Harder, faster, better

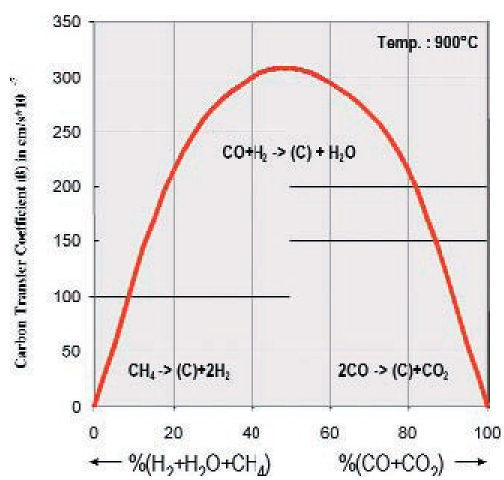
— improved carburising through advanced control

Treating carbon steel components to improve their surface properties such as hardness via the carburising process is a well-established technology. And yet even today, after many years of development, variations in the carburising quality and therefore the hardness at the surfaces of the parts being treated are still problems for heat-treaters and component manufacturers. With ever-increasing competitive pressures, such as the need to meet higher quality standards and lower costs, such problems need to be addressed to ensure that furnaces operate at maximum productivity and with minimum levels of rejects. A new mass flow controller system that has been developed by Air Products and implemented on a customer's furnace seems set to achieve just that by eliminating process variations and providing high quality, uniform carburising.

The problematic variation in carburising quality is caused by the monitoring and control systems used to run the carburising furnace and regulate the atmosphere and temperature. Common control systems work by measuring the furnace temperature and the oxygen partial pressure. This allows the carbon potential – a measure of the carbon available in the furnace atmosphere for carburising – to be calculated and maintained, as long as the level of carbon monoxide (CO) is known. The actual CO level is not normally measured in real time in the furnace, but is instead set manually in the controller, as are the flow rates of the gases making up the atmosphere in the furnace. However, in both endothermic atmospheres and manually regulated nitrogen-methanol atmospheres, variations in these supposedly fixed variables can occur in a number of ways. These include poor regulation of gas flows, changes in the composition of the natural gas, pressure variations in the nitrogen and methanol lines, and so on.

Using the new system from Air Products, in which a nitrogen-methanol atmosphere is regulated by mass flow controllers (MFCs), overcomes these problems and improves carburising quality. MFCs can regulate the flow rates independent of furnace pressure and temperature, compensate for all variations in the line pressures, and keep the blend of gases – and therefore the CO-level – in the furnace constant. The system, first developed three years ago, includes the calculated CO level, derived from the gas flow rates into the furnace, in the calculation of the carbon potential of the furnace, and therefore enables a much more accurate and uniform process. Using this MFC technology also offers the opportunity to use the accelerated carburising process (ACP), which can shorten the carburising cycle by up to 20% and significantly increase productivity. ACP uses a higher carbon potential, making the need for accurate regulation of the atmosphere more important.

Trials showing the feasibility and benefits of using the new MFC technology and ACP have been carried out recently with one of Air Products's customers, Mubea, in Germany, in one of the company's chamber furnaces. Mubea was interested in increasing the production rate of a new component in its hardening furnace, and so Air Products installed MFC panels, and combined ACP with the new process control system for carbon potential regulation. The trials have been very successful, and Mubea has also installed a MFC panel on a continuous working carburising furnace. In addition, there is now an ongoing project at another



Carbon transfer coefficient based on levels of CO and hydrogen at 900°C

Guido Plicht and colleagues from Air Products report on the development and implementation of a new mass flow controller system that measures the carbon monoxide (CO) level in a furnace during the carburisation process and thereby allows greater reliability and uniformity of the treatment process, speeding up productivity – as demonstrated during recent trials with Mubea in Germany

customer's site, in which the MFC technology and ACP has been linked with an existing carburising control system in a furnace. Start up took place at the end of last year and the results to date are very promising.

Although the success of the new control system relies on very fine-tuning of the process, the basics of carburising are relatively simple. The process itself can be divided into two phases – carbon deposition and carbon diffusion. During deposition, the carbon-containing species from the furnace atmosphere are transferred to the surface of the steel component being treated and decompose to give carbon. The main component containing carbon in carburising atmospheres is CO, and the rate of the process is influenced by process temperature and atmospheric composition, see figure 1. This highlights the importance of tight control of these variables using the new MFC technology. In the diffusion phase, the deposited carbon diffuses into the steel component from the surface. This process is only dependant on temperature, and not the composition of the atmosphere.

Endothermic atmospheres for carburising are produced by partial burning of natural gas and air, to give a mix containing 20% CO and 40% hydrogen, the rest made up of nitrogen and residual carbon dioxide and water. Problems with costs and reliability of these atmospheres mean that most heat-treaters now use the direct injection of nitrogen and methanol to produce the carburising atmosphere. By cracking methanol directly in the furnace, variable compositions of carburising atmospheres can be created – and although traditionally the blend is 20% CO and 40% hydrogen, the CO level can be increased to as much as 33% for accelerated carburising. This higher level of CO leads to a higher carbon potential inside the furnace, and so a shorter time is needed to deposit the same amount of carbon, making the process more efficient. Clearly, though, the control needs to be extremely accurate.

The new MFC provides this and, together with the accelerated carburising process, can be installed as a complete atmosphere control system including a control of the carbon potential. MFC technology can also be implemented in existing systems, if control of the carbon potential already exists. The control unit is based on a PC for the visual interface, parameter setting and documentation of the process. For each furnace a hardware controller is used that directly communicates with the PC. This controller regulates the carburising process independent from the PC and so maintains control over the atmosphere even if the PC is shut down. The regulation of the carbon potential is based on the reading from an oxygen probe, the measured temperature and the CO level in the atmosphere, which is calculated from the nitrogen and methanol flow rates. In some cases, an additional CO analyser can be installed. The MFC technology enables the CO level to be changed in the different steps of a carburising cycle, especially for ACP.

Overall, MFC technology can increase productivity by up to 20% and help to reduce running costs as well, not to mention reduce the number of reject components produced. In addition, the accurate setting of the required flow rates enables component production with very small tolerances in surface hardness. The PC-based technology allows the running of different carburising programmes and provides reproducible results from each, while another option allows the installation of a telemetry unit to allow system checking via a modem. All in all, the new control system offers a major improvement on previous manually set systems, and should prove another significant step forward in the ongoing development of the carburising process.

Further information

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