New Dry and Spray: High efficiency liquid coolers

Capable of exchanging great quantities of heat at low temperature, near that of the dry bulb air temperature to secure lowest possible impact on the environment.

By Stefano Filippini and Umberto Merlo, R & D Managers at LU-VE S.p.A., Varese

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Introduction

The new range of large capacity dry coolers and condensers, based on the DRY and SPRAY® operating principle, are the result of intense research and development carried out at the laboratories of the LU-VE Group under the supervision of noted scientific consultants from Politecnico di Milano University. The DRY and SPRAY® products represent the most advanced point in the development of dissipaters capable of exchanging great quantities of heat at low temperature, near that of the dry bulb air temperature.

The objective underlying the research was to create a product that has the lowest possible impact on the environment and therefore able to allow heat exchange temperatures near the ambient temperature (guaranteeing high COP of the installation) combined with low ventilation consumption.

General operating principle

The products in the DRY and SPRAY series work as traditional dry coolers (or condensers) with dry fins for as long as the ambient air temperature is low enough to maintain cooling power and the temperature of the cooled liquid (or the condensation pressure) at the projected conditions (DRY operation). However, once the ambient air temperature becomes too high to maintain cooling capacity and cooled liquid temperature at the projected conditions, the system automatically starts to spray the required amount of water onto the fins (WET operation).

The evaporation of the water sprayed on the fins dramatically increases the capacity of the unit, allowing it to maintain the temperature of the cooled liquid at the projected conditions at any ambient air temperatures. This innovative technology also permits, as a function of the wet bulb ambient air temperature, a cooled liquid temperature equal to or lower than the dry bulb ambient air temperature, with significant energy advantages (COP).

The ambient transition temperature from DRY operation to SPRAY operation is a design option and is generally set at around 20°C.

It should be stressed that most of the water sprayed onto the fins evaporates off. This means that it is not necessary to fit a drain tray beneath the unit to collect and recirculate the sprayed water, with enormous health benefits.

Research activity

The design activity for the new DRY and SPRAY® series has been inspired by the principles of ecological protection and environmental sustainability:

- to reduce energy consumption;
- to reduce water consumption;
- to reduce overall running costs (Life Cycle Cost);
- to reduce sound emission;
- to eliminate the recirculation of water and the consequent risks associated with legionella.

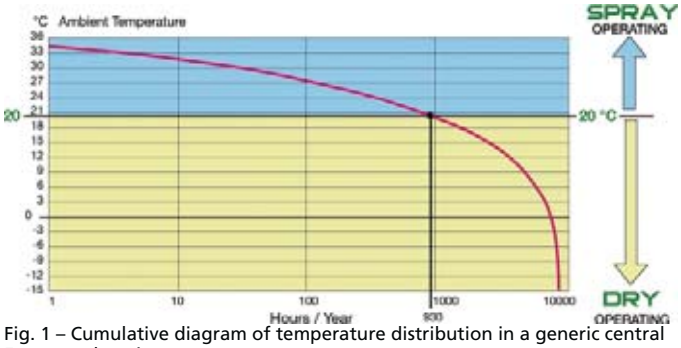

Fig. 1 – Cumulative diagram of temperature distribution in a generic central European location.

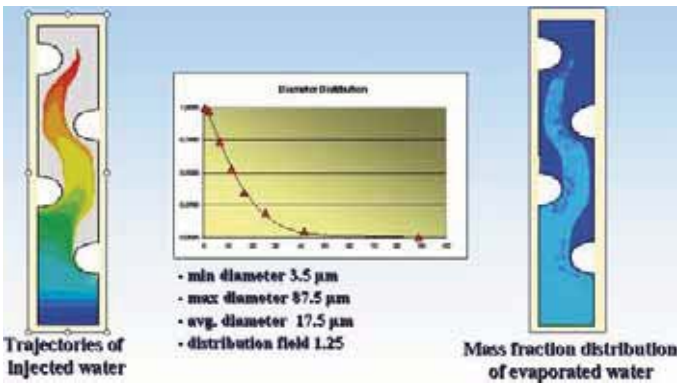

Fig. 4 – Injected water trajectories and mass fraction distribution of evaporated water.

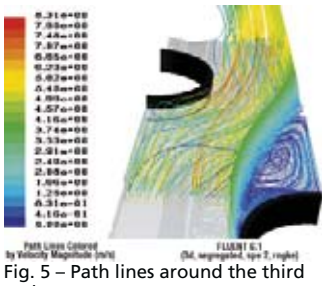

Fig. 5 – Path lines around the third exchanger row.

The main theoretical and experimental principles used to support the research were as follows:

- the use of CFD (Computational Fluid Dynamics) codes to study the thermofluido-dynamic processes in the heat exchangers in DRY operation;
- the use of the Discrete Phase model in combination with the CFD code to study the thermofluido-dynamic processes in the heat exchangers in WET operation;
- analyse the best combination of materials and the quality of the water to be nebulized in order to guarantee maximum reliability over time;
- examine the hygiene aspects in order to offer a product with maximum guarantees.

The use of CFD codes, as shown in the figure, permitted the development of an especially efficient exchange geometry in both dry surface operation and also during the injection of water. In order to optimize performance with wetted surfaces, the Politecnico di Milano carried out specific research focussed on determining the dimensions of the water droplets produced by the nozzles used on the D&S machines, as the nebulization pressure changes between 4 and 16 bar. The measuring device used was a laser Doppler anemometer capable of measuring the speed and diameter of spherical particles in the micrometric field.

Product description

DRY and SPRAY® equipment has six main components: liquid cooler, ramps with special atomization nozzles, solenoid valves, system of electronic control, special equipment to treat the water and special air pressure pump.

- Liquid cooler (or condenser) with high efficiency heat exchangers with aluminium fins coated with a special material specifically for optimum performance with wet surfaces.
- Ramps with special atomization nozzles: The ramps are fitted with special atomization nozzles for the distribution of water onto the surface of the coils.
- Solenoid valves: The Solenoid valves to open and close the water distribution ramps depending on the thermal load, temperature and humidity of the ambient air.
- System of electronic control: A sophisticated system of electronic control which optimizes the operation of the DRY and SPRAY system, varying according to the thermal load of the liquid

Fig. 6 – Dry & Spray liquid cooler.

Fig. 7 – Special atomization nozzle for the distribution of water onto the surface on the coils.

cooler (or condenser) and the ambient air temperature, completely managing water injection and fan operation.

During DRY operation, fan rotation speed is regulated to the essentials with a consequent reduction of energy consumption and sound level.

During SPRAY function, the quantity of water to be sprayed onto the coils is regulated to the essentials with a consequent reduction of water consumption.

This regulation operates in parallel with the regulation of the air velocity, which enables the consumption of water and electricity to be minimized at the same time.

Additional components

Dry and Spray equipment has also these main components:

- Special equipment to treat the water to be sprayed onto the coils during SPRAY operation.
- A special high pressure pump to supply the distribution ramps with water for the surface of the coils.

These components must be installed in an enclosed place with a temperature above 5°C.

Advantages

Using DRY and SPRAY liquid coolers and condensers as an alternative to the traditional cooling towers and evaporative condensers has the following important advantages:

- Water consumption in SPRAY operation is limited a brief period of the year. For long periods of the year, during DRY operation, water is not used; so the total annual water consumption on average is from 3 to 10 times less than the traditional cooling tower
- As a result of not having a drain tray full of stagnant warm water beneath the coils. This excludes the possibility of any build-up of impurities in the water, above all any risk of environmental contamination (no legionella).

Further advantages

Using DRY and SPRAY® liquid coolers and condensers allows further advantages:

- low energy consumption;
- quiet operation;
- amortization of the unit in a short time period.
- possibility of high thermal capacity through free cooling.
- Plant operation without any water drops being released into the environment and without the formation of ugly vapour plumes.

The essential advantages deriving from the use of DRY and SPRAY liquid coolers and condensers as an alternative to traditional liquid coolers and condensers with dry surfaces are:

- Important overall reductions in the space taken up by the equipment (up to 1/3);
- Important air flow reduction (up to 1/3);
- Important energy consumption reduction (up to 1/3);
- Quieter running;
- The liquid can be cooled to a temperature below that of the ambient air dry bulb.

Performances

The new DRY and SPRAY technology allows the construction of high unit capacity plants. Indicatively, the *Fig. 6* here shows a qualitative diagram with the performance of a unit fitted with 800mm 6 pole fans. Performance increases exponentially compared to the traditional dry configuration to the reduction of DT1 and depending greatly on the choice of nebulizing pressure. This

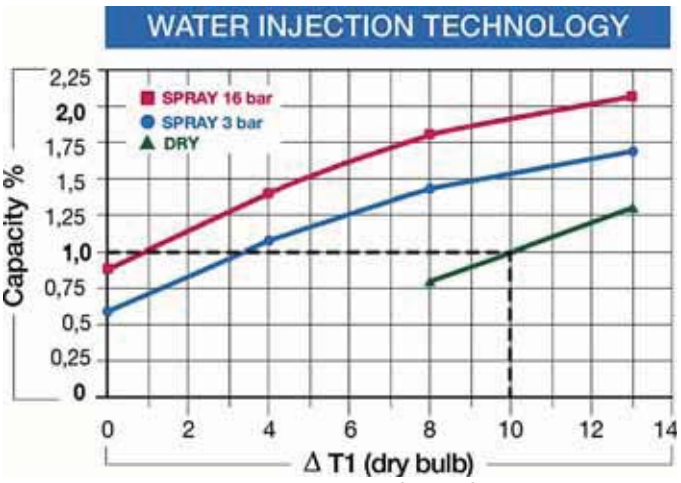

Fig. 8 – Comparison between dry and wet surface performance.

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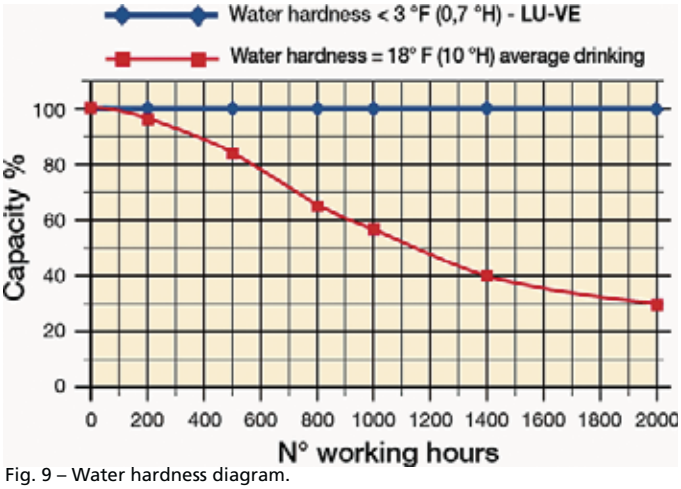

Fig. 9 – Water hardness diagram.

pressure, depending on the conditions of operation, is between 2.5 and 16 bar, without prejudicing the constraint of maintaining the conditions of operation of the water (see dedicated section).

Health aspects

Great attention has been paid to this aspect in order to offer a product which can guarantee absolute reliability. The principle aspects which characterize this product are:

- Absence of recirculation of the atomized water. There is no tank to collect atomized water which, once sprayed onto the fins, evaporates (for the most part) or rolls down the fins and falls to the ground where it is disposed of as rain water.
- Absence of deposits or biofilm. The sprayed water is a carefully treated and purified liquid and therefore the possible formation any deposits or biofilm, typical areas for the formation of bacterial colonies, is excluded.
- Absence of air dispersal of water droplets. Elimination of any air dispersal of water droplets which, after traversing the surface of the exchanger, are expelled into the atmosphere by the fans. To arrive at this result, a solution was adopted which provides for the injection of finely atomized water, at the temperature of the mains supply, upstream of the heat exchanger coils; and to check in every operating condition that the relationship between the air flow and water flow is always above the values which could lead to saturation. In fact, the optimization of the system means that the values of the relative humidity of the air at the outlet of the coils never exceed 65%. This therefore eliminates any possibility of the presence of water in liquid form. This projected data has been verified by numerous experimental tests, conducted under all kinds of conditions. Thus it is physically impossible for any water droplet to be present in the outlet air flow.
- Absence of bacteria contamination risks. The water supplied by the SPRAY system is drinking water and therefore by definition cannot be water that has been contaminated by bacteria (legionella) dangerous to health. The water inside the ramps of the SPRAY system could, if the system remains unused, warm up due to the heat of the sun. From the specific tests carried out by the Istituto Zooprofilattico di Pavia (Italy), it clearly emerges that the softened water treated in accordance with LU-VE specifications, does not have any proliferation of legionella pneumophila. An automatic emptying system for the ramps is available at the request of the client for even greater safety.
- Total safety. In confirmation of its quality and safety, the DRY and SPRAY system has been awarded the Health Safety Certificate issued by the prestigious Domatec laboratory in Germany.

Should there ever be any uncertainty about possible bacterial contamination of the drinking water supply to the system, LU-VE can provide upon request a kit including a special UV lamp capable of guaranteeing sterilization of the water.

Nebulization water quality

An enormous amount of attention has been paid to the definition of this aspect. Sophisticated tests were done in the laboratories, in particular, concerning the resistance to corrosion and limescale deposits on aluminium fins with special protective coatings with conditions of different water qualities. The results obtained are indeed spectacular. For the DRY and SPRAY units to function correctly, the water in the system needs to have the following characteristics:

- be in accordance with European Directive 98/83/EC
- PH in the range 6 to 8
- Conductibility < 1500 µS/cm
- Chloride < 200 mg/l (200 ppm)

This water, before being nebulized, has to undergo a softening process to reduce its hardness which has to be between 2 and 4°F (or 1,1 - 2,2°H). It must also be dosed with a special protective agent (LU-WET 30), which is completely biodegradabile, to guarantee reliable operation over time - with the constraint that the SPRAY system is used for a maximum of 900 hours in a year. If the chloride is < 100 mg/l, it is not necessary to add the special protective agent LU-WET 30. The annual limit of 900 operational hours of the SPRAY system remains valid.

Finally, if the chloride level is between 100 and 200 mg/l, LU-WET 30 need not be added but the operational limit is reduced to 300 hours per year.

The use of untreated water, even if it is of average hardness, quickly causes the deposit of carbonates on the fins with a consequent loss of performance. This can clearly be seen in the graph below which shows the results of a series of experimental tests we carried out with water at 3°f and 18°f.

Conclusions

The latest generation of DRY and SPRAY® is based on leading edge technology to maximize the performance of condensers and dry coolers. Their design and construction is based on the most prudential and the most modern criteria for the care of the environment, with the objective of reducing energy consumption, water consumption, overall running costs, sound levels and eliminating risk stemming from legionella.

The DRY and SPRAY® units are the most advanced of their type in the world, the result of heavy investment in research and development. It is no coincidence that world leading prestigious brand names (such as BMW, Mercedes, Volkswagen, Wienstrom GmbH, the Frankfurt Fair and the Clinical University of Marburg to name but a few) have chosen them specially for their innovative and ecological characteristics.


Fig.10 – Dry & Spray liquid cooler installation at Frankfürt exhibition centre.