

New Bitzer factory: Higher precision with air conditioning

Central cooling unit for cutting oils and cooling lubricants replaces 25 decentralised coolers



Air-cooled direct condensers from the GVH series made by Güntner. They are installed on the roof above the central cooling room of the new Bitzer factory in Rottenburg-Ergenzingen approximately 20 km south of Sindelfingen.

Line of Business:	Air conditioning
Application:	Air conditioning
Country / City:	Germany / Rottenburg-Ergenzingen
Fluid:	Water, R407C, R134a
Product:	Condenser GVH

By discontinuing the use of decentralised cutting oil and cooling lubricant coolers fitted to machining centres and using instead a centralised cooling system, Bitzer, a manufacturer of cooling machines, has saved about 30 % of electricity in its new factory in Rottenburg-Ergenzingen. As the new production halls have also been air-conditioned for the first time, it is now possible for precision in manufacturing to reach just a few thousandths of a millimetre. The air-conditioning equipment and the cooling circuit to cool the cutting oil are

cooled by separate air-cooled split liquid coolers made by Combitherm. The necessary axial condensers in the GVH series originate from Guntner.



The screw compressors are manufactured in the new Bitzer factory in Rottenburg-Ergenzingen.

A growing number of manufacturers of machine tools are discovering that the precision of the machined parts can be increased by a factor of 8 to 10 by maintaining constant ambient temperatures during machining. If an accuracy of several hundredths of a millimetre used to be achieved, the same machine tool now achieves an accuracy in the range of thousandths of a millimetre if the ambient temperature is kept constant. Constant room temperatures during the production of machine parts not only reduce the number of rejects but also make it unnecessary for operating staff to constantly measure turned and ground parts, to readjust the tools and to "pair" parts, i.e. manually match machine parts with hole and shafts according to the selection of fits described in DIN 7157.



Quality assurance in the Bitzer factory: Precision during production was increased by a factor of 8 to 10 compared with non air-conditioned production.

Albrecht Höpfer, technical sales and sales promotion manager at Bitzer Kühlmaschinen GmbH in Sindelfingen, explained the problem of temperature-dependent manufacturing tolerances: "To manufacture our coolant con-

densers and their parts with high-precision we need comprehensible temperature curves in production. Although we don't have to have exactly the same temperature, it should be constant in the course of the day. What causes problems are the fluctuations during the day in summer, i.e. relatively low room temperatures at the beginning of the early shift followed by an increase to the highest temperatures during late afternoon when the late shift starts. For high-precision parts such as rotors or condenser housings, such temperature fluctuations necessitate constant recording of the tolerance deviation together with appropriate readjustment of the tool and the machine. This results in relatively large tolerances in the range of hundredths of a millimetre with the result that fits of rotors and condenser housings have to be paired in time-consuming procedures. In contrast, air-conditioned product lines in combination with constant cutting oil temperatures open up the way for precision that is in the range of thousandths of a millimetre. This obviates the need for time-consuming pairing, i.e. we can match condenser parts with drilled holes and rotor shafts at random. This saves costs, reduces the numbers of rejects and improves the efficiency of our condensers."

Factory for the future in Ergenzingen

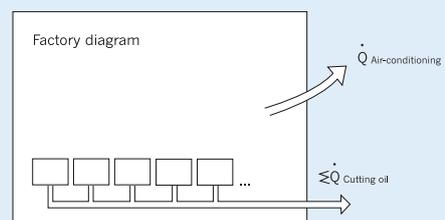
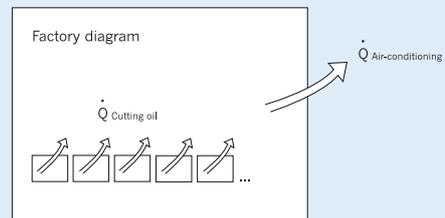
With this in mind, it was an obvious conclusion for Bitzer to completely air-condition the machine production of the factory for screw compressors in Rottenburg-Ergenzingen. During the initial planning it became clear that a relatively high cooling capacity of 1,430 kW would be needed for the big factory with about 16,200 m². When the thermal values were examined more closely, it was revealed that the cutting oil and cooling lubricant coolers allocated to the roughly 25 decentralised machining centres were a major factor contributing to the heating up of the room air and thus to the load on the air-conditioning equipment. This "refrigerator within the refrigerator" principle that used to be used in production was certainly however no longer Bitzer's philosophy, in particular because most factories have been certified by an independent environmental ex-

part in accordance with the DIN/EN 14001 regulations. It soon became clear that the problem of decentralised cutting oil cooling can be best solved by having a separate cold water system with a liquid cooling unit installed externally in a machine room. The cutting oil and lubricant preparation stations, which are still decentralised, are each connected by a plate heat exchanger with the 17/24 °C cold water system.



A cooling unit used to be fitted to every cutting oil - preparation centre. Now the cutting oil is cooled using a plate heat exchanger and a 17/24 °C cold water system.

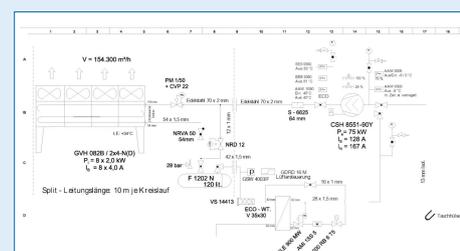
As the cutting oil, which is maintained at 20 °C, also keeps the workpiece to be machined at a constant temperature, most of the heat produced during machining can be dissipated, i.e. the temperature of the workpiece remains virtually unchanged during cutting and grinding work. It is however important that the parts to be machined have already been stored for several days at constant room temperatures so that there is a homogenous temperature in the blanks or housings. The actual air-conditioning of the production hall uses suspended source air outlets with adjustable air deflection for heating or cooling. There is a second liquid cooling unit installed in the machine room to supply the central air-conditioning with cooling energy, i.e. cooling energy is produced separately for the cutting oil cooling system and the air-conditioning system.



The split liquid coolers are designed so that they can be used and regulated under various operating conditions.

Innovative split liquid coolers with CSH screw compressors

With the installation of two centralised cooling units for cutting oil and for air-conditioning systems Bitzer had the opportunity of using the compact compressor in its own factory and of demonstrating it on site as a reference system to the growing number of Bitzer customers. The partner for these technically sophisticated cooling machines was the Combitherm company in Fellbach. Combitherm is a renowned manufacturer of machines and plants for all kinds of cooling and refrigerating purposes and of standard liquid coolers. The following cooling concept was developed based on Bitzer's requirements and Combitherm's special know-how:



Cooling diagram for cutting oil and coolant lubricant with separate condensers

A Cooling for air-conditioning

- Low temperature cold water distribution system at 6/12 °C to supply two room air temperature systems in the machine production, one room air temperature system for quality assurance, one room air temperature system in the staff rooms and one circulation cooler in the server room.
- A liquid cooling unit with R407C as refrigerant consisting of two refrigerating circuits with two CSH 8551 110Y screw compressors, which are connected so that each screw compressor can be used separately. This allows infinitely variable adjustment of the capacity from $Q_{\min} = 50 \text{ kW}$ to $Q_{\max} = 500 \text{ kW}$. There is also a buffer tank with a volume of 1,480 l for very low demand or brief peak demand.
- One air-cooled condenser, Model Güntner GVH 102 B/2x4-L(D). The speed of the condenser fans can be variably controlled by a phase cut controller. The necessary signal comes from a digital pressure sensor, i.e. if the pressure of the refrigerant increases, the speed of the condenser fans increases.

B Cutting oil and coolant lubricant cooling

- High temperature cold water distribution system at 17/24 °C to currently supply 19 plate heat exchangers of the cutting oil preparation system and three other coolers
- One liquid cooler with R134a as refrigerant consisting of two refrigerating circuits with two CSH 8551-110Y screw compressors, variable capacity control from 50 to 500 kW. There is also a buffer tank with a volume of 900 l for very low demand or brief peak demand.
- One air-cooled condenser, Model Güntner GVH 082 B/2x4-N(D). It is controlled using the same principle as the air-conditioning equipment.



The split liquid coolers are designed so that they can be used and regulated under various operating conditions.

In order to make transparent the extraordinarily flexible regulating possibilities of the Bitzer compact compressor during part load operation, the following values can be called up by the energy management system:

- operating current in amps
- kVA consumption
- electrical power in kW
- total kilowatt hours
- $\cos \phi$ as a instantaneous value

In addition, various manual switching functions are included for tests and demonstration purposes in order to explain certain properties that are characteristic of screw compressors.

Highly efficient demonstration system in split design



Liquid receiver with control and pressure absorber for controlling the condenser fans

Assessing the cooling system design, Steffen Klein, the managing director of Combitherm, said, "Together with the experts from Bitzer we have installed two highly efficient demonstration systems whose design is optimised to suit the two applications of air-conditioning, cooling and cutting oil cooling. Bitzer also has the unique opportunity of demonstrating the ad-

vantages of its new generation of optimised compact screw compressors in its system in practice. It is remarkable that the same screw compressor can be used for the R134a and for the R407c refrigerating circuit.

Further special features include the design of the water coolers, each of which has an economiser circuit and a refrigerating circuit with an internal heat exchanger for subcooling liquid and suction gas superheating to achieve the maximum performance efficiency. In addition, the R407C system has been fitted with electronic expansion valves to enable the technical possibilities to be demonstrated with this part of the system, too."



CNC machining in a group improves machine utilization and allows around-the-clock production.

He continued to say that even the design of the split liquid cooler, i.e. the installation of the condenser outside on the roof, had been specifically selected as it reduces the heat exchanger surface needed for drycooling by about 20 to 30 % thanks to its optimum Dt compared with a similar glycol system and it also improves the efficiency of the refrigerating circuit. "A split system is still the most elegant solution," said Steffen Klein. "Not using heat exchangers having losses increases the efficiency of the refrigerating circuit. Split systems are generally much thinner and thus cheaper." As glycol is no longer considered as environmentally safe, the higher amount of filling needed in split systems is just tolerated. "As manufacturers of refrigeration equipment and liquid coolers, we therefore prefer – whenever possible – air-cooled split liquid coolers," said Steffen Klein. Answering the question why he uses Güntner products, Steffen Klein gave a simple reply: "Nowadays, entire branches of production depend on refrigeration equipment. This means a great responsibility for us as manu-

facturers. We therefore rely on premium products such as Bitzer and Güntner to serve our customers as well as possible. As the biggest manufacturers on the market, Bitzer and Güntner are our most important suppliers."



An exemplary central cooling system. Visitors are particularly impressed by the low noise levels of the Bitzer screw compressor.

Summary of advantages of centralised cutting oil cooling

- No heat dissipated into the hall
- No "refrigerator within a refrigerator" principle in air-conditioned production halls
- Improved working environment for staff
- Better dimensional accuracy of the machined parts
- No need to service many decentralised coolers
- Space savings of approx. 2.5 m² per machining centre because no cooler is needed
- Electricity savings of about 30 % compared with decentralised method
- Lower current connection value
- Improved availability due to redundant cooling capacity
- Improved utilisation of the centralised cutting oil cooling due to simultaneity factor
- Lower specific purchase costs
- High regulating accuracy of the cold water system
- Noise reduction at the workplace

Advantages of air-conditioning production halls containing CNC machining centres:

- Dimensional accuracy improves from hundredths to thousandths of a millimetre
- No need for temperature-dependent adjustment of tools and machines
- Dimensional tolerance checks can be minimised
- No need for manual matching of machine parts with drilled holes and shafts (pairing)
- Lower reject rates
- Higher product quality due to lower tolerances, thus better overall efficiency of the compressors
- Simpler parts replacement in case of repair
- Higher productivity as a result of better environment for humans and machines
- Smaller space requirements



Christian Wehrle (left) and Albrecht Höpfer (right), both with Bitzer: "Air conditioning allows for a precision that strongly improves the production process, production safety and efficiency of our screws and minimises rejects."