There are several methods of measuring dewpoint on the market, but few that can offer reliable measurement at minimal maintenance and reasonable cost. Vaisala offers just that, with the DMP248 dewpoint transmitter and the DSS10 sampling system, which are ideal for applications in high temperature metal treatment furnaces.

Vaisala's DMP248 dewpoint transmitter meets the requirements of demanding industrial applications where stable measurement in low dewpoints is important.

High temperature metal treatment furnaces are used in metallurgical processes such as annealing, brazing and sintering. Control of the atmosphere in these furnaces is important not only because it vitally affects the quality and consistency of the final product, but also because it can ultimately minimize processing costs. To optimize the furnace, the operator needs to understand what atmosphere composition works best for the parts being treated and how to verify that this atmosphere is present.

The importance of furnace atmospheres

Several types of atmosphere are commonly used in high temperature furnaces. They include exothermic and endothermic generated atmospheres, dissociated ammonia, and nitrogen-based systems enriched with either hydrogen or dissociated methanol (CH3OH). If the appropriate knowledge is not already in-house, the proper furnace atmosphere may be selected by consulting the metallurgical division of a reputable gas supplier company.

Annealing

Annealing is the heating and cooling of a material in order to soften it and make it less brittle. Annealing in a protective atmosphere gives the product a bright, clean, attractive surface appearance, without the need for costly cleaning.
procedures after heat treatment. The annealing atmosphere can be either pure hydrogen or a hydrogen-nitrogen mix. The hydrogen helps to keep the surface of the product in a reduced condition at high temperatures, while producing the desired bright surface appearance. Although pure hydrogen may be the preferred atmosphere, economics and safety usually dictate the use of lower levels of hydrogen.

To determine the appropriate level of hydrogen, measurements should be made of both the hydrogen and water vapor concentrations in the furnace. For one of the goals of an annealing atmosphere is to maintain a reducing environment instead of an oxidizing one. This is determined not by the absolute hydrogen percentage, but by the ratio of partial pressure of water to partial pressure of hydrogen (P_{H2O}/P_{H2}). The P_{H2O} can be determined from a dewpoint measurement, while the P_{H2} can be determined from a percent hydrogen measurement. When the dewpoint of the furnace is low, the percentage of hydrogen can also remain low. Ideally, if the furnace were not open at both ends allowing oxidizing gases (water vapor and oxygen) to enter, no hydrogen would be required for surface brightness.

**Brazing**

Brazing is a high temperature joining operation. The process generally uses a nonferrous metal or alloy that melts at a lower temperature than that of the metals being joined. The brazing atmosphere affects the spreading of the braze, the fillet size and void formation in the material joining the multiple components together. When the atmosphere composition is optimized, a consistently high quality braze joint can be produced and the processing costs can be minimized.

The proper atmosphere, much like the annealing atmosphere, serves to keep the base metal surface reduced by removing metal oxides and preventing their formation. A hydrogen-nitrogen system permits the greatest atmospheric consistency, due to the high purity of the gases and the flexibility they give to custom-blend the desired atmosphere composition.

When a hydrogen-nitrogen gas mixture is used as the brazing atmosphere, the ratio P_{H2O}/P_{H2} determines whether or not the metal will oxidize at a given temperature. As mentioned above, the P_{H2O} can be determined from a dewpoint measurement and the P_{H2} from a percent hydrogen measurement.

At a state of constant oxidation potential (P_{H2O}/P_{H2}), the base metal passes from its oxidizing state (ambient air) to its reducing state (hot zone) upon heat-up to the brazing temperature. The oxidation state will again be entered in the cooling zone after the brazing is completed. At higher P_{H2O}/P_{H2} values, the equilibrium transition occurs at higher temperatures. Understanding the oxidation potential is important when considering the critical braze temperature and the base metal oxidation/reduction state, both of which will help in optimizing the process.

**Sintering**

Sintering is the process of becoming a coherent mass by heating without melting. In most sintering furnaces this refers to the carbon content of the steel being sintered. Sintering in a controlled atmosphere helps to maintain or control the carbon content of the steel, by maintaining a certain level of active carbon which is considered to be the carbon potential of the sintering atmosphere.

Certain gases affect the carbon potential in the atmosphere more than others do, these gases being water (H2O), methane (CH4), carbon monoxide (CO), carbon dioxide (CO2), oxygen (O2) and hydrogen (H2). It is a well-known axiom in carburizing that the higher is the ratio of CO2 to CO, the lower is the dewpoint or oxygen level, the higher is the carbon potential. Since the carbon potential is determined by the ratio [O2] / [CO2], the dewpoint is related through the water gas shift reaction. The water gas shift reaction states simply that water will react with CO to form CO2 + H2, thereby decreasing the carbon potential. The carbon potential can be increased by the addition of a hydrocarbon. So low dewpoint levels allow the carbon potential to be maintained, with small hydrocarbon additions.

In addition to low dewpoint helping to prevent decarburization, it also enables lower hydrogen levels to be used while maintaining the same reducing potential. For the sintering atmosphere is similar to the annealing and brazing atmospheres, concerning oxidation and reduction levels. As in all nitrogen-based sintering atmospheres, the systems rely on the low dewpoint of nitrogen to help prevent decarburization and to increase the reducing potential. Dewpoints of –35 to –45 °C (–37 to –43 °F) are typical in the hot zone of the furnace to help maintain these stated conditions.

**A typical belt furnace**

The belt furnace shown in Figure 1 is a typical sintering furnace. The parts being sintered enter the preheat zone, where delubing occurs (if the organic components used in lubrication are not removed by vaporization, this will add carbon to the part). From the preheat zone the part then travels to the hot zone where the actual sintering takes place. Once the sintering has been completed (based on the furnace temperature, size of the part and the atmosphere), the part enters the cooling zone where it is brought back down to ambient temperature and exits the furnace.

To optimize the furnace for carbon control, the methane and dewpoint in the hot zone are monitored and adjusted accordingly. This can be done with a three-segment system—a sample line and analysis panel, a programmable logic controller (PLC), and a fresh feed...
gas flow mix panel. The main sampling line is connected to the hot zone, and a secondary sampling line may be connected to the cooling zone, preheat zone or both, if desired. The information from the dewpoint and methane analyzers is transmitted back to the PLC in the control panel. The PLC determines whether the dewpoint and methane levels are appropriate for the part’s carbon content. If either the dewpoint or residual methane concentration is out of range, then the PLC activates the appropriate flow meters to adjust the nitrogen, hydrogen and methane flows to maintain the desired balanced atmosphere.

**Measuring dewpoint**

There are several methods of measuring dewpoint on the market, but few that can offer reliable measurement at minimal maintenance and reasonable cost. Vaisala offers just that, with the DMP248 dewpoint transmitter and DSS10 sampling system.

The DMP248 dewpoint transmitter with the DRYCAP polymer sensor is able to measure dewpoint from as low as -55 °C (~-67 °F) up to condensation, with a ±2 °C (±3.6 °F) or better accuracy. The unique polymer has a high barrier against contamination, is immune to high hydrogen concentrations and has proven that it can maintain accuracy over extended periods of operation. The dewpoint transmitter can be configured with or without a local display and has multiple outputs for interfacing with a controller or recorder.

The DSS10 configurable sampling system can be designed to meet various customers’ needs and process requirements. The design shown in Figure 2 is Vaisala’s standard high temperature sampling system designed for measuring the dewpoint of furnace atmospheres.

The system has been designed to overcome the basic obstacles of any high temperature belt furnace. It has a vacuum pump to remove gas samples from the low-pressure zones of the furnace and to draw the samples to the dewpoint sensor. It has a dual sub-micron filter system to filter out carbon soot and other possible contaminants that might otherwise affect the performance of the measurement. It has a cooling coil to ensure that the high temperature of the process gas has been cooled to within the operating limits of the sensor prior to measuring the dewpoint. All this comes assembled and mounted ready for operating in minutes.

The maintenance of a standard system like this is minimal. It is recommended that the dewpoint sensor be calibrated once a year. When the filters or pump needs to be replaced, the cost is minimal and only a few minutes are required.

**The benefits of atmosphere control**

If the furnace atmosphere is continuously monitored and adjusted for proper gas consistency (percentages of water vapor, methane, oxygen, etc.), the process will provide much tighter tolerances in the parts. The improved quality and reproducibility needed for hardness, machinability, sizing, and dimensional control will result in increased quality standards for customers, a reduction in the reject rate and improvements in productivity. These improvements are certain to be reflected in increased knowledge of the furnace dewpoint when integrating a Vaisala on-line dewpoint system.

Finally, I would like to thank Paul Kilhefner from the Metallurgical Division of Air Products & Chemicals, Allentown, PA, for supplying technical brochures on the various processes and offering his process expertise in making sure that the material presented is accurate.

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Figure 1. The belt furnace is a typical sintering furnace.

A sintering furnace for brake pads used in airplanes, cars and trains.