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Innovative und nachhaltige Rückkühlung mit Hybriden oder A diabaten Trockenkühlern

Author

Joachim Weber
Sales manager CH/A

Summary

Whether it be climate protection, resource conservation or cost reduction – energy efficiency is the order of the day and is a hot topic not only among politicians but also in many companies. The EER value (Energy Efficiency Ratio) is particularly worthy of note: it indicates how energy-efficient refrigeration chillers are. The higher the value, the more energy-efficient the chiller. In the case of dry cooling plants, however, not only the energy efficiency but also the water consumption needs to be assessed in order to ensure efficient dry cooling. With hybrid cooling technology, the company JAEGGI provides a dry cooling system which combines maximum energy efficiency with minimal water consumption.

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JAEGGI Hybridtechnologie AG
Hirschgässlein 11
CH-4051 BASEL
SWITZERLAND

Member of Güntner Group

Chillers are energy-intensive machines

When planning and designing cooling and cold water systems, various procedures for dry cooling the circulating water are used depending on the required temperature level. For cooling water temperatures below approx. 20 °C, machines called cold water chillers are used. These can be air or water cooled and, depending on their layout and operating point, can achieve EER values between 4 (i.e. 1 kW of electrical compressor drive power is needed for 4 kW of cooling capacity) and 10.
For cooling water temperatures above 20 – 25 °C, operators can forgo these energy-intensive chillers. Instead, evaporative coolers or dry coolers provide corresponding temperatures and use significantly less electricity in the process. When planning new systems, planners and operators should therefore ask themselves whether water temperatures of less than 20 – 25 °C are really needed in the cooling process or whether higher water temperatures are possible.

Dry cooling is often not enough

With dry coolers, finned heat exchangers are cooled with ambient air. This means that the ambient temperature is the theoretical cooling limit. In Central Europe, however, where systems are usually designed for an ambient temperature of 32 °C, minimal cooling water temperatures of only around 35 – 37 °C can be achieved. As a result of global warming, systems are now being designed for an ambient temperature of at least 35 °C. This means that the minimum achievable cooling water temperature increases to approx. 38 – 40 °C. Lower water temperatures can be achieved economically only using evaporative coolers.

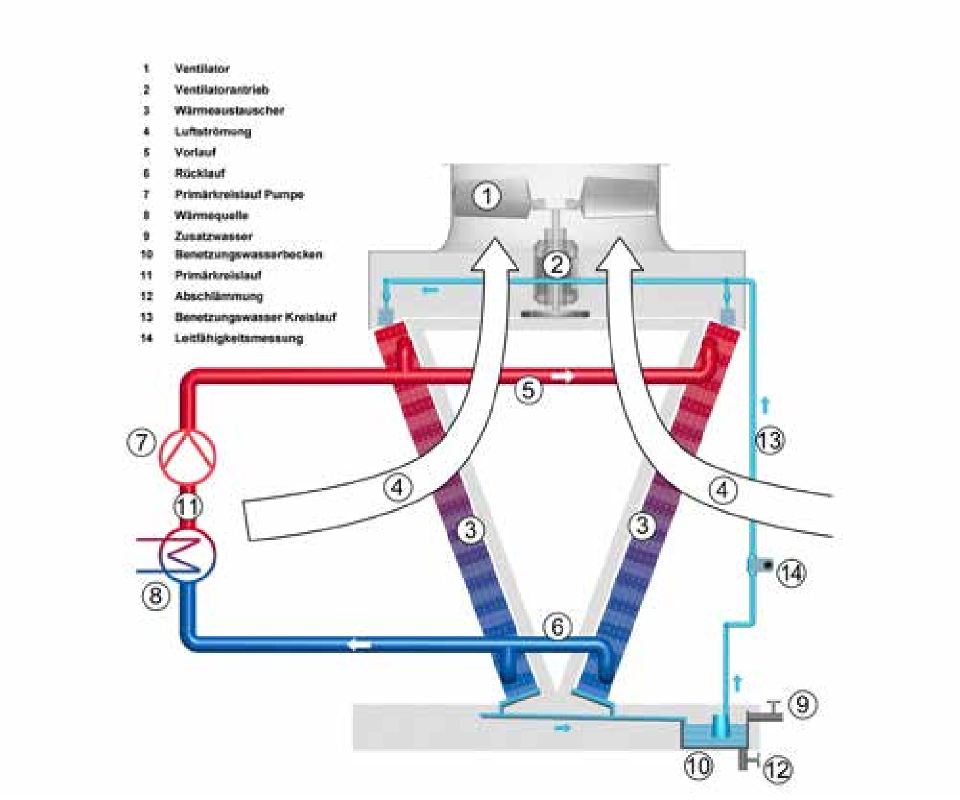
Flatbed dry cooler, Photo: Güntner GmbH & Co. KG

Evaporative cooling is most efficient

With dry coolers, one has to accept not only high water temperatures and large setup areas but also the relatively high electricity consumption, even if it is lower than with chillers. In contrast, evaporative coolers are considerably cheaper. By using the natural principle of evaporation, maximum energy efficiency and a significantly smaller setup area are possible. The water which evaporates into the atmosphere effectively removes excess heat from the process. For evaporative coolers, the wet bulb temperature is the theoretical cooling limit; in Central Europe, systems are designed for a cooling limit of 21 – 23 °C. Depending on the design of the evaporative coolers, the water temperatures that can be achieved in reality are 2 - 8 K above this limit.
Evaporative coolers in a variety of designs and with a wide range of cooling capacities are available on the market. These include open and closed wet cooling towers or evaporative condensers.
However, these systems have a number of disadvantages, too. Depending on the operating mode and construction, they emit a visible vapour plume which many people find unpleasant and which can also cause hazards such as mist/reduced visibility or ice on neighbouring roads. In addition, relatively large quantities of fresh water are needed to compensate for evaporative and blowdown losses. At the same time, most cooling towers are relatively loud owing to the sound of falling water and reducing this noise is only possible with considerable outlay. With open cooling towers, the cooling water is often contaminated with dust, leaves, insects, pollen, etc. from the ambient air because the open cooling tower works indirectly as an air washer.

Hybrid dry coolers – low water consumption, energy-efficient, plume-free and quiet

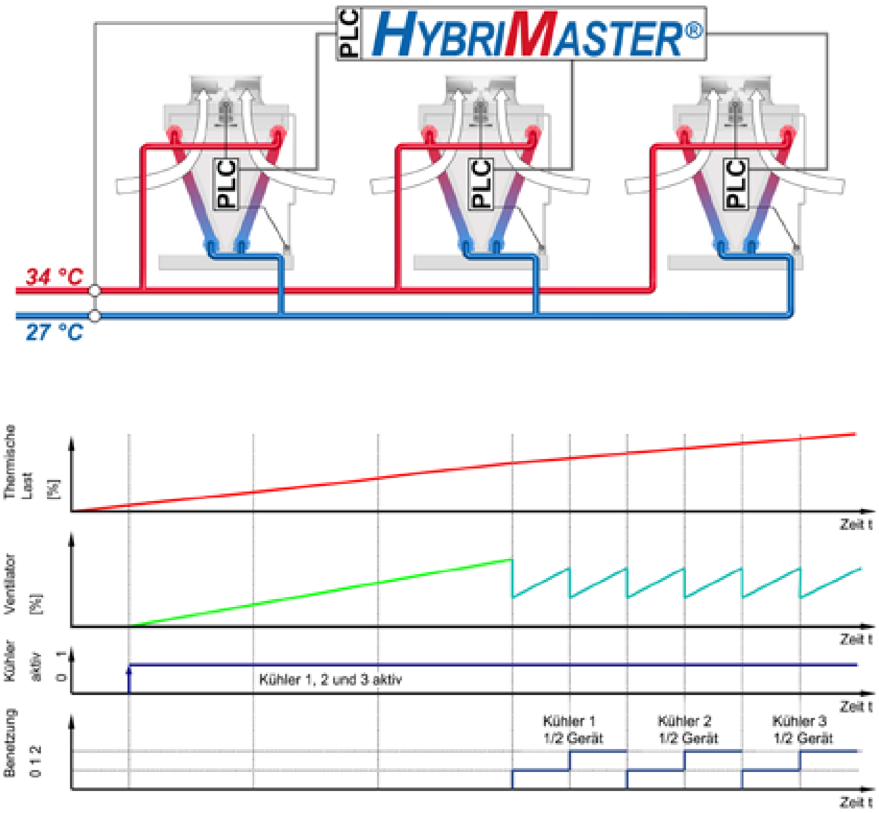
The hybrid dry cooler, a modern and innovative cooling concept, was therefore developed by the company JAEGGI in Switzerland in 1992. Since then, over 3,000 hybrid dry coolers have been produced. Depending on the design, fluid temperatures up to 3 K above the wet bulb temperature can be achieved. The hybrid dry cooler from JAEGGI combines the advantages of conventional dry cooling and wet cooling but without their disadvantages. As a result, customers benefit from highly efficient dry cooling technology with minimal electricity and water consumption. The coolers are also extremely quiet, are guaranteed not to produce plumes and, thanks to the integrated HYBRIMATIC control system and their compact design, can be installed as a turnkey solution in existing or new systems.



Function diagram of the hybrid dry cooler, JAEGGI Hybridtechnologie AG

HYBRIMATIC control system for optimum operation

The hybrid dry coolers are always optimized to save water. During cooler periods or under partial load, the JAEGGI *HYBRIMATIC* control system operates the coolers entirely dry, i.e. dissipating heat to the ambient air purely by convection. It automatically switches to the wetting circuit only when dry operation is unable to achieve the required cold water temperature. By taking advantage of the natural evaporation principle, the coolers are extremely energy-efficient. Depending on the operating point and design, they use 70 – 90 % less water than wet cooling towers and thus help to reduce water costs.
Systems with several hybrid dry coolers are controlled in accordance with the master-slave principle via the superordinate *HYBRIMASTER* control system.



Master-slave control principle in compound systems with several hybrid coolers

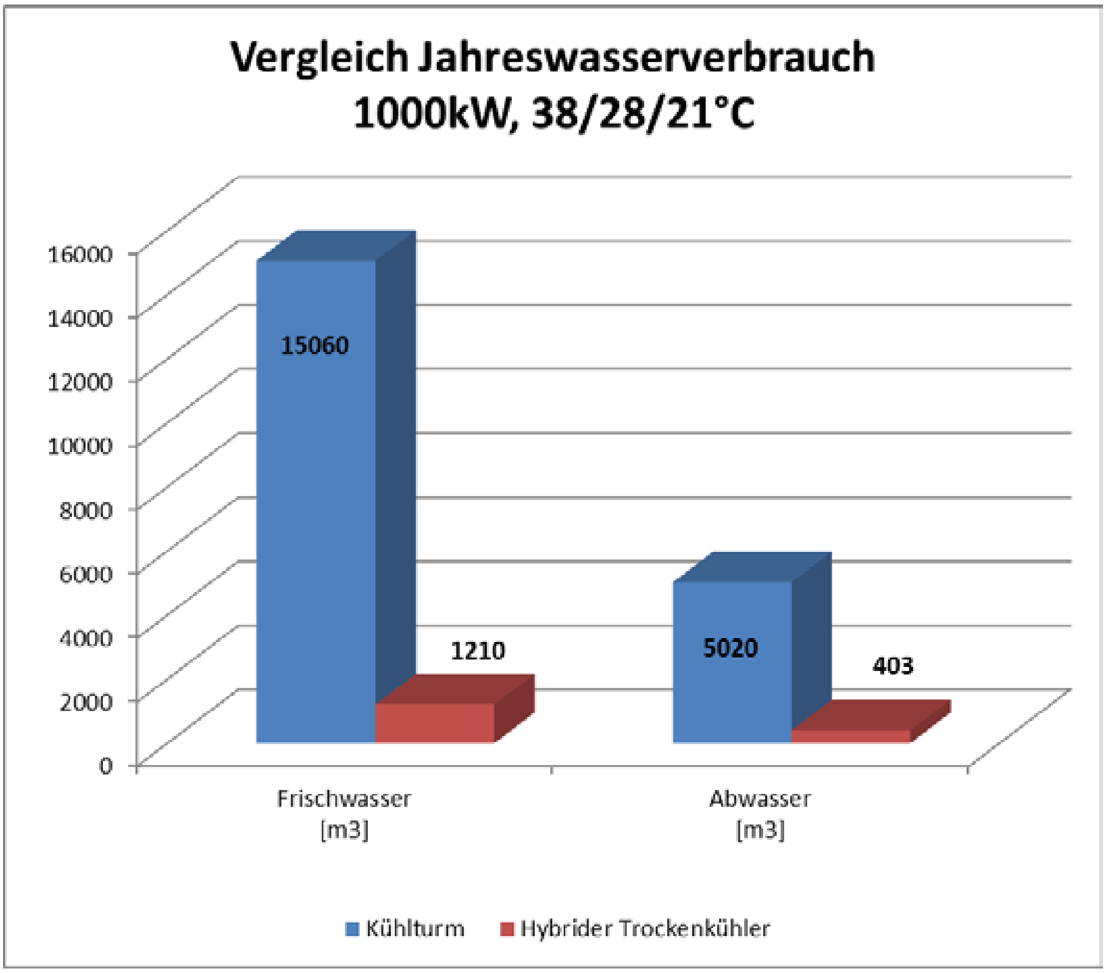
Operating characteristics of hybrid dry coolers

Thanks to the innovative hybrid technology, energy-efficient dry cooling based on the natural evaporation principle can be combined with water-saving dry cooling in a single unit. As soon as the planned switch point for dry operation is reached, the cooler automatically disables wetting and then works in dry mode without using water. Depending on the design, the switch points for dry operation are usually between 10 °C and 20 °C ambient temperature. Compared to conventional wet cooling towers, considerable amounts of water can be saved because the coolers are in dry or only partially wet operation for many hours each year.
Typical operating characteristics for a hybrid dry cooler in Munich, Germany, are shown in the following table. In this example, the switch point for dry operation is 18 °C, assuming a constant load of 1,000 kW all year with fluid temperatures of 38/28 °C in 3-shift operation.

Air condition range (Operating status)			Operating mode of the cooler		Fan speed	Water consumption		Power consumption total	Opera-ting hours	Cooling capa-city	Cooling water	
						Fresh water	Waste water				On	Off
from [°C]	to [°C]	RH %	dry	wet	%	CF = 3 [m³]	CF = 3 [m³]	[kWh]	h	[MW]	[°C]	
-29.0	-20.0	0	1	0	28	0	0	2	5	1.000	38.0	28.0
-20.0	-17.0	0	1	0	30	0	0	7	16	1.000	38.0	28.0
-17.0	-14.0	0	1	0	31	0	0	19	38	1.000	38.0	28.0
-14.0	-11.0	0	1	0	34	0	0	47	77	1.000	38.0	28.0
-11.0	-8.0	0	1	0	36	0	0	97	129	1.000	38.0	28.0
-8.0	-5.0	0	1	0	39	0	0	257	276	1.000	38.0	28.0
-5.0	-2.0	0	1	0	42	0	0	649	552	1.000	38.0	28.0
-2.0	1.0	0	1	0	45	0	0	1‘911	1263	1.000	38.0	28.0
1.0	4.0	0	1	0	50	0	0	1‘952	972	1.000	38.0	28.0
4.0	7.0	0	1	0	55	0	0	2‘635	959	1.000	38.0	28.0
7.0	10.0	0	1	0	62	0	0	4‘117	1‘038	1.000	38.0	28.0
10.0	13.0	0	1	0	72	0	0	6‘894	1‘117	1.000	38.0	28.0
13.0	16.0	0	1	0	87	0	0	10‘769	1‘005	1.000	38.0	28.0
16.0	18.0	0	1	0	100	0	0	7‘289	446	1.000	38.0	28.0
18.0	19.0	66	1/2	1/2	77	187	63	1‘430	175	1.000	38.0	28.0
19.0	22.0	60	1/2	1/2	89	456	153	4‘518	374	1.000	38.0	28.0
22.0	24.1	56	1/2	1/2	99	223	74	2‘768	165	1.000	38.0	28.0
24.1	25.0	55	0	1	53	100	33	201	53	1.000	38.0	28.0
25.0	28.0	48	0	1	56	176	59	357	84	1.000	38.0	28.0
28.0	31.0	41	0	1	59	59	20	123	26	1.000	38.0	28.0
31.0	33.0	36	0	1	61	9	3	18	4	1.000	38.0	28.0
						1210	403	46060	8760			

Operating characteristics of an example system for hybrid coolers with year-round full-load operation and constant cooling power of 1,000 kW with fluid temperatures of 38/28°C in Munich

For the hybrid dry cooler, the annual water consumption (evaporation and blowdown at 3-fold concentration) is 1,210 m3 with a waste water volume of 403 m3.
If a wet cooling tower had been installed instead, this would have consumed 15,060 m3 of fresh water and generated 5,020 m3 of waste water.



Water consumption of a cooling tower compared to that of a hybrid cooler of an example system for year-round full-load operation and constant cooling power of 1,000 kW with fluid temperatures of 38/28°C in Munich

In this example, using hybrid dry cooling reduces the water consumption by approx. 90 %. This not only reduces operating costs significantly – it also protects the environment and our dwindling resources including water.

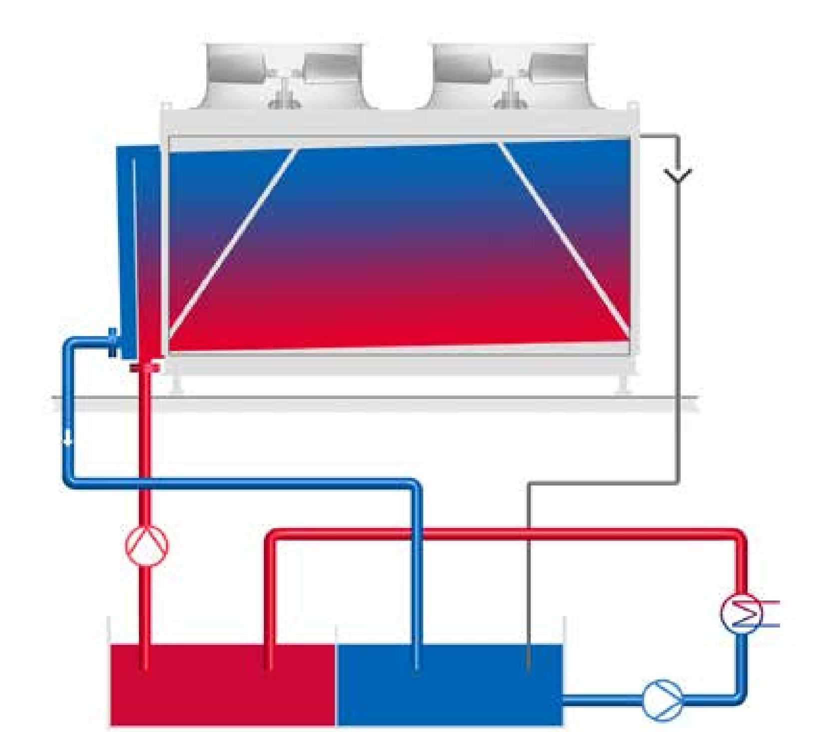
"EER" = 120: Hybrid dry cooling makes it possible

Using an example system, the energy efficiency of the hybrid dry cooler can be demonstrated impressively: The HTK 2.4/9.0 cooler shown is used for cooling a test facility. With a power consumption of 3 x 4.8 kW for the fans and 2 x 0.7 kW for the wetting pumps (= 15.8 kW in total), it has a cooling capacity of 1,900 kW (water quantity 230 m3/h, warm water temperature 35 °C, cold water temperature 28 °C, wet bulb temperature 21.5 °C). This results in a very high, energy-efficient "EER" value of 1,900 kW/15.8 kW = 120 (Note: the EER value actually applies to chillers and is used in a figurative sense here).

Hybrid dry cooler HTK 2.4/9.0 for cooling a test facility, cooling capacity 1,900 kW at fluid temperatures of 35/28 °C, Photo: JAEGGI Hybridtechnologie AG

Under partial load or at relatively low wet bulb temperatures, the fan speed is continuously reduced by frequency converters in the HYBRIMATIC control system. Because the power consumption of the fans decreases in proportion to the third power of the speed, the "EER" value then increases exponentially. In the example above, the cooler thus achieves an "EER" value of 590 at half the fan speed.

Hybrid dry cooler in self-draining design



Function diagram for dry cooler system with cooling water and self-draining hybrid cooler

Hybrid dry coolers are usually operated with a water/glycol mixture in order to prevent frost damage in winter when the system is not operating. For replacing existing open wet cooling towers or planning new systems without glycol, JAEGGI also offers a self-draining design for use with plain water. This specific construction ensures that the coolant automatically flows into an on-site frost-proof tank when the system is not operating.

Adiabatic coolers

An increasing number of units called adiabatic spray coolers have been available on the market for several years now. Depending on the design conditions, these can be a low-cost alternative to hybrid dry coolers. With these dry coolers, water is sprayed either against or with the air flow in order to cool the cooling air to below the ambient temperature and thus achieve fluid temperatures below the ambient temperature. The problem with spraying is that the cooling coils designed for dry operation become wet and this increases the risk of corrosion and deposits. The spraying time is limited, and softened or fully demineralised water is needed if spraying takes place for relatively long periods. JAEGGI has therefore opted for a different solution using humidification pads at the air intake.

ADC series, adiabatic dry cooler with humidification pads at the air intake
Photo: JAEGGI Hybridtechnologie AG

The main advantage of this solution is that no treated water is needed for the humidification pads because the cooling coils remain dry. Unlike with spray coolers, the operating times in wet mode are not limited. The coolers can therefore operate with a floating setpoint. The fluid temperatures achieved are around 6 K above the wet bulb temperature. Compared to hybrid dry coolers which are more expensive depending on their design, the switch point for dry operation is higher and the water costs are lower. The only disadvantage is that more space and electricity are required.

ADC cooler for air conditioning in a building in London
Photo: JAEGGI Hybridtechnologie AG

Bigger units, bigger savings

Further energy savings can also be achieved by deliberately opting for oversized dry coolers. The cooler is then designed to work with a reduced air quantity and a lower fan speed. This reduces electricity consumption exponentially because the power consumption of the fans decreases in proportion to the third power of the speed. Thanks to the larger coolers in adiabatic or hybrid dry coolers, the switch point for dry operation is also increased. This results not only in reduced electricity consumption but also in reduced fresh water costs. Although the investment costs for the larger cooler are initially higher, the significantly lower operating costs make up for this. Depending on the project-specific electricity and water costs, the difference in price for the larger cooler can be recouped in less than a year.

Saving energy with “free cooling”

With cold water systems, significant energy savings can be achieved through “free cooling”. A cold water system with a water-cooled cold water chiller is planned in such a way that the energy-intensive cold water chiller can be switched off at low ambient temperatures. The dry cooler (cooling tower, adiabatic or hybrid dry cooler) then takes over process cooling alone instead of condenser cooling. Here too, the extra costs for oversized coolers and for hybrid dry coolers in particular can be recouped in a very short time.

Example of a data centre application with “free cooling”. The chiller operates only at high wet bulb temperatures. In the normal operating mode, the chiller is bypassed and only the hybrid coolers are used.

Conclusion

In many cases, only investment costs are taken into account owing to short-sighted business strategies. As a result, supposedly inexpensive systems are installed which result in high costs and damage the environment through their higher primary energy use. With well planned systems and modern dry coolers, companies can save a great deal of energy, reduce costs and protect the environment at the same time. Evaporative coolers and in particular hybrid dry coolers which save both electricity and water make an effective and valuable contribution towards conserving resources and protecting the environment.