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HEAT-TREATMENT OF METALS

Alfred Gordon Evans Robiette, London, England

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1

The present invention relates to an improved process for heat-treating metals in a controlled atmosphere which is substantially non-oxidising to the metal being treated, at the temperature of treatment. Such a process is ideal for example, for the bright annealing of steels and nickel alloys, the reheating for rolling and forging of most metals and alloys and the decarburisation of malleable iron.

At present it is common practice to carry out such a process in a sealed furnace or a sealed container of some form into which is introduced the controlled atmosphere.

In most cases this atmosphere is specially prepared outside the furnace in a gas generator which may take the form of an apparatus for the controlled partial combustion of ammonia or even of solid fuel such as charcoal.

Hitherto it has not been found possible, except in the case of copper and certain copper alloys, to carry out the combustion of a fuel within a furnace in such a way that whilst the heat liberated is sufficient to heat the furnace and its charge, the atmosphere produced protects the metal from oxidation. The reason for this is that for most metals such as, for instance, ferrous metals, the amount of heat liberated by burning the fuel to partial combustion is unsufficient to give either effective or economic heating conditions. For example, when treating steel it is necessary to use an air to coal gas ratio between 2.0 to 1 and 2.6 to 1 to get an atmosphere which is protective to steel or iron at temperatures of say 1000° C., whereas the ratio for complete combustion is of the order of 4.2 to 1. In other words, only about half of the calorific value of the gas is liberated and as the bulk of this heat is used to heat the products of combustion there is little effective or useful heat which can be utilised in the furnace. This is specially the case where the temperature of treatment is high, say, between 700° C., and 1100° C.

The reason why direct combustion with air of any fuel can provide a protective atmosphere in the case of copper alloys is because the products of complete combustion, namely water vapour and carbon dioxide, do not oxidise copper and certain copper-rich alloys at their annealing temperatures.

It is obviously very desirable to use if possible a system wherein the gaseous products of partial combustion can be used to protect metals other than copper from oxidation; in other words, to achieve a controlled-atmosphere heat treatment in a direct fuel-fired furnace.

According to the present invention there is provided a process of heat-treating metal in a substantially closed furnace in which the metal to be treated is passed in one direction through

2

the furnace and fluid fuel and a gas containing 70% or more of oxygen are passed in the opposite direction, the fuel and gas being partially burnt at the exit end of the furnace to produce an atmosphere which is non-oxidising to the metal and which is passed to the cooler, entry, end of the furnace where it is burnt to substantially complete combustion so as to preheat metal entering the furnace.

The expression "fluid fuel" is intended to include substances which can behave as fluids such as powdered carbonaceous material blown into the furnace.

If desired the process can be adjusted by controlling the oxygen-nitrogen to fluid fuel ratio so that the atmosphere is decarburising as well as non-oxidising to the metal being treated, such conditions being required for the annealing of white-heart malleable iron, for example.

For the treatment of most metals the amount of oxygen required is about half that required for complete combustion and as the nitrogen content of the mixtures used is low the heat required to heat the products of combustion up to the furnace temperature is relatively small. In the normal known process of burning with air 60% to 70% of the sensible heat of the combustion products is due to the nitrogen content. whilst in the present process, although only about half the calorific value of the fuel is liberated in the furnace, most of this heat can be usefully used for heating the metal.

The atmosphere produced consists principally of carbon monoxide and hydrogen with smaller contents of carbon dioxide, water vapour and nitrogen. This gas can be collected on passing out of the furnace and can be used for other heating operations or for preheating the fuel and the oxygen-nitrogen mixture. The gas resulting from the partial combustion of town gas, for example, will have an appreciable calorific vaule between 180 and 250 B. t. u. per cubic foot.

The oxygen-nitrogen mixture for combustion is normally prepared by liquefaction of air followed by fractional distillation and the cheapest form of oxygen is normally that containing 4 to 10% of nitrogen. For carrying out the process of the invention the less nitrogen the better, but from an economic aspect a content of 1 to 10% is the best compromise.

By a "substantially closed furnace" is meant one from which the entry of the atmosphere is restricted and the exclusion of air is mainly accomplished by the pressure of gases within the furnace. It must, however, be open in so far as to permit the charging and discharging of the metal.

The process may be carried out in a straight-through type of furnace or in an annular rotating hearth type of furnace where, in the latter case,

the points of charging and discharging are contiguous or adjacent since this type of furnace is in effect a straight-through type of furnace converted to circular form, the tunnel being made to assume an annular channel.

In furnace practice, and as used herein, the term "continuous" does not necessarily mean that the material is in continuous motion, but that the material is transported progressively from the charging to the discharging point continuously or intermittently.

In a modification of the invention complete combustion can be effected by means of oxygen, or mixtures of oxygen and air, instead of air alone, but as a general rule this is not economical unless oxygen is obtainable very cheaply as a by-product of another process.

If desired a controlled protective atmosphere generated or prepared outside the furnace can be injected into the heating chamber to augment the volume of gas in the furnace, but generally this is not necessary.

In carrying out the invention I may proceed as follows:

Metal ingots to be heat treated are fed at regular intervals into the cooler end of a continuous type of furnace and are moved through the furnace at an appropriate speed, which may be uniform or intermittent, by any convenient conveying means.

At the exit end of the furnace, which is the hotter end, there is injected into the furnace through a plurality of transverse ports, a fluid fuel such as town gas and a mixture of oxygen and nitrogen containing between 70% and 100% of oxygen. These gases are burnt in the furnace to partial combustion so as to provide an atmosphere which is relatively non-oxidising to the metal at the temperature of treatment at the hotter end of the furnace, which in the case of iron and steel is of the order of 700° C. to 1250° C.

In some cases it is not necessary to exclude oxidation entirely, but the conditions can be controlled so as to limit or restrict the amount of oxide produced.

The partially combusted gases pass toward the entry end of the furnace and at this end air is injected into the furnace through a further set of transverse ports to burn the heating gases to substantially complete combustion, the heat generated by this secondary combustion serving to preheat the ingots passing through the entry end of the furnace. At the entry end of the furnace the conditions, of course, are oxidising, but as the metal is being subjected in this zone to initial heating at lower temperatures, the amount of oxidation produced is small. If necessary, the film of oxide produced can be reduced in the controlled atmosphere zone.

The furnace is so draughted that the gas passes in contra-flow to the charge and the flue or waste gases can be passed, as is usual in reheating furnace practice, through a recuperator to preheat either gas, air or oxygen, or all or two of these to increase efficiency.

If coal gas is used having a calorific value of 450 B. t. u.'s per cu. ft., then approximately half of the calorific value of the gas is burnt in the non-oxidising zone where the metal is between, say, 650° C. and 1200° C., and the ratio of oxygen to gas is .45 oxygen to 1 of coal gas, whilst sufficient air preferably preheated by a recuperator is injected in the inlet or preheating zone to burn the products of the first combustion substantially completely whilst the charge is being raised from room temperature to between 600° to 650° C.

The process is preferably maintained continuously.

I claim:

1. The process of heat treating metal in a substantially closed furnace in preheating and final heating stages successively, which comprises passing the metal to be treated in one direction through the furnace and a fluid fuel and a gas containing 70% or more oxygen in the opposite direction, partially burning the fuel and gas at the exit end of the furnace in direct contact with the metal to produce an atmosphere which, at the temperature of treatment at said exit end, is non-oxidising to the metal, and passing the products of partial combustion to the cooler entry end of the furnace and burning said gases to further combustion in direct contact with the metal at said entry end so as to preheat the metal entering the furnace.

2. The process of heat treating metal in a substantially closed furnace, in preheating and final heating stages successively, which comprises burning a fluid fuel to partial combustion with an oxygen-nitrogen mixture containing between 70% and 99% of oxygen in direct contact with the metal in the final heating stage to maintain the temperature of the metal in that stage at 700° C. to 1250° C. and burning the products of that partial combustion in direct contact with the metal in the preheating stage.

3. The process of heat treating metal in a substantially closed furnace, in preheating and final heating stages successively, which comprises burning a fluid fuel to partial combustion with an oxygen-nitrogen mixture containing between 70% and 99% of oxygen in direct contact with the metal in the final heating stage to maintain the temperature of the metal in that stage at 700° C. to 1250° C. and burning the products of that partial combustion to substantially complete combustion in direct contact with the metal in the preheating stage.

ALFRED GORDON EVANS ROBIETTE.

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