



UDC 3500 Application Note

CARBON POTENTIAL CONTROL

A major factor in determining the physical properties of a steel part is its carbon content. Often the part is fabricated with a low percentage of carbon and then adding more carbon, followed by quenching from a high temperature, hardens it. The critical process most used for adding carbon is gas carburizing. Both the furnace atmosphere and the temperature must be controlled closely - typically ± 0.05 % Carbon and ± 10 degrees F.

SOLUTION

Honeywell can provide a UDC 3500 digital controller to control both percent carbon and furnace temperature well within the required limits. This solution includes:

- High Accuracy
- Direct % Carbon Readout
- Compatibility with all ZrO₂ Carbon Probes
- Simple Installation and Operation
- Field Proven Equipment
- Easy Configuration via Simple Prompts in 5 Languages

PROCESS DESCRIPTION

The furnace atmosphere may be either a synthetic nitrogen-based atmosphere or it may be supplied by reacting a hydrocarbon gas (usually natural gas) with air over a catalyst in an endothermic generator. In either case, the result is a mixture of gases containing carbon, oxygen, hydrogen and nitrogen. The ability of the furnace's atmosphere to supply carbon to the heated steel is called its "carbon potential" and it is defined as the percent carbon (by weight) in a piece of steel which has achieved thermodynamic equilibrium with the atmosphere. For example, if a part with 0.6% Carbon neither takes carbon from the furnace's atmosphere nor gives up carbon to it, the atmosphere is said to have a carbon potential of 0.6%C. In such an atmosphere, a part with 0.5%C would take carbon from the atmosphere (i.e., be carburized) and a part with 0.7%C would be decarburized.

There are several ways to determine the carbon potential of a furnace atmosphere, but one of the most popular approaches uses a zirconium oxide sensor. Actually, the ZrO₂ sensor generates a voltage signal based on the carbon potential of the atmosphere. For a given temperature, the atmosphere's carbon potential can be calculated or determined from charts; however, this can



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be error prone and tedious. The Honeywell UDC 3200 carbon potential controller is the ideal solution to this problem because it automatically calculates the % carbon as described below.

The % CO (carbon monoxide) in the enriching gas has a major impact on the actual Carbon Potential of the gas. If the gas has inconsistent quality or composition, the resulting % Carbon will also vary. The impact of a deviation in actual % Carbon from the target value is reduced product quality, resulting in possible rework or scrap - a costly consequence. A solution to this is to perform on-line or continuous CO compensation by measuring the actual % CO with an analyzer/transmitter and using the actual CO value to compensate the % Carbon calculation being performed by the carbon controller. The typical CO value is near 20; however, the ranges of values that may be encountered vary from 2 to 30 % depending upon the enriching gas source.

UDC 3500 FEATURES

- Direct read out in percent carbon (0.00 to 2.00%). No look-up tables.
- Accurate to $\pm 0.02\%$ Carbon
- The following manufacturer's probes are characterized in UDC 3500:
 - Advanced Atmosphere Control Corporation (AACC)
 - Bricesco
 - Cambridge Instruments
 - Corning
 - Furnace Control Corporation
 - MacDhui
 - Marathon Monitors
 - Super Systems
- Percent CO setting from 2 to 35% may be entered at a fixed value
- Easy configuration via multi-language prompts in 5 languages
- Probe temperature input type is selectable from complete input menu
- Temperature control plus Carbon control is possible on a single UDC3500
- Two controller outputs are available for duplex control
- Output form may be on-off, time proportioning or current-proportioning.



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- Separate PID values are used for dilution air and enriching gas control
- Automatic sooting condition warning via flashing prompt
- Up to 2 alarm relays, each with 2 configurable setpoint is available
- Optional auxiliary 4-20 mA output for recorder or a control output
- Serial communications options are available
- 3 local Setpoint are a standard feature
- Setpoint ramp/soak is optionally available
- Dew point Algorithm is also available. Range: -50 °F to +100 °F

APPLICATION OF UDC 3500

Figure 1 shows a UDC 3500 Controller being used to control the carbon potential of a furnace's atmosphere. A carbon probe consisting of a ZrO₂ sensor and a thermocouple (to measure the temperature at the sensor) provides two inputs to the controller. The microprocessor-based controller computes the atmosphere's actual carbon potential from these two inputs and compares the computed value with the desired setpoint. The PID control algorithm determines the controller output necessary to keep the actual carbon potential at the setpoint. Usually only one output is used to add more or less enriching gas (typically natural gas) to the furnace's atmosphere, which has a relatively low carbon potential. The enriching gas raises the carbon potential to the desired level; however, it is often necessary to add dilution air to lower the carbon potential instead of enriching gas to raise it. This requires duplex control, and a second output from the controller provides this function. When duplex control is used, a different set of PID tuning constants is available for dilution air control and enriching gas control.

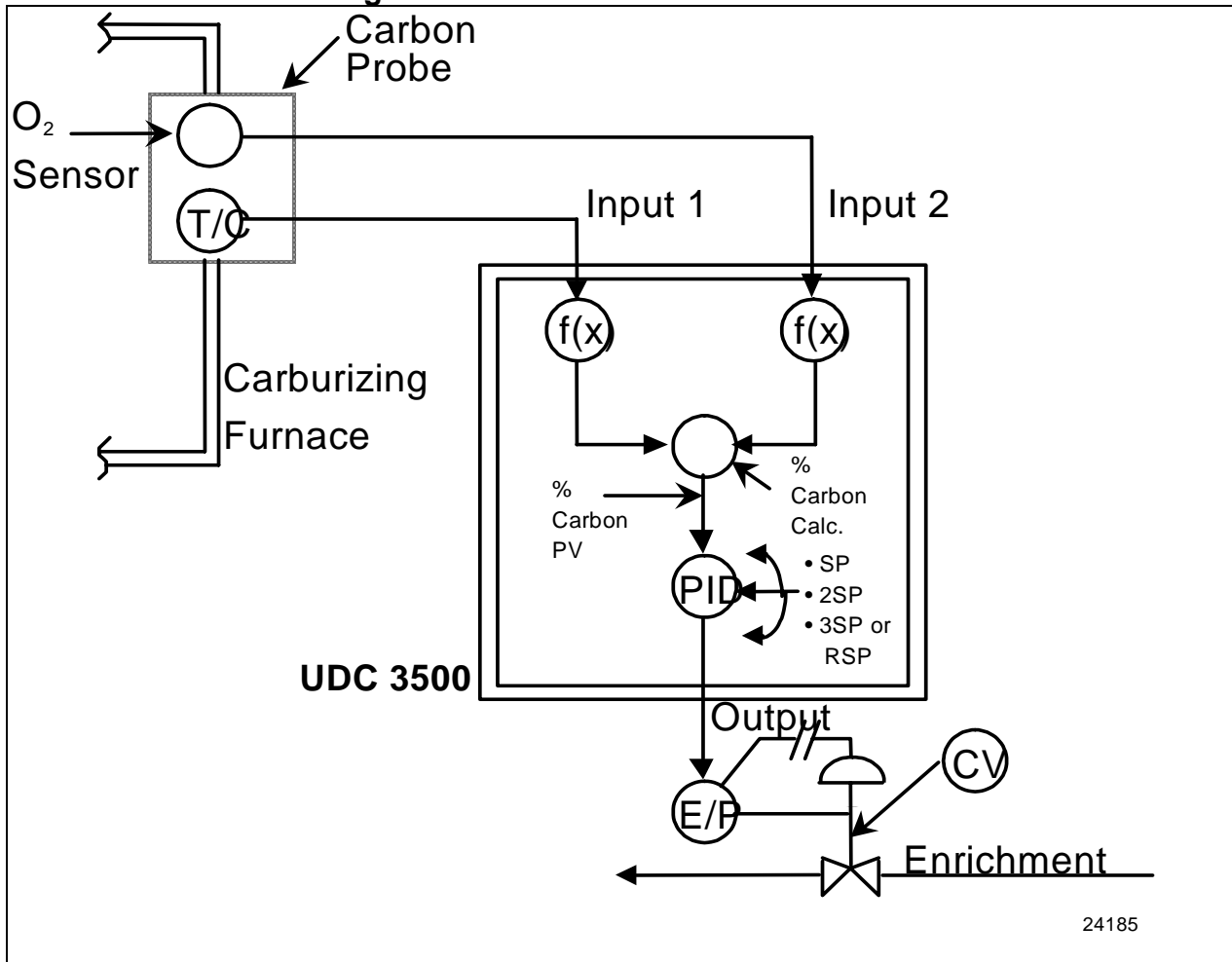
Both the carbon potential loop and the temperature control loop can be provided in a single UDC 3500 by also using Input 1 from the probe's thermocouple as the temperature process variable for Loop 2. Note that the output signal hardware requirements must not exceed the outputs available.

The diagram below shows a typical Carbon Potential control loop as implemented with UDC 3500. It would also be possible to control temperature in the same UDC 3500 by adding a second loop and configuring Input 1, the carbon probe temperature signal, as Loop 2's process variable source and choosing an appropriate output algorithm to control the heating final control element.



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Figure 1:



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