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Critical and non-critical aspects of achieving expected results in heat treating processes — Endo carburizing

THERE HAVE BEEN THOUSANDS of scholarly articles and how-to books written about heat treating and its related metallurgy. In past columns, I've opined that the success of any heat treat — captive or commercial — is directly associated with the competence of its maintenance supervisor and staff. Heat treat furnace maintenance is an acquired skill requiring years of hands-on experience plus knowledge of the process, meaning how and why the process works.

This and subsequent columns will explain what's critical and what's not for a heat treat process to provide the expected result. Let's start with endo carburizing.

Endo carburizing begins with the generator to produce the carbon source, CO. Although carbon monoxide is the source of carbon, for the process to function properly hydrogen, oxygen and water vapor must exist in quantity to create the reduction/oxidizing balance.

The endothermic generator is the evolution of trial and error dating from the days of pack carburizing. Over the decades, the endo generator has gone through many iterations all consisting of a retort filled with catalyst, primarily a 6% nickel solution soaked into cubes of insulating fire brick (IFB). Nickel is the primary metal although platinum and other noble metal compounds can work but are extremely expensive for the capacities of generators used in the U.S.

Creating endo gas is a fairly simple process. You must pass a 2.5:1 air to natural gas ratio through a nickel catalyst heated to between 1850°F to 1950°F (1010°C to 1065°C) for a duration of seconds, and the resulting gas will contain 20% + CO, 40% + H_2 and 40% + N_2 with traces of CO_2 and water vapor the controlled parameter(s). For years, the only control of the 2.5:1 gas ratio was an ingenious but complex carburetor with air and gas adjusting knobs that made very small changes to the ratio. Adjustments were required because the moisture content of the ambient or plant air would change from day-to-day as local weather systems dictated. In addition, as utility companies altered their winter/summer natural gas mixtures the resulting endo ratio would also change. Also, in those by-gone days, a dew cup or Alnor dew point tester was required to measure the output gas. Eventually, infrared CO_2 analyzers were the devices of choice. More recently, as their reliability has improved, continuous dew point monitors have replaced infrared CO_2.

For economic and scaling of capacity reasons, one endo generator will provide enough gas to satisfy several furnaces. However, there are times when the maximum capacity of a generator is not required as furnaces are taken offline for maintenance. Thus, there must be a method of reducing the output of a generator. Years ago, as the pressure in the supply header to the heat treat increased to a predetermined level, a back-loaded regulator would recirculate a portion of the pump driven air to about one-third of capacity resulting in two-thirds of the maximum output. Fortunately, reducing the generator capacity by one-third would not cause a significant change in the mix ratio to obtain the +35°F (1.6°C) or 0.2% CO_2, but reducing the gas flow by more than one-third would create a need to change the air-to-gas ratio. This required a continuous and automatic alternative to the manual carburetor and prompted the development of CO_2 infrared analyzers and automatic ratio control systems.

Ever since endo generators took on the traditional vertical retort within a heated chamber, the only way to replace the catalyst as it aged was to locate the generator in a high bay with bridge crane access over it to pull the retort up vertically. Obviously, this created a labor-intensive effort for the crane and forklift operators working in combination to first raise the retort then flip it horizontally to facilitate its clean out and then reposition it vertically to fill with new catalyst and lower into the chamber.

AFC-Holcroft made a monumental change to the generator design by adding, of all things, a door. Dubbed the EZ™ Endo generator, this simple change created a why-didn't-I-think-of-that moment, which was the response by all who witnessed its operation. The integrated door now allowed the heat treater to locate the EZ™ Endo unit anywhere in their heat treat without regard for an overhead crane. With the available forklift adaptor, the door is opened, the overhead cooler is unbolted, the inlet piping is disconnected, and the retort is simply removed and manipulated to whatever position required, vertical, horizontal, or in between. It's as simple as that — EZ™ Endo.

As water was slowly eliminated from the heat treat, air cooling the endo gas as it exited the retort was the alternative, but this created another headache. To prevent carbon from precipitating from the cooling gas, water was ideal in quenching the process. However, the air, although acceptable, allowed a little carbon to form and this can clog the ID of the finned tube heat exchanger. The top located cooler is designed to reduce the carbon dropout potential, but the EZ™ generator provides an easy method of cleaning the tube ID in the event carbon does form.

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