High-precision control of metal heating elements

Constantly rising electricity costs are a factor of increasing importance in the construction of furnaces. Efficient energy management is therefore crucial for business success. Low-pressure aluminium die-casting is used to produce intelligent heating systems consisting of modern heating elements in combination with innovative power controllers that reduce energy costs by 30 % while significantly increasing process reliability.

Wheel rims add a special touch to many cars. They are manufactured from steel or aluminium alloys. The melting and holding of these metals are by nature energy-intensive processes. A new retrofittable heating technology developed primarily to save energy in the production of aluminium rims was the goal of a joint research project of the companies amTec Furnace Technologies GmbH (amTec), Sandvik Materials Technology Deutschland GmbH (Kanthal) and Gefran Deutschland GmbH (Gefran).

PREVENTION OF ENERGY LOSSES

In the rim manufacturing process the aluminium bars are first melted in a shaft furnace. From there, the molten material is transported in transfer ladles to an impeller station. Addition of additional alloy components during constant stirring of the molten mass achieves the optimal metal quality. The completed alloy is then transported to a low-pressure furnace (**Fig. 1**), where the rims are cast. The entire process is designed so that the metal flows with practically no turbulence to minimize the formation of metal oxides to the greatest extent possible. The low-pressure process results in cast parts with excellent mechanical properties. Especially this last process step requires a heating system that can be operated without transformer equipment. In the past, heating elements made of silicon carbide (SiC) were used here. They withstand high surface loads and high temperatures, which makes their use in a furnace relatively unproblematic. Since they require a voltage of only 82 V, however, the standard mains voltage of 230 or 400 V must be adapted by means of transformers or thyristors. The thyristor operates in a phase controlled process in which part of the sine wave is suppressed and is no longer available as usable energy. In both cases 100 % of the power must be paid for, although only 40 to 60 % of the current can actually be used. The phase control process also introduces harmonic components into the power grid, which has to be compensated by expensive filters. According to amTec Managing Director Jens Glücklich it makes little sense and does not increase the efficiency to connect an expensive energy management system to such a system with low efficiency or high reactive power. He had the idea that a metal heat conductor with constant ohmic resistance could be the solution. For the tests, Kanthal provided suitable heating elements with a linear resistance that can be operated at 230 V. This eliminates the need for transformation and the subsequent energy losses. The result is virtually 100 % efficiency with no harmonic components requiring compensation (**Fig. 2**).

POWER CONTROLLERS WITH OVERCURRENT PROTECTION

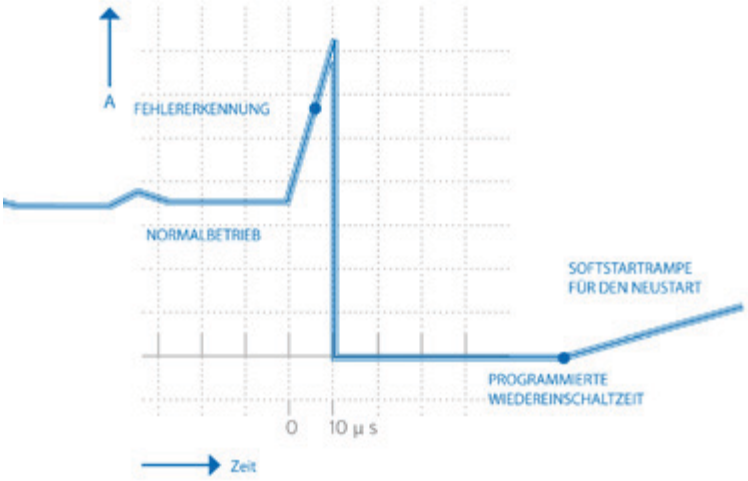
The new heat conductors are integrated in a cascade control system with the onboard GFW control loop (**Fig. 3**), which allows faster control of the system – partly because the metal heat conductors react much more quickly than SiC heating elements to disturbances. This also means, however, that they require much more precise and finer control. The GFW power controllers with overcurrent protection of the Xtra series from Gefran provide such control (**Fig. 4**). In addition, the company offers energy management software that required only very little adaptation of the parameters for the specific application. The GFW Xtra features numerous options for controlling the process as well as programming options for fast and easy configuration.

Fig. 1: Transfer of the aluminium alloy into the low-pressure casting furnace

Fig. 2: amTec low-pressure casting furnace with the new heating system

Fig. 3: Installation in control cabinet

Source: amTec Furnace Technologies GmbH



Source: Gefran Deutschland GmbH

Fig. 4: GFW power controller with overcurrent protection from the Xtra series

Fig. 5: Graphical display of the system with a soft-start ramp

It is completely bus-capable, therefore enabling integration in the overall control system. But the intelligent power controller also offers another decisive advantage: it uses IGBT (Insulated-Gate Bipolar Transistor) technology. The software quickly and continuously measures the current at the load. If it exceeds a configured value the circuit is interrupted immediately before the load or the power component can be damaged. The power cut takes place within microseconds. Various options are available for resuming heating operations. Generally, automatic reset is the preferred option. This allows a very fast restart of the system with a soft-start ramp (**Fig. 5**). No intervention by a technician is necessary in this case. This sets the Xtra power controller apart from conventional thyristor power controllers. If the fuse is triggered in those controllers, a certified electrician must open the device and replace the internal fuse. During this entire procedure production is not possible. If this state goes unnoticed, the downtime can easily last four to six hours and in the worst case scenario no suitable fuse is in stock or no certified electrician is available. In addition, if the fuse is triggered the power cut is delayed, since the thyristor is not cleared immediately, but only in the zero crossing. This short time can already be enough to destroy the load and the power component.

SHORTER DOWNTIMES, HIGHER MACHINE AVAILABILITY

The power controllers of the Xtra series are different. The electronic fuse is extremely easy to operate and a short-circuit – for example due to condensation or metal spatter – does not automatically result in machine downtime. On the contrary: the fuse detects whether the damage is permanent and signals an alert accordingly. In the event of a temporary disruption such as a short-circuit through the refractory lining, mains voltage fluctuations, humidity or dust at the load, the power controller restarts the heating system. It also detects problems early on and precisely identifies which components – heating elements, transition resistors, etc. – caused the disruption. In addition, each phase is controlled separately. Failure of one heating element therefore does not cause an overload in the remaining intact elements. They remain undamaged. The Xtra power controllers therefore ensure a high level of production reliability as well as user and maintenance friendliness. The shorter downtimes and higher machine availability have a direct positive effect on productivity and profit. Especially in the operation of continuously heated furnaces or in two and three-shift systems, the use of Xtra power controllers significantly reduces the necessity of intervention by a technician. Production is much more trouble-free.

LONG-TERM TESTS STARTED

The power controller from Gefran also brought other advantages for the tests: since it not only records the necessary test data, but also features an integrated PID input and analogue inputs for the thermal elements, a significant reduction of the necessary lab equipment is possible. Initial tests in practice showed that the power consumption can be drastically reduced by use of the new heating technology. The energy costs of the new system are up to 30 % lower than those of current processes. The elimination of transformers also means there is no loss of efficiency. In addition, the service life increased, while power losses decrease. Long-term tests for determining the reduction of reactive power, for example, have just started. Jens Glücklich assumes that it will be possible to deliver the first system with the new heating technology before the end of this year.

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