Monitor Instruments

# Gas Analysis in Steel Manufacturing

Gas analysis is a valuable tool in modern steel manufacturing processes. The gas analysis tool of choice is mass spectrometry, arguably the fastest, most flexible, and most precise gas analyzer technology. A mass spectrometer both identifies and measures the relative abundances of gases by ionizing and then selectively detecting the individual ions. The resulting mass spectrum can identify unknown contaminants, or be used in precise quantitative analysis for process control. As shown in the following examples, mass spectrometer data can assure the safety of production equipment and personnel and provide information for economical process operation.

## Blast Furnace Top Gas Analysis

Top gas analyzers on blast furnaces are used to guide operation at the optimum balance between process variables. In a blast furnace, iron oxide is reduced through a series of chemical reactions involving coke, oxygen and water. The carbon in coke reacts with the oxygen and water introduced to the blast furnace to form CO and $H_2$. The CO and $H_2$ reducing gases then react with iron oxide to produce iron, water and $CO_2$. The amount of $H_2$, $H_2O$, $O_2$, CO, and $CO_2$ in the blast furnace gases accurately reflect the chemical processes within the furnace—an important control and diagnostic tool.

Mass spectrometer data can also be used to guide maintenance operations. Depending on process temperatures and slag conditions, furnaces require at least a partial relining of the refractory material every 4-6 years. When this maintenance is needed two procedures, called *Blowdown* and *Quench*, are used to substantially shorten the turnaround time. The purpose of a *Blowdown* is to empty the blast furnace by continuing to burn coke with the furnace on $O_2$ “blast” without adding burden materials (coke and ore). In normal production, the coke burden absorbs heat from the hot gases. Since no burden material is being added during *Blowdown*, the top gas temperature can increase substantially as residual coke is consumed. The top gas temperature is controlled in this process by injecting water at the top cone and at several levels in the furnace stack. The *Blowdown* process is controlled via the furnace “wind rate”, which affects the top gas temperature, and via the top spray water flow, which affects the top gas $H_2$ concentration. Several mass spectrometers are often used during this procedure (one primary and one back-up) since $H_2$ levels could easily reach explosive levels. Typically the operator will try to keep the $H_2$ below 12%, but brief surges to 15-17% are not uncommon. A typical analysis is shown in Figure 1.

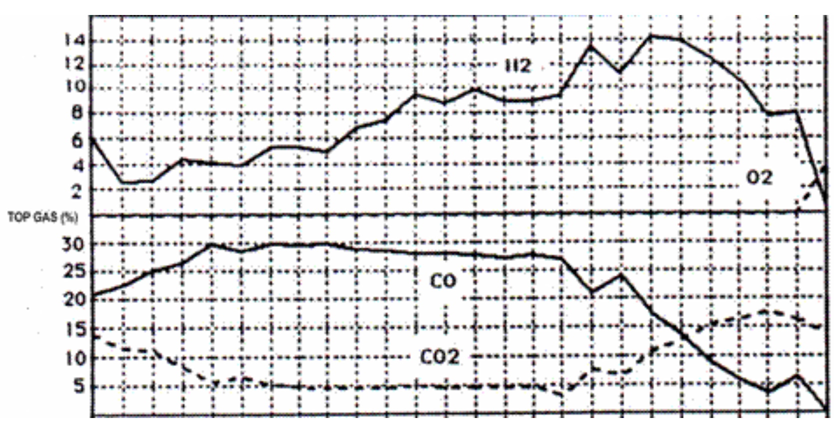


Figure 1. Mass Spectrometer top gas analysis of a 13 hour *Blowdown*

In the *Quench* procedure, water is introduced to the furnace through the top sprays. The quench water is used to cool the residual coke mass and to bring the furnace hearth temperature down to 800 degrees F as quickly as possible. The rapid cooling provided by this technique prevents damage to the carbon refractory material. During this stage of the process, the $H_2$ level may surge, but can be is diluted with nitrogen purge to maintain safe conditions. In addition, the gas temperatures are lower, as are the top gas $O_2$ levels.

By using a mass spectrometer to monitor these processes, equipment and personnel safety are assured while minimizing furnace down time.

Basic Oxygen Process (BOP) Steel Manufacturing

The BOP is used in refining pig iron to produce steel with a desired carbon content. High purity oxygen and flux materials are added to reduce sulfur levels in the steel. Analysis of CO and $CO_2$ in BOP off-gas with a process mass spectrometer monitors carbon removal. The carbon remaining in the charge can then be determined through a carbon balance calculation.

Secondary Steelmaking, Ladle Metallurgy

The primary purpose of a secondary steelmaking process is removing entrapped gases, primarily $H_2$ and $O_2$. This is most commonly done with a vacuum furnace in a process which can also remove carbon in the form of CO. Mass spectrometry, an inherently vacuum based analytical method, can be easily configured to monitor gas composition in this process.

Other non-vacuum processes have been developed to remove gases and other undesirable elements including carbon. An example of these is the AOD (argon-oxygen decarburization) process, in which the steel is heated and sequentially blown with different ratios of argon and oxygen in the presence of flux materials. This process is capable of producing steel with $H_2$ content less than 10 ppm and $N_2$ and sulfur levels below 50 ppm. Analysis of the AOD process off-gases by mass spectrometry can be used to optimize process conditions.

Monitor Instruments' Series 3000 cycloidal mass spectrometers provide process analysis in a wide variety of industries. Our application specific inlet systems, versatile Gas-Wizard™ software, and stable analyzers assure cost effective, high quality process control information. We invite you to visit our website (www.monitorinstruments.com), to request information via e-mail at info@monitorinstruments.com, or post at 290 East Union Rd., Cheswick, PA 15024, USA, or to contact us by telephone at +1.724.265.1212 or fax at +1.274.265.1199. We will give your application the careful, confidential consideration it deserves.