Surface Combustion

Atmospheres For Heat Treating Equipment

SECOND EDITION

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Table of Contents

Generation, Application and Control of Furnace Atmospheres - By William M. Dempster

The original source of furnace atmosphere for protection or change of heated metal surfaces was the combustion of a fuel, such as wood or coal, or oil. However, if combustion to provide heat was uncontrolled resulting in unreacted oxygen or in the case of hydrocarbons, undesirable water vapor, the resulting environment detrimentally affected the piece of metal being processed. Therefore, the first step was to provide an externally heated working chamber and introduce a prepared gas mixture to exclude air and accomplish the desired result.

There are various substances which can be combined with air to provide atmosphere gas suitable for a number of processes. The elements involved are: (1) a type of carbon bearing reactant; (2) a breakdown of this reactant with the absence of air; (3) various completenesses of reaction between this reactant and air; (4) a combination of hydrocarbon with steam; (5) removal of the products of a reaction by some means. The reactants most commonly used are: (1) carbon such as wood charcoal; (2) simple hydrocarbon gases such as methane, propane, and butane; (3) simple common hydrocarbon liquids such as methanol, ethanol, acetone, and complex hydrocarbons such as kerosene, No. 2 fuel oil, or toluene. The choice of reactants also is dependent on the end analysis desired, as some are suitable for one type of prepared gas, but not for another.

Certain forms of hydrocarbon are not suitable: (1) those containing sulphur (for example coal, coke and heavy petroleum compounds), which is destructive to most metals at high temperature and to most metallurgical processes; (2) complex hydrocarbons such as iso-propane and iso-butanes which will not react completely, or which will produce a solid carbon when they dissociate under heat; (3) reactant of analysis too inconsistent to accomplish certain metallurgical reactions.

Therefore, in choosing a reactant it should be the simplest and purest form of hydrocarbon. First, it is necessary to determine what metallurgical process is desired for the particular metal involved. These metals commonly are copper and brass, low carbon steel (up to .20% C), medium carbon steel (.20% C to .60% C), high carbon steel (.60% C and over), and stainless and special steels.

Hydrocarbon Reactions

The various gases produced in reactions of hydrocarbons with air ($0^2 + 4\ N_2$), and their reactions with common metals are shown in Table 1 (found at the end of this article). Nitrogen is considered inert to all metals, except for atomic nitrogen produced by the dissociation of ammonia which produces Fe_3N in nitriding applications.

The various atmosphere gas mixes available through the use of an external atmosphere generator, or internal furnace reaction device, and method of generation are as follows.

Charcoal Gas

Production is by controlled partial combustion of pure hardwood charcoal (minimum of impurities). Air under pressure flows up through a heated retort filled with the lump charcoal, after venting the undesirable gases from the green charcoal entering the retort from the top. The usable gas is drawn off the retort at its maximum temperature zone. The gas composition is 34.7% CO, 1.2% H_2, 64.1% N_2 and trace of CO_2 according to adjustment.

One kilogram (2.2 lb) of charcoal will provide approximately 5 cubic meters (176.5 cu.ft.) of gas. The gas will carburize and can be enriched for high carbon potentials in treating steel.

Lean Exothermic Gas

This gas is manufactured by the controlled combustion of hydrocarbons. It is prepared in a separate combustion chamber with proper ratio controls to ensure a constant analysis. The products of combustion are then cooled to 30°C (86°F) or less in a heat exchanger system in order to reduce the percentage of H_20.

An approximate analysis of this gas is CO_2 - 12. 7%, CO - 1 .0%, H_2 -1.0%, balance - N_2; dew point from 30°C to 5°C (86°F to 41°F). It is considered non-explosive, and would be suitable for bright annealing of copper. The gas can be manufactured from gaseous hydrocarbons, and from light hydrocarbon liquids. With the liquid fuels, the smallest sized generator would be approximately 30 cubic meters (105 may be required to remove traces of SO_2 originating from the fuel.

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The gas produces a blue finish on steel, or serves as an atmosphere for brazing.

Rich Exothermic Gas

This gas is produced in the same manner as the lean type, except that the combustion mixture is controlled to reduce the amount of O_2 in order to increase the amounts of CO and H_2. The average analysis of this gas is CO_2 - 6%, CO - 8%, H_2 - 8%, balance - N_2; dew point from 30°C to 5°C (86°F to 41°F). It can be manufactured from gaseous hydrocarbons, very light hydrocarbons such as CH_3 OH methanol and C_2H_5OH ethanol. The gas is considered explosive.

Applications of this gas include bright annealing low and medium carbon steels, brazing with bright finish or clean hardening low and medium carbon steels.