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General processing

Control crucial to copper rod quality

Dieter Klefoth and Stefan Seemer look at a demand-based speed-controlled pump system. This, with new submersible pumps together with state-of-the-art control systems, has been instrumental in lowering the power consumption and raising the reliability and quality of a copper wire manufacturing process in Germany.

Deutsche Giessdraht GmbH at Emmerich in the Lower Rhine valley is one of the leading manufacturers of high quality continuously cast copper wire rods. At the company's Emmerich production plant, it manufactures 256,800 tonnes of copper rod having diameters between 8 and 16mm each year. These are the shipped around the world.

Electrolytically won copper cathodes are used as the starting material. After these have been melted, the liquid copper is continuously cast to an 'endless' bar at a temperature of 1,110°C using the 'Southwire' process. This involves a casting wheel (Figure 1). Next, the extremely hot bar is shaped into wire in a rolling mill.

Efficient cooling

Because the copper is liquefied and, therefore, extremely hot at the start of the manufacturing process, the next production process steps need a highly reliable and efficient cooling system. Indeed, the Emmerich plant operators have to discharge around 814 MJ of heat/year.

The quality of the wire to be manufactured largely depends on a precisely controlled cooling process and an equally precisely calculated volume of cooling water. In view of the dramatic rise in the price of electricity, the efficiency of the

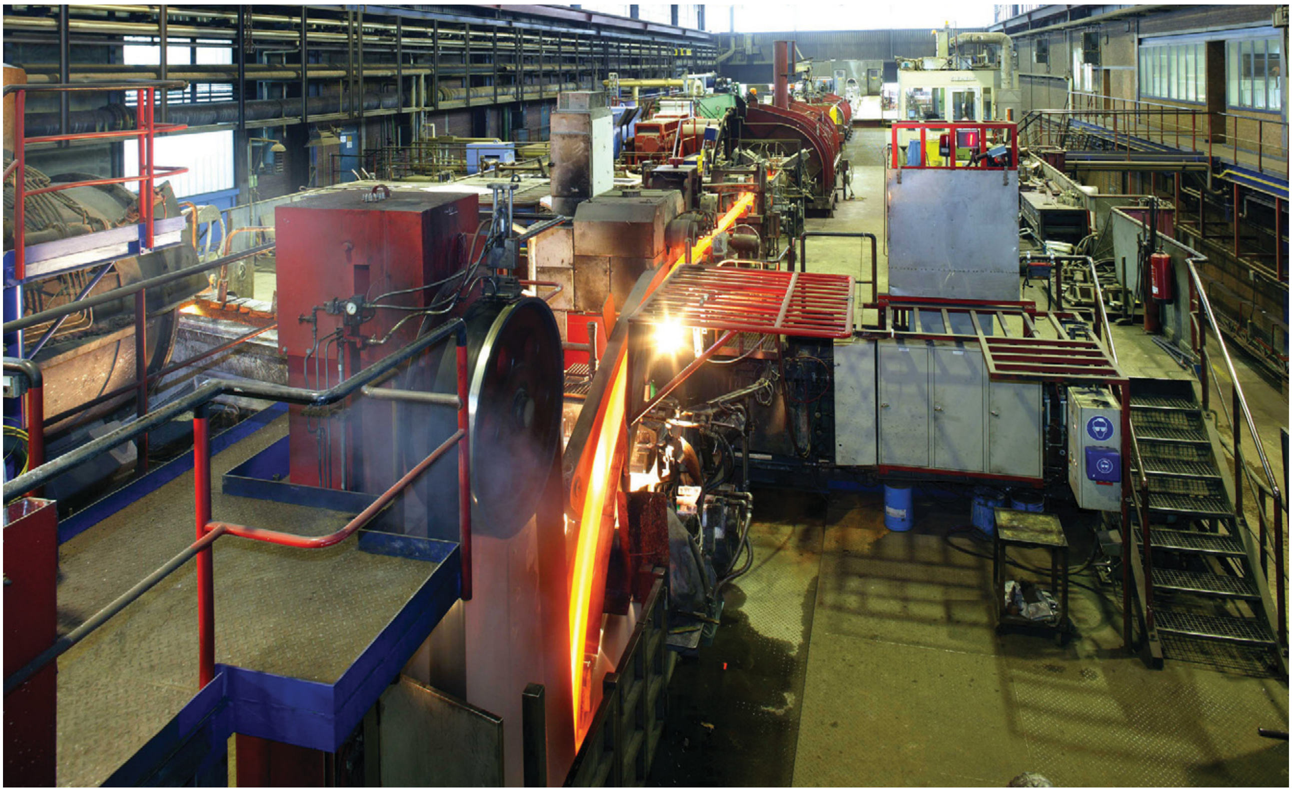

Figure 1. The Southwire' process at Deutsche Giessdraht GmbH involves a casting wheel.

Figure 2. Taking advantage of the production plant's location, water from the Rhine is used for cooling.

cooling system is now more important than ever. However, the aim of all technical improvements is – first and foremost – to raise plant availability and, simultaneously, keep the cooling water temperature constant at all times.

Taking advantage of the production plant's location, water from the Rhine is used for cooling (Figure 2). The two-branch system comprises three water extraction pumps installed in the inlet basin at the Rhine docklands, plus three main cooling water pumps for the production process and a single auxiliary pump (see diagram in Figure. 3).

On its way into the inlet basin, the river water first flows through a coarse-dirt screen. From there it is pumped into a large cooling water reservoir by way of a revolving screen. The reservoir serves two purposes: as a water supply source and for mixing the incoming flows of water to a constant temperature. From the reservoir, several main cooling water pumps supply the production plant with cooling water.

Seasonal temperatures changes and varying levels of the Rhine's river water make it difficult to keep the water temperature constant for the cooling process. Cooling water temperature and production velocity are the key parameters for the solidification process at the casting wheel and, consequently, for flawless rod microstructure. This, in turn, is decisive in terms of attaining the necessary high quality of the final product.

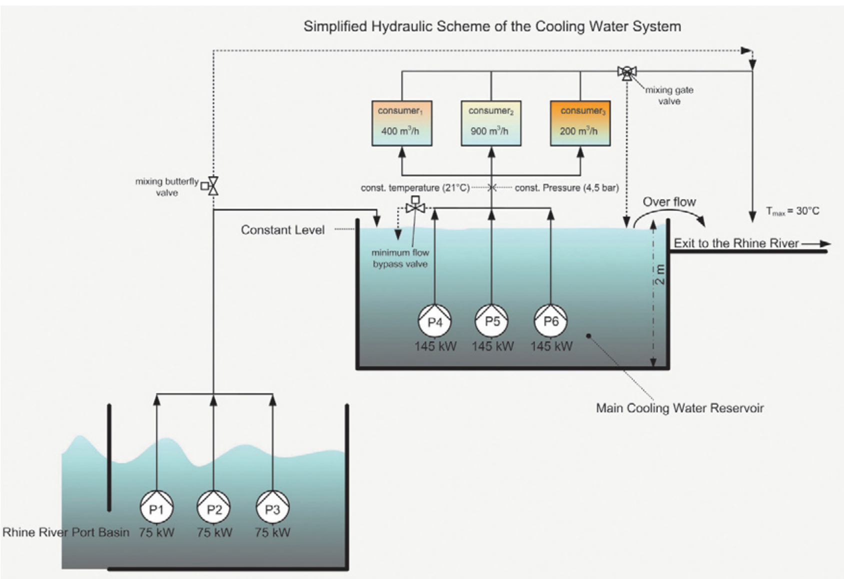

Figure 3. Schematic, showing how the two-branch system comprises three water extraction pumps installed in the Rhine docklands inlet basin, plus three main cooling water pumps for the production process, plus one auxiliary pump.

Figure 4. All pumps are jacket-cooled submersible motor Amarex KRT machines, made by KSB Aktiengesellschaft.

Optimal results at maximum production output are achieved at a cooling water temperature of 21°C. At the same time, the cooling water pressure has to be kept at a constant 4.5 bar to make sure that the cooling nozzles supply the right amount of water spray. In addition, the local authority's rules and regulations for the protection of the environment state that the water pumped back into the Rhine must not exceed 30°C.

State-of-the-art control

A modern process control system was needed to meet all system requirements set by the process across the entire production line. To cope with the fluctuating demands of the production process, varying water extraction conditions and the resulting close temperature and pressure tolerances, and to achieve as low a power consumption as possible, all pumps (extraction, as well as main cooling water pumps), have been fitted with frequency inverters. All of these pumps are jacket-cooled submersible motor machines of the type Amarex KRT, made by KSB Aktiengesellschaft (Figure 4).

The production conditions result in the required amount of water tending to vary greatly, so the pumps' duty points also frequently change. This means that the volume rates of flow have to be adjusted to suit their respective production processes. As a further requirement, control of the cooling water circuit is not allowed to affect the central process control system. To ensure this, it was decided to design the fully automatic cooling water arrangement as a closed-loop autonomous control system. From a control point of view, the system is fully independent. The interfaces to the plant process control system only serve data exchange purposes.

To be able to operate the continuous speed control most efficiently, the system comprises two closed loops with two pump control systems for continuously variable speed control type Hyamaster SPS (Figure 5).

One system is dedicated to water extraction pumps P1 through P3, the other to main cooling water pumps P4 through P6. As far as hardware and software are concerned, the two systems are modular. Closed and open loops are controlled using a programmable logic controller (PLC). In addition, each pump is monitored and all sensors are redundant in design. The system checks all incoming signals with respect to their logic. However, in an emergency, the operators can also operate the processes manually.

Greater efficiencies

The volume of water to be extracted from the Rhine is calculated on the basis of the pump characteristics, power input, frequency and differential pressure. As the volume of water extracted from the river never exceeds that which is needed for cooling, the cost of water and electricity has gone down considerably.

The planning consultants calculated pump heads very carefully so as to avoid unnecessary safety margins, which would have oversized the pump unnecessarily. When selecting the pumps, the efficiencies from the speed curves were constantly compared with the load profile of the plant, which helped them achieve the best possible total efficiency over time. By designing connecting pipes with a larger diameter, they were able to reduce the pump input power of the newly installed pumps from 90 to 75 kW.

This shows that, by careful dimensioning of plant and pump, a major contribution can be made to lowering energy consumption. Whenever necessary, a number of automated bypass butterfly valves will secure the minimum pump flow. The system transmits all input signals, operating statuses and fault messages to the process control system using a Profibus DP interface. The pumps in the inlet basin are

Figure 5. To operate most efficiently, the system comprises two closed loops with two pump control systems for continuously variable speed control, type Hyamaster SPS – this is the control panel.

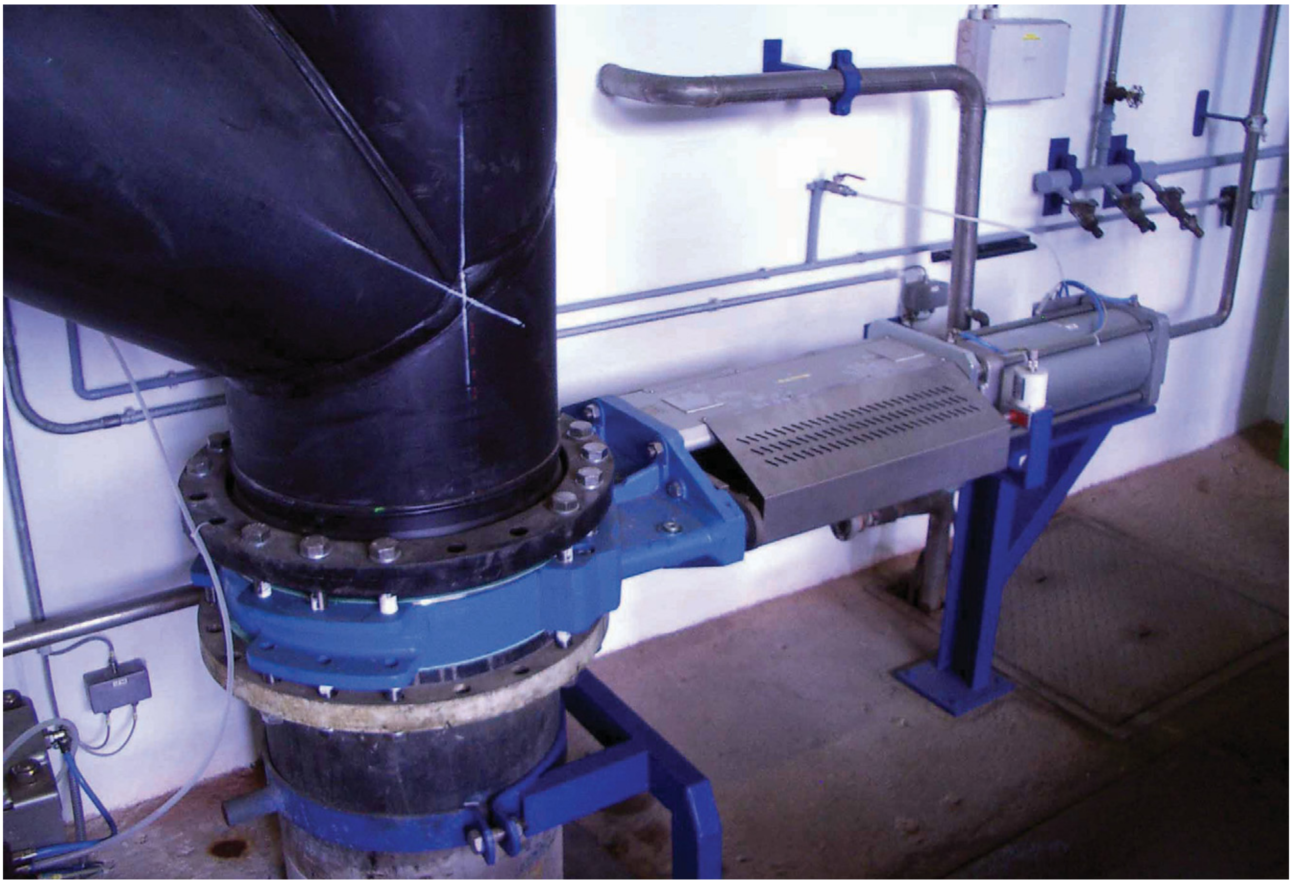

Figure 6. The temperature is controlled using two mixing gate valves with pneumatic actuators that make the valves respond very fast.

controlled in such a way that the water level in the cooling water reservoir never falls below the set value of 1.97m. For this control requirement, one pump running at minimum capacity always has to be in operation for self-cooling. Whenever the water level rises above the 2 m high overflow edge, the water is immediately diverted into the outlet pipe to the Rhine.

The pumps in the cooling water reservoir pump the water to the points of consumption in the production plant via a common manifold. The set point of the closed-loop control is a constant 4.5 bar pressure. As soon as the pump minimum flow is reached, a butterfly valve opens the bypass. The set point for controlling the cooling water temperature is 21°C – this is in no way linked to the pump control. The temperature is controlled using two mixing gate valves with pneumatic actuators (Figure 6), which cause the valves to respond very quickly. Their positions are transmitted to the PLC by a position sensor. Depending on the gate valve's position, more or less warm water flows back to the cooling water reservoir and raises the water temperature.

As soon as the cooling water temperature exceeds 21°C, the gate valve will close fully and the water then runs into the outlet pipe back into the Rhine. Closing the gate valve results in a quick change of the outlet temperature. To ensure that the maximum outlet temperature of 30°C is never exceeded, not even briefly, it was necessary to link up the valve control and the control of the pumps in the inlet basin. As a result, a little more cold river water is now pumped over the overflow edge whenever the gate valve closes.

The arrangement does away with temperature peaks at the outlet and allows the cooling water temperature to be kept at exactly 21°C. Sudden changes in the production process are signalled to the pump control system by the plant process control system. This means that, if the casting wheel comes to a standstill, the position of the gate valves is stored. As soon as the production process starts up again, the gate valves are quickly returned to the exact position they had prior to the standstill.

Reducing spare parts

Because of the new control mechanism, only an increase in the river water to more than 21°C will raise the temperature of the cooling water. It is possible to reduce the cost of electricity to a minimum by installing a demand-based speed control system and high-efficiency pumps, as well as by optimising pipes and valves.

In addition, using modern submersible motor pumps means that the expense of keeping spare parts stocks is now also unnecessary. Repairs can be carried out at short notice at the nearby service centre maintained by the pump manufacturer.

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Facts and figures

Amount of cast copper/year:	264,600 tonnes
Amount of heat to be discharged/:	215,385 GJ
Water volume extracted from Rhine/year:	6,511,757m^3 (2007) / 3,355,000m^3 (2008)
Number of pumps:	7
Number of frequency inverters:	7
Number of sensors:	30