lenses will dry rapidly, causing them to curl, creating a very uncomfortable condition.

Also, drying of the surface results in a sticky film which prevents the eyelids from properly cleaning the lenses during blinking. This sticky film allows faster build-up of proteins and bacteria and results in eye infections. In fact, a study of eye infections from soft contact lenses shows a marked increase in these conditions during the winter months.

Isothermal and adiabatic humidification

In the atomisation instruments the water is finely atomised in the air stream or the ambient to be humidified; the heat necessary to transform water from liquid to steam is supplied by air, which decreases its temperature.

Since there is no supply of thermal energy from the outside, this process is defined as adiabatic.

In the humidification process with steam inlet, the steam is dispersed in the air stream or in the ambient to be humidified after having been generated for the boiling of the water contained in a suitable generator, within which the energy necessary for the change of state is supplied.

Because of the moderate incidence of the steam sensitive heat, the temperature of the air increases slightly. This process is defined as isothermal. ■

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