Doing the sums

– adsorption dehumidifier or cooling plant for keeping the dew point constant in ice rink facilities?

Dehumidification is a must for any ice rink facility, because the large area of ice has a significant cooling effect on the entire building structure and its installations. This in turn means there is a high risk that any moisture present in the air will condense on the cool parts of the structure, resulting in a wide range of problems. This moisture must therefore be removed.

Such moisture enters the ice rink along with the natural circulation of air from outside the building. This air is relatively hot and humid, especially in the summer, and has a higher dew point than the temperature on the cold surfaces within the building.

To prevent condensation forming when the air with a high dew point comes into contact with the many cold surfaces within the building, it is important to maintain a dew point that is lower than the temperature of the coldest surface in the ice rink facility.

There are two different technologies available for managing the humidity in the air in order to make this possible – dehumidification via cooling and condensation or by adsorption.

In this article, we will consider the technical issues associated with the two different technologies. We will also compare the operating costs for each of these two solutions.

1. Given data

Ice rink building volume	: 50,000 m^3
Density	: N = 0.1
Room conditions	: 15°C, dew point + 4°C, 5 g/kg
Maximum outside conditions	: 20°C, 12 g/kg

The following calculations are carried out for the conditions normally experienced during the night, when there are no spectators present. These are the kind of conditions under which the ice rink operates for about 90% of the time.

2. Calculation of dehumidification requirements

$Mw = V \times 1.2 \times N \times (Xu - Xr)$, g/h

V = room volume = 50,000 m^3

N = air change = 0.1

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1.2 = density for air, kg/m^3

Xu = maximum moisture content in outside air = 12 g/kg

Xr = moisture content in room air = 5 g/kg

Mw = 50000 x 1.2 x 0.1 x (12-5) = 42000 g/h

3. Adsorption dehumidifier

Selection of the most appropriate model of adsorption dehumidifier depends on how best to ensure effective exploitation of surplus or waste heat from the ice system.

Based on the given data, a Cotes CRT12000EW adsorption dehumidifier, with a capacity of 43 kg/h and with a regeneration air temperature of 88°C, would be appropriate.

CRT12000EW power consumption:

Regeneration, surplus heat from cooling plant (70°C) = 59 kW *)

Regeneration, power heating element = 21 kW *)

Regeneration, total = 80 kW

*) Regeneration air flow increased compared to standard configurations, in order to achieve the most efficient exploitation of surplus heat from the ice system.

Electrical power needed for technical installations associated with a adsorption dehumidifier

Ventilators, process and regeneration air = 7.5 + 1.5 = 9 kW

Electrical power, dehumidifier = 21 kW

Electrical power for ice cooling plant = 76 kW

Total electrical power required = 106 kW

Heating contribution to the ice rink space = 13.6 kW

(14400 x (31.3-27.9)/(4.18 x 0.86)

4. Cooling plant

It is assumed that the cooling plant must operate without ice forming on the cooling surface. This means an evaporating temperature of +1°C is required.

To obtain the required dehumidification capacity of 43 kg/h, a flow of air through the cooling surfaces amounting to 50,000 m^3/h is required.

Electrical power needed for technical installations associated with a condensation dehumidifier

Power consumption, cooling/dehumidification	= 250 kW
Power consumption, reheating to 15°C	= 219 kW
Power consumption, total	= 469 kW

Compressor, power consumption	= 65 kW
at +1°C evaporator temperature and 25°C condenser temperature	
Ventilator for air circulation	= 22 kW
Electrical power for ice cooling plant	= 76 kW
Total electrical power required	**= 152 kW**

Heating contribution to the ice rink space	= 0 kW

The calculations shown above show that for an installation with the listed specifications humidity management using an adsorption dehumidifier is 30% more effective than with a condensation dehumidifier. This generally means operating costs are approx 30% lower.

In the scenario shown above, an additional benefit stems from the 13.6 kW of heat energy released into the ice rink space, which improves the cost/benefit parameters still further.

5. Additional cost/benefit parameters

Duct system for process air

The duct system required to provide the air flow needed for a condensation dehumidifier solution would have a cross section more than 400% greater than for an adsorption dehumidification installation with similar capacity. It would therefore be significantly more expensive.

CRT12000 adsorption dehumidifier = duct system configured for 12,000 m^3/h air flow

Condensation dehumidifier = duct system configured for 50,000 m^3/h air flow

The same difference applies to the operating costs associated with equipment such as filters, and to the service and maintenance costs.

Air filters for process air

Significantly larger filters are required for the cooling plant compared to the adsorption dehumidification system. This has to be taken into consideration in any comparison of operating costs.

CRT12000 adsorption dehumidifier = filters configured for 12,000 m^3/h air flow

Condensation dehumidifier = filters configured for 50,000 m^3/h air flow

Service and maintenance

Cooling plants normally require inspection and service at intervals ranging from quarterly to annual, depending on national legislation.

In the case of a Cotes adsorption dehumidifier installation, one single annual service is recommended, but there are no legislative requirements about this.

6. Advantages from using adsorption dehumidifier technology

As previously mentioned, dehumidification can be done either by cooling the air so that the moisture condenses or by adsorption of moisture present in the air. Which of the two types of systems that is the best suited for any given situation depends on the inlet conditions for the dehumidifier.

Cooling is usually the more economical solution at higher temperatures and higher levels of humidity (%RH), whereas adsorption dehumidifier technology is more efficient at lower temperatures and lower level of humidity.

The conditions normally found in an ice rink facility are a borderline case for what can be considered a sensible use of cooling and condensation in order to manage humidity.

In cases where cooling systems and condensation dehumidifiers are still installed with a view to controlling humidity in an ice rink, this is usually due to a lack of awareness about the full potential of dehumidification systems on the part of the architect or consulting engineers. Current know-how about the advantages and disadvantages of the two types of systems is not always taken into consideration when designing this type of structure. Cooling is usually the best-known technology, but is often far from being the most cost-effective solution.

Uses the most accessible and most economical energy

One major advantage that adsorption dehumidifier systems have, in comparison with cooling and condensation dehumidifiers, is that the main use of energy (for the regeneration of the rotor) can come from many different types of sources, including natural gas, steam, water (at temperatures of 60–120°C), or a combination of these.

This gives much greater flexibility when deciding on the suitable source of energy, based on either price profiles or the reliability of access to the different types of energy.

Efficient use of other energy sources

Making use of surplus or waste heat from the ice rink cooling system for the regeneration zone of the dehumidifier is a familiar, well-proven technology. Using thermal transfer makes it possible to use this "free" energy for some or all of the energy needed for the regeneration zone.

Dehumidification is normally most needed during the summer, when there is little call for using surplus or waste heat for other heating purposes. It then makes good financial sense to use such heat for the regeneration zone in an adsorption dehumidifier system.

Furthermore, the cooling system only has to be configured to match the requirements of the ice rink itself – there is no need to purchase extra capacity so that it can also function as a dehumidifier.

An adsorption dehumidifier can also be equipped with a heat recovery unit that can reduce the energy consumption of the dehumidifier unit by a further 20–25%.

Easy maintenance and reliable operation

An adsorption dehumidifier is a relatively straightforward mechanical/electrical system that is easy to maintain with only basic technical skills – there is no need for special technical knowledge and experience with cooling systems to maintain if an adsorption dehumidifier system is installed at an ice rink facility.

In addition, there are no legislative requirements concerning service of adsorption dehumidifiers (with the exception of units fitted with a gas-fuelled regeneration system).

Adsorption dehumidifiers have very few wearing parts. The only moving parts are the ventilators and the silica-covered adsorption rotor, which usually turns at a rate of ten revolutions per hour.

All in all, adsorption dehumidifiers are substantially less complicated compared with cooling/condensation dehumidifiers. This results in a greater likelihood for efficient, reliable operation with a minimum of maintenance costs and/or downtime.

Smaller, more efficient installation

The large capacity of adsorption dehumidifiers (in terms of g water/kg air) means a smaller volume of air to treat (only 25% of the volume that cooling/condensation dehumidifiers have to treat to obtain the same conditions). This means it is possible to install a smaller, less expensive, simpler system with lower operating costs. The operation of ventilators and changing of filters is also significantly less expensive.

Proper installation of adsorption dehumidifier systems in an ice rink would normally be configured to deal with the dehumidification requirements during night-time conditions, with very few people present. Such conditions represent the operating requirements for approx 90% of the time.

Such a capacity configuration makes it possible to install the dehumidifier with its own duct system, independent of all other ventilation systems – and only this smaller ventilation system has to be running 90% of the time, thus saving on operating costs.

7.0 Conclusion

Any cooling system/condensation dehumidifier installed in an ice rink under the conditions mentioned above would be operating on the outer margins of the viable conditions for such a system.

By comparison, an adsorption dehumidifier would provide the following benefits:

- Less power consumption for both dehumidification unit and ventilation system
- Lower power system specifications for in the building
- Alternative sources of energy, such as natural gas, waste heat from the cooling plant, etc. can be used
- Filter replacements are less expensive
- Lower installation costs – approx. 33% – due to significantly smaller dimensions of the duct system.
- Reliable dehumidification, efficient operation
- Straightforward – and therefore less expensive – service and maintenance
- No legislative requirements to comply with
- Significantly lower running costs
- Smaller overall investment.