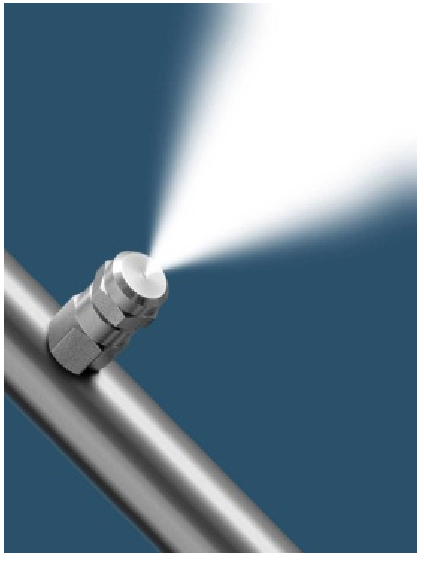
Fogging
to enhance dry cooling

Evaporative cooling can help dry cooling during high ambient temperatures by cooling the air.



Evaporative coling can be done in two ways.

1. By wetting the heat transfer surface (fins)
2. By cooling the air with small droplets of water, fogging.

Wetting the fins

The disadvantage of wetting fins are:

- Corrosion of the bundles
- Damage to motors and gearboxes
- Algues on the structure and equipment
- Lime stone fouling when using hard water.

This can happen when wetting the Bundles with townwater

Why fogging

By fogging a water mist is released in the air flowing through the fans and heat exchanger bundles

- No wet fins
- Fast evaporation

Train station cooled with fogging

How does it work

By evaporating water in air, the evaporation heat needed is taken from the air.

As a result of this, the air will cool down.

The only requirement is air with a relative humidity allowing evaporation, say 50 to 60% RH.

The maximum quantity of water to be evaporated is the quantity necesary to raise the relative humidity to 95-100%

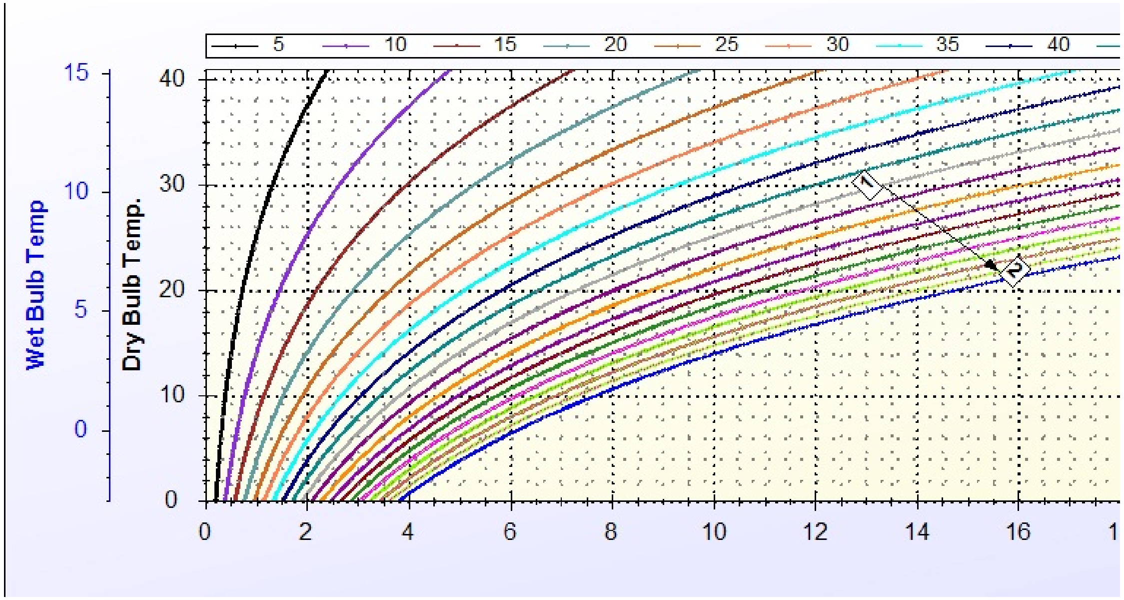
Terasses can be cooled with fogging

Practical example

We will discuss a practical example of an small ACC

- 4 cells
- Air flow through each fan 375 m3/s
- Ambient temperature 30 C, RH 50%
- Vacuum at the turbine exhaust 182.3 mBara
- Enthalphy steam 2271.19 kj/kg

Mollier diagram results



	Point 1	Point 2
air temp.	30 C 86 F	21.8 C 71.2 F
Relative humidity	50%	95%
Water content	13.3 gr/kg	15.6 gr/kg
Enthalpy air kJ,kCal/kg	63.4 15.09	60.8 14.47

Water needed

With a density of air of 1.153 kg/m3

And an airflow of 4 x 375= 1500 m3/s

We need 2.3gr x 1500m3= 3.45 liter/sec.

This is 207 l/min

To guarantee the evaporation of this water, droplets must be between 25 and 40 microns

To achieve this, we can either use an atomising system or a high pressure spray nozzle system

The latter is considered the most efficient as the number of nozzles is high.

Thermal data.

	without fogging	with fogging
Air temperature in	30 C, 86 F	21.8 C, 71.2 F
Air density	1.155 kg/m3	1.186 kg/m3
Air flow total	1500 m3/s	1510 m3/s
Air flow in kg	1733 kg/s	1791 kg/s
Relative humidity	50%	95%
Static pressure	78.1 Pa	79.5 Pa
Turbine back pressure	0.182 BarA	0.126 BarA

The fan settings were identical

The air flow increase in kg is 3.35%

The fogging, in this case, will result in a turbine backpressure improvement of 56 mBar

nozzles

The nozzles giving the best results to date have a capacity of 0.1242 l/min

This means we need 1667 nozzles for this ACC

This nozzle has an opening of 0.2 mm

This small size is the reason that the water has to be clean.

Demin or soft water (<2 degree), has to be used.

Diameter top 7mm

Controls and water quality

The maximum humidity should be just below 100%.

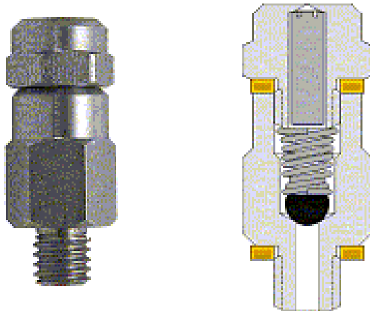
A humidity sensor can control the pump speed with a frequency controller.

The water has to be soft, softener can be used

This is a resin water softener which
Regenerates the resin with salt

Unit built

The pictures show the unit built in the UK.



Nozzle design

Investment costs

In our example the costs are:

Investment 125000 euro= 27.5 Euro /day used

Usage 5 months a year for 8 hours a day, over the life time of 30 years

Water consumption 0.207 x 60 x 8= 100 m3/day

Price of Demin water 12.5 Euro per day

Price per day 40 Euro

Result

Decrease of ambient temperature is 8.2 degree C

Enthalpy of steam into ACC is 2271.19 without fogging

and 2254.99 kj/kg with fogging

Difference in Enthalpy is 16.2 kJ/kg

With a flow of 61409 kg steam the turbine output rises 994.8 MJ which is 0.276 MW/h

On a day the result is 2.21 MWh

With a MWh price of 80 Euro the result is 177 Euro per day, net result 137 Euro per day= 20550.- Euro per year

The water plumes are visible for about one meter, after that the droplets are evaporated

Turbine trip protection

Fogging can help preventing turbine trips during high ambient temperatures.

If the backpressure at the turbine exhaust reaches the trip point, fogging can lower the vacuum enough to ptrevent this.