APPLICATION NOTE

UT/UP750 Carbon Potential Control

WHAT IS CARBURIZING?

Any steel part subjected to sliding or rolling requires a hard surface (high carbon content) to resist surface wear. Since most steel parts need to be soft (low carbon content) to allow them to be formed (forged, stamped, cut, etc.) into their desired shape, the hard surface needs to be added after the part is formed.

Many heat-treating techniques are used to harden the surface of steel parts. The five most common techniques are: Carburizing, nitriding, carbonitriding, flame hardening, and induction hardening. Each technique has its own set of benefits and limits. *Carbon Master* applies specifically to the carburizing process.

HOW DOES THE CARBURIZING PROCESS WORK?

Carburization occurs when a part is placed into a furnace with a furnace atmosphere of almost pure carbon. The part is held at a temperature of 1500-2000° F for some prescribed time to achieve the required case depth (depth of the hardened surface).

HOW IS *CARBON MASTER* USED IN THE CARBURIZING PROCESS?

A carbon rich atmosphere is introduced into the furnace. As the carbon is absorbed from the atmosphere into the part the carbon in the atmosphere needs to be replaced to maintain a consistent carbon potential in the atmosphere. *Carbon Master* controls the amount of carbon in the furnace atmosphere by adding air or natural gas into the furnace atmosphere.

HOW DO YOU MEASURE CARBON POTENTIAL?

Because there is no practical direct method to measure carbon content in a furnace atmosphere, indirect methods are used. There are two common methods:

1. Carbon Probe. The Carbon Probe is actually an oxygen probe. By measuring the oxygen content, the probe temperature, and CO content (normally assumed to be 20%), the carbon content of the atmosphere can be calculated. There are many suppliers of carbon probes. *Carbon Master* works equally well with all of them.

1. Dewpointer: This device measures the actual dewpoint of the gas. Assuming a stable 20% CO content in the sample gas, this dewpoint may be related directly to carbon content in the gas. This measurement is typically taken as a spot check of the furnace atmosphere. It is often used an independent check on the atmosphere control system.

In both of the above cases, CO% is assumed to be stable. If sooting is a problem, CO may not be stable and should normally be measured rather than assumed. *Carbon Master* can accommodate a CO% input as either a fixed input or as a measured variable.

A TYPICAL FURNACE CONTROL FOR TEMPERATURE & CARBON ATMOSPHERE

Figure 1 shows a typical *Carbon Master* configuration. Using a UP750 (or UT750) *Carbon Master* Controller, both the carbon atmosphere and the furnace temperature are controlled in one controller. “IN2” is the furnace temperature input and “A02” is the furnace temperature control signal.

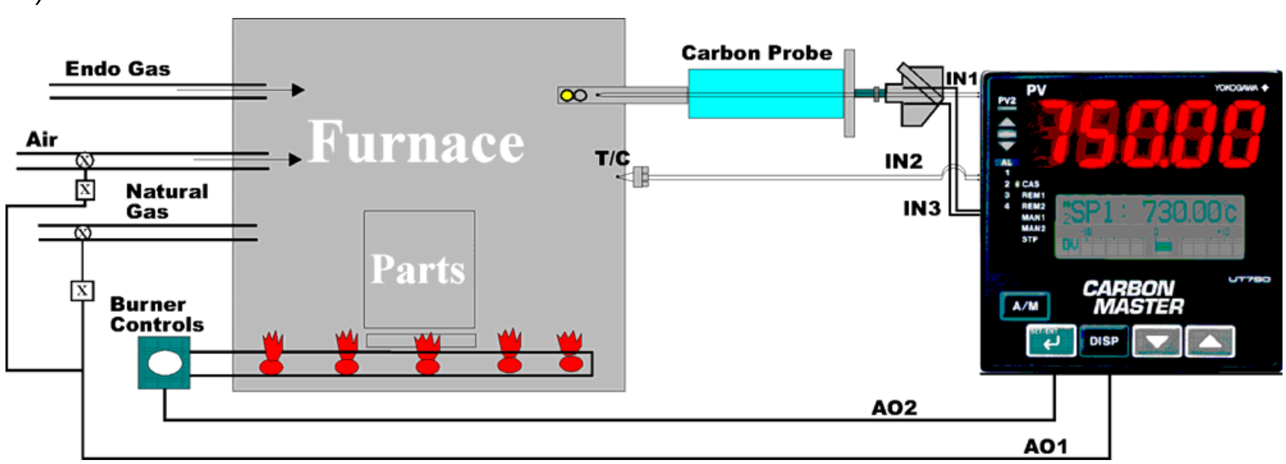

Figure 1

IN1 and IN2 inputs come from the carbon probe. The carbon probe is actually an oxygen probe because carbon cannot be directly measured in a practical way. By knowing the oxygen content ("IN1"), the probe temperature ("IN2"), and the CO content (normally assumed to be 20%), the carbon content of the atmosphere can be calculated.

The carbon-rich gas from the endothermic generator is introduced into the furnace at a fixed rate. The carbon content of the furnace atmosphere is trimmed by the introduction of natural gas or air. "A01" is a split signal output (similar to "Heat/Cool). An increase in natural gas flow increases the carbon content. Increasing the air flow decreases the carbon content.

The set point of the controller is normally expressed in "points" of carbon. An alternative way of expressing carbon content is as a "dew point". An increasing dew point represents a decreasing carbon content. *Carbon Master* can be set up with the computational algorithms to accommodate either way of expressing carbon content.

WHY IS CARBON CONTROL SO DIFFICULT?

First, the measurement of carbon in the atmosphere is difficult. Even after measurements are made, the calculation to determine carbon content is complex. Any computational inaccuracies affect the precision of the control. The powerful computational capabilities of *Carbon Master* provide unsurpassed precision.

Second, variations in furnace loads, fluctuations in gas pressures, changing carbon demand, and variable carbon content of the enriching gases each create control challenges. Taken together, the process dynamics are quite difficult to control. Poor control can cause many problems: Reduced part quality, ruined batches, increased scrap, decreased furnace efficiency, wasted gas, and increased energy usage. Again, the combined power of *Carbon Master*'s Auto tuning function and *Super Control* provide significantly better control precision than any other controller on the market.

WHAT IS PROBE BURNOFF?

Because of the harsh environment, and sooty nature of the furnace, the carbon probe needs to be cleaned periodically by opening a solenoid and allowing air to flow down the ceramic tube. The air on the heated probe creates an intense burning action that cleans the probe tip. This "burnoff" can be integrated into *Carbon Master* and the user can enter Burnoff interval, Burnoff duration, and Burnoff cycles.

WHAT IS "PROCESS FACTOR"?

Carbon Master can accept an analog signal (4-20mADC) through "IN2" representing CO% as measured by a CO Analyzer (see Figure 2 on the following page). This input automatically adjusts the PV. When "real time" CO% is used as a "process factor" input, a second controller is required for furnace temperature.

ENDOTHERMIC GENERATOR CONTROL

An endothermic gas generator supplies the carbon rich atmosphere gas to the carburizing furnaces in a heat treat shop. One generator typically can supply several furnaces. In an endothermic gas generator, natural gas is mixed with air and passed through a retort filled with a catalyst. By elevating the retort temperature to approximately 1900° F, the air/gas mixture breaks down into a gas that is high in free carbon content. The method for controlling the degree of carbon in the gas produced ("Endo" gas) is almost identical to the control method used for the carburizing furnace.

The only common difference between furnace atmosphere control and endothermic generator control is the set point units. Endothermic generators are normally controlled to "dewpoint" level rather than a carbon percentage. There are two reasons for this difference. First, controlling to a dewpoint allows a direct comparison check of the atmosphere with an "Alnor Dewpointer". This instrument has been around for a long time and enjoys a high degree of acceptance among heat treaters for its accuracy. The second reason is that, if an endothermic generator is feeding multiple furnaces at differing operating temperatures, controlling to a dew point, instead of %carbon, may provide a more stable control.

SUMMARY

Carbon Master provides the solution for a very dificult control application. The computational capabilities provide an accurate carbon potential input, carbon control and temperature control all in one box. The UP750 *Carbon Master* is a program controller with up to 300 temperature patterns possible. A CO analyzer can be used to adjust CO% in "real time". *Carbon Master* is the most versatile carbon controller available.

APPLICATION NOTE

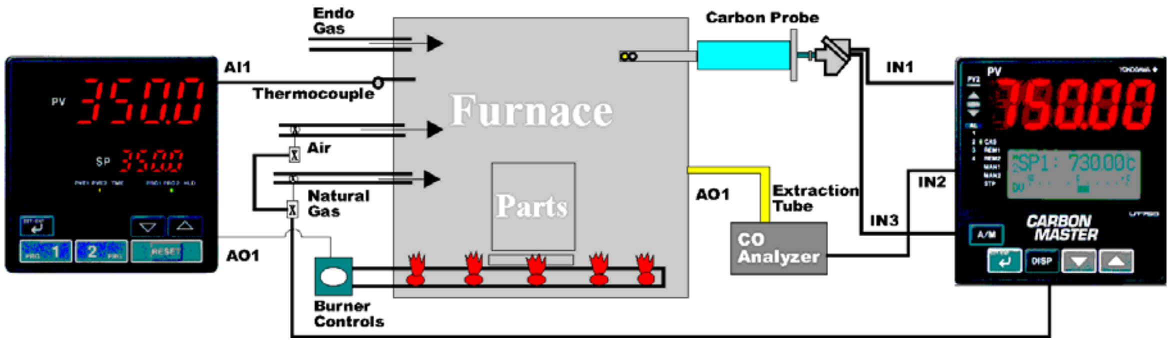

Figure 2: In this configuration, CO% is being measured by a CO Analyzer to automatically adjust the PV for CO variations. Carbon Master can accept an analog signal (4-20ma) representing CO%. When "real time" CO% is used as an input, a second controller is required for furnace temperature.