FURNACE ATMOSPHERES ARE CRITICAL TO MEETING SPECIFICATIONS

by Jim Oakes

THE MAKEUP OF A FURNACE'S ATMOSPHERE in the heat treating process varies depending upon the application. Sensor technology allows for the in-situ monitoring of furnace atmospheres, but many assumptions are made relative to how carbon potential is calculated based on the prepared atmosphere being used.

ENDOTHERMIC ATMOSPHERE

Typical endothermic gas generators supply an atmosphere using air and hydrocarbon gas, which are mixed and passed over nickel bearing catalyst at about 1900° F. Using methane (CH_4) mixed at an air-to-gas ratio of 2.77:1, a properly functioning generator will in theory produce an endothermic gas consisting of 20% carbon monoxide (CO), 40% hydrogen (H_2), and 40% nitrogen (N_2). Using propane (C_3H_8) in lieu of CH_4 and an air-to-gas ratio of 7.16:1, the resulting endothermic gas composition will be approximately 24% CO, 32% H_2 and 44% N_2. The gas is then cooled to maintain the integrity of the gas composition. Correct cooling of the gas is critical to avoiding carbon monoxide from reversing into carbon (soot) and CO_2. This is the base atmosphere used in the carburizing process. A few assumptions must be made when determining carbon potential in the furnace with a supply of endothermic gas. Measuring this atmosphere can be accomplished in a number of ways; the focus of this article is the use of oxygen sensors, dew point, and infrared measurement.

NITROGEN METHANOL

When used in a furnace at the typical operating temperatures, the methanol immediately dissociates into carbon monoxide and hydrogen. When mixed, 33% methanol (CH^3OH), 66% nitrogen, and endothermic equivalent atmosphere are formed in the furnace. Using sensors and the base atmosphere in the furnace under equilibrium conditions, these assumptions must be consistent, known, and repeatable.

To determine the amount of methanol and nitrogen required, the Total Required Flow (TRF) of gas, which is usually posted on the furnace nameplate, is divided by 1.60. The resulting value is then multiplied by 0.33 to determine the amount of methanol required in standard cubic feet per hour (SCFH). That same value is multiplied by 0.66 to determine the nitrogen required in SCFH.

FURNACE ATMOSPHERE

Dew point, shim stock, NDIR (non-dispersive infrared) analyzers, and carbon sensors have traditionally been used to measure the endothermic atmosphere in a furnace. The carbon sensor is actually measuring the oxygen content in the furnace, which is why the terms oxygen probe and carbon probe are often used interchangeably. An oxygen probe used in-situ for a furnace application has been the standard of the industry for years. Because of its durability, reaction time, and continuous measurement, it is the most common form of measurement. The calculation of carbon using the oxygen probe includes the millivolts produced by the probe based on the partial pressure of oxygen in air versus partial pressure of oxygen in the furnace, the furnace temperature, and a calculation factor referred to as COF (CO Factor), PF (Process Factor), or Gas Factor. The COF takes into consideration the furnace atmosphere, alloy, probe readings, and so forth. The purpose of the COF is to restore a repeatable measurement of carbon that is verified using an alternate method. In many situations, the COF is primarily factoring in the CO composition of the base prepared atmosphere produced by the endothermic generator or nitrogen methanol system. A higher CO content of the prepared atmosphere results in a higher COF. Again, the reference point for the carbon potential is typically done using shim stock, NDIR, and dew point.

An NDIR three-gas analyzer can be used to measure the atmosphere in a furnace or generator by first extracting a sample of the gas atmosphere. The consistency of the endothermic gas produced at the generator significantly affects all downstream processes. In order for the atmosphere to be controlled consistently and accurately in the furnace using an in-situ sensor, an assumption

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regarding the content of the endothermic gas must be made. For endothermic gas, values should be between 18.8% and 20.5% for CO. The CO_2 should be between 0.25% and 0.50%, with a preferred value of 0.40%. If the methane (CH_4) content is 0.50% or less, the generator is performing correctly. If the CH_4 is above 0.50%, there may be a problem. It is advisable to burnout the generator as quickly as the facility can take the generator offline. If, after burnout, the CH_4 climbs back above 0.50% within a week or two, replace the catalyst. If the catalyst is depleted, uncracked CH4 from 0.50% to 8.00% will be present.

An NDIR gas analysis can also calculate carbon using the values of CH_4, CO_2, and CO from the furnace atmosphere. Using this gas analyzer, a suggested setting for the COF can be used so that the oxygen sensor is accurately calculating carbon potential. The Super Systems website has a calculator that can be used to determine different settings for both NDIR gas analysis and oxygen/carbon sensors. This calculator, called SuperCALC, is available at www.supersystems.com/calculators.html. A smartphone/tablet app is also available. To find it, simply search for the SuperCALC app on your Android or Apple smartphone or tablet.