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(54) **Method and apparatus for controlling a furnace atmosphere dew point**

Verfahren und Vorrichtung zum Kontrollieren des Taupunktes einer Ofenatmosphäre

Procédé et dispositif pour contrôler le point de rosée de l'atmosphère d'un four

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Description

[0001] This invention relates to the control of the dew point in a protective atmosphere within a furnace, and in particular a furnace atmosphere containing hydrogen.

[0002] It is common for furnaces to be provided with a protective atmosphere, for example to prevent oxidation adversely affecting the processes within the furnace. For example, a Vertical Bright Annealer (VBA) furnace, used to anneal stainless steel sheet or strip, operates with a protective atmosphere having a composition of about 75% hydrogen and 25% nitrogen. Such an atmosphere is highly reducing and very dry. In fact, the furnace dew point can attain minus 70°C or even drier. At such dryness levels there is a strong tendency toward the formation of a white powder deposit, particularly in the cooler regions of the furnace (for example the jet coolers), and these deposits inhibit the operating efficiency of the furnace. In order to remove the powder build-up it is usually necessary to shut down the furnace, which is time consuming and inefficient.

[0003] It has been discovered that the problem of powder deposition can be alleviated by controlling the furnace dew point. In particular, in a VBA furnace such as that described above, maintaining the hot zone dew point between about minus 40°C and minus 55°C has been shown to minimise the formation and deposition of white powder. The volume of water typically required to promote a dew point change from minus 70°C to minus 55°C is 1.3ml per 100m³ of total furnace atmosphere flow. A method of humidifying the furnace atmosphere, to effect the necessary increase in furnace dew point, employs the introduction of water mist, or vapour, into the protective atmosphere gas stream supplied to the furnace. Such an arrangement has been reasonably successful in curbing an excessively low dew point, but is inaccurate and unable to maintain a controlled dew point. In practice, a lubrication misting unit having a water-filled reservoir is employed, the water mist being introduced from the unit into the furnace atmosphere gas stream. Such arrangements are also dependent on the operator remembering to refill the unit with water.

[0004] According to the invention, an improved method of controlling a furnace atmosphere dew point (wherein, in use, the furnace is supplied with an atmosphere consisting at least in part of hydrogen) comprises withdrawing at least part of the flow of hydrogen being supplied to the furnace, reacting the withdrawn hydrogen with an oxygen-containing gas so as to produce a gas mixture consisting of an oxygen-free product gas, residual hydrogen and water, and directing the gas mixture into the atmosphere supplied to the furnace so as to maintain the water vapour content of the furnace atmosphere within a predetermined range.

[0005] Such an arrangement enables the provision of a controllable, automatic method of dew point adjustment of the furnace atmosphere, and enables the dew point to be accurately controlled and maintained within

a given range.

[0006] The water vapour-containing gas mixture may be directed in to the flow of hydrogen prior to its introduction in to the furnace or, more preferably, may be directed in to the hot zone(s) of the furnace. In either case, the water vapour content can be accurately controlled, however the latter arrangement advantageously humidifies only a proportion of the total atmosphere flow in to the furnace and hence is inherently more efficient than the prior art methods in which the total atmosphere flow in to the furnace is humidified.

[0007] In the manufacture of industrial gases it is common to use catalytic gas deoxygenation ("deoxo") units. In operation, such units cause any oxygen present in the feed gas to react with hydrogen to form water; the resulting output from such a deoxo unit is a combination of oxygen-free product gas, residual hydrogen and water. Such deoxo units can profitably be used in the present invention to humidify a furnace atmosphere, being employed primarily as "water generators". These deoxo units are highly efficient, and therefore water output can be precisely controlled; accordingly, the installation of a catalytic deoxo unit in the hydrogen pipeline serving the furnace enables the provision of a highly controllable method of dew point adjustment of the furnace atmosphere. Those skilled in the art will appreciate that the addition of a dew point sensing means and a suitable control device, such as a suitably programmed micro-processor, will produce a simple, inexpensive yet effective automatic dew point control system. Commercial deoxo units are also advantageous as they are completely self-contained, and do not require any external services or attention for their operation.

[0008] The invention further relates to an apparatus, as defined in claim 7, for controlling a furnace atmosphere dew point.

[0009] The invention will now be described by way of example and with reference to the accompanying drawing, Figure 1, which is a schematic diagram of an apparatus for humidifying the atmosphere supplied to a VBA furnace, and thus for controlling the dew point thereof.

[0010] In the apparatus of Figure 1, a proportion of the hydrogen feed passing along supply line 2 to the VBA furnace is diverted along line 4 leading to a catalytic gas deoxygenation unit 6 thereto react with the oxygen in a supply of air passing along line 8 (the air typically being provided by a compressed air system, as cylinder gas or from a small compressor). Flow meters 10 measure the flows of hydrogen and air into the deoxo unit 6, these flows being controlled by regulator valves 12. Check valves 14 prevent back flows. A valved off-take 16 is provided for sampling the gas supplied by the deoxo unit 6 for measuring the dew point.

[0011] In practice, hydrogen is supplied to the furnace atmosphere control system at high pressure (about 8bar) and the hydrogen withdrawn along line 4 is regulated to a lower pressure before passage through the deoxo unit 6. Passage through the deoxo unit results in

a chemical combination of a proportion of the hydrogen and all of the oxygen in the air supply to the deoxo unit 6 in the ratio 2 to 1 by volume to form water vapour. The outlet gases (hydrogen, water vapour and a small amount of nitrogen) is reintroduced back into the furnace atmosphere at a suitable low pressure (less than 8bar) location, such as into the main hydrogen feed immediately prior to its ingress into the furnace, or into the furnace itself.

[0012] The dew point "shift" necessary to obtain dew point temperature levels within the range minus 40°C to minus 55°C is relatively minor. A water vapour content within the above-mentioned VBA furnace atmosphere of 128ppm is equivalent to the higher dew point condition while 22ppm represents the dryer condition. As the required water vapour levels are so low it is possible to accomplish the necessary humidification of the furnace atmosphere by treating only a small sidestream of the feed hydrogen supply to the furnace. Accordingly, up to about 3m³/hr of hydrogen (about 2.0% of the total hydrogen flow) is withdrawn for humidification.

[0013] As will be appreciated by those skilled in the art, the amount of water vapour produced can be controlled with great accuracy because the input flow rates of both hydrogen and air to the deoxo unit can be very accurately measured and controlled. Moreover, deoxo units are highly efficient in operation, and the size and hence expense of deoxo unit necessary could be reduced if it were desired to humidify the atmosphere in the furnace hot zone(s) only.

Claims

1. A method of controlling a furnace atmosphere dew point wherein, in use, the furnace is supplied with an atmosphere consisting at least in part of hydrogen, the method comprising withdrawing at least part of the flow of hydrogen being supplied to the furnace, reacting the withdrawn hydrogen with an oxygen-containing gas so as to produce a gas mixture consisting of an oxygen-free product gas, residual hydrogen and water, and directing the gas mixture into the atmosphere supplied to the furnace so as to maintain the water vapour content of the furnace atmosphere within a predetermined range.
2. A method as claimed in Claim 1 comprising controlling the amount of hydrogen withdrawn and/or the amount of oxygen-containing gas reacted therewith in order to maintain the predetermined water vapour content range between about 10ppm and about 200ppm, preferably between about 22ppm and about 128ppm.
3. A method as claimed in Claim 2 comprising monitoring the temperature and/or dew point of the furnace atmosphere and controlling the amount(s) of

hydrogen withdrawn and/or oxygen-rich gas supplied for reaction accordingly.

4. A method as claimed in Claim 1, Claim 2 or Claim 3 wherein the gas mixture is directed into the flow of hydrogen prior to its introduction into the furnace.
5. A method as claimed in Claim 1, Claim 2 or Claim 3 wherein the gas mixture is directed into the hot zone(s) of the furnace.
6. A method as claimed in any preceding Claim wherein the oxygen-containing gas is air.
7. Apparatus for controlling a furnace atmosphere dew point wherein, in use the furnace is supplied with an atmosphere consisting at least in part of hydrogen, the apparatus comprising means for withdrawing at least part of the flow of hydrogen being supplied to the furnace, means for supplying an oxygen-containing gas, means for reacting the withdrawn hydrogen with the oxygen-containing gas to produce a gas mixture comprising oxygen-free product gas, residual hydrogen and water and means to direct the gas mixture into the furnace, means being provided to control the amount(s) of hydrogen withdrawn and/or of oxygen-containing gas so as to maintain the amount of water vapour produced, and hence the water vapour content of the furnace atmosphere, within a predetermined range.
8. Apparatus as claimed in Claim 7 wherein the reacting means comprises a catalytic gas deoxygenation unit.

Patentansprüche

1. Verfahren zur Steuerung eines Ofenatmosphären-taupunkts, bei welchem im Gebrauch der Ofen mit einer Atmosphäre beschickt wird, die mindestens teilweise aus Wasserstoff besteht, wobei das Verfahren das Abziehen mindestens eines Teils der zum Ofen zugeführten Wasserstoffströmung, das Reagieren des abgezogenen Wasserstoffs mit einem sauerstoffhaltigen Gas, so daß ein aus einem sauerstofffreien Produktgas, restlichem Wasserstoff und Wasser bestehendes Gasgemisch erzeugt wird, und das Leiten des Gasgemischs in die zum Ofen zugeführte Atmosphäre umfasst, um den Wasserdampfgehalt der Ofenatmosphäre innerhalb eines vorgegebenen Bereichs zu halten.
2. Verfahren nach Anspruch 1, welches das Steuern der Menge von abgezogenem Wasserstoff und/oder der Menge von damit reagiertem sauerstoffhaltigem Gas umfasst, um den vorgegebenen Was-

serdampfgehaltsbereich zwischen etwa 10 ppm und etwa 200 ppm, vorzugsweise zwischen etwa 22 ppm und etwa 128 ppm, zu halten.

3. Verfahren nach Anspruch 2, welches das Überwachen der Temperatur und/oder des Taupunkts der Ofenatmosphäre und die Steuerung der Menge(n) des abgezogenen Wasserstoffs und/oder des für die Reaktion zugeführten sauerstoffreichen Gases umfasst. 5
4. Verfahren nach Anspruch 1, 2 oder 3, wobei das Gasgemisch in die Wasserstoffströmung vor deren Einleitung in den Ofen geleitet wird. 10
5. Verfahren nach Anspruch 1, 2 oder 3, wobei das Gasgemisch in die heiße Zone(n) des Ofens einge- 15
leitet wird.
6. Verfahren nach einem der Ansprüche der vorher- 20
gehenden Ansprüche, wobei das sauerstoffhaltige Gas Luft ist.
7. Einrichtung zur Steuerung eines Ofenatmosphä- 25
rentaupunkts, bei welcher im Gebrauch der Ofen mit einer Atmosphäre beschickt wird, die minde-
stens teilweise aus Wasserstoff besteht, wobei die Einrichtung Mittel zum Abziehen mindestens eines 30
Teils der zum Ofen zugeführten Wasserstoffströmung, Mittel zum Zuführen eines sauerstoffhaltigen Gases, Mittel zum Reagieren des abgezogenen Wasserstoffs mit dem sauerstoffhaltigen Gas zur Erzeugung eines Gasgemischs, das sauerstofffrei-
es Produktgas, restlichen Wasserstoff und Wasser 35
enthält, und Mittel zum Leiten des Gasgemischs in den Ofen umfasst, und wobei Mittel zur Steuerung der Menge(n) des abgezogenen Wasserstoffs und/
oder des sauerstoffhaltigen Gases vorgesehen sind, um die Menge des erzeugten Wasserdampfs und folglich den Wasserdampfgehalt der Ofenatmosphäre innerhalb eines vorgegebenen Bereichs 40
zu halten.
8. Einrichtung nach Anspruch 7, wobei die Reaktions- 45
mittel eine katalytische Gasesoxiginierungseinheit umfassen.

Revendications

1. Procédé pour contrôler le point de rosée de l'atmosphère d'un four dans lequel, en utilisation, le four est alimenté avec une atmosphère se composant au moins en partie d'hydrogène, le procédé comprenant le prélèvement d'au moins une partie du flux d'hydrogène qui est fourni au four, la mise en réaction de l'hydrogène prélevé avec un gaz contenant de l'oxygène afin de produire un mélange ga- 50

zeux se composant d'un gaz de production exempt d'oxygène, d'hydrogène résiduel et d'eau, et l'envoi du mélange gazeux dans l'atmosphère fournie au four de manière à maintenir la teneur en vapeur d'eau de l'atmosphère du four dans une plage pré-déterminée.

2. Procédé selon la Revendication 1, comprenant le contrôle de la quantité d'hydrogène prélevée et/ou de la quantité de gaz contenant de l'oxygène mis à réagir avec celui-ci de manière à maintenir la plage prédéterminée de teneur en vapeur d'eau entre environ 10 ppm et environ 200 ppm, et de manière préférée entre environ 22 ppm et environ 128 ppm.
3. Procédé selon la Revendication 2, comprenant la régulation de la température et/ou du point de rosée de l'atmosphère du four et le contrôle correspondant de la (des) quantité(s) d'hydrogène prélevée(s) et/ou de gaz riche en oxygène fournie(s) à la réaction.
4. Procédé selon la Revendication 1, la Revendication 2 ou la Revendication 3, dans lequel le mélange gazeux est envoyé dans le flux d'hydrogène avant son introduction dans le four.
5. Procédé selon la Revendication 1, la Revendication 2 ou la Revendication 3, dans lequel le mélange gazeux est envoyé dans la(les) zone(s) chaude(s) du four.
6. Procédé selon l'une quelconque des Revendications précédentes, dans lequel le gaz contenant de l'oxygène est l'air.
7. Dispositif pour contrôler le point de rosée de l'atmosphère d'un four dans lequel, en utilisation, le four est alimenté avec une atmosphère se composant au moins en partie d'hydrogène, le dispositif comprenant des moyens de prélèvement d'au moins une partie du flux d'hydrogène qui est fourni au four, des moyens d'alimentation d'un gaz contenant de l'hydrogène, des moyens de mise en réaction de l'hydrogène prélevé avec le gaz contenant de l'oxygène afin de produire un mélange gazeux se composant d'un gaz de production exempt d'oxygène, d'hydrogène résiduel et d'eau, et des moyens pour envoyer le mélange gazeux dans le four, des moyens étant prévus pour contrôler la(les) quantité(s) d'hydrogène prélevée(s) et/ou de gaz contenant de l'oxygène afin de maintenir la quantité de vapeur d'eau produite, et donc la teneur en vapeur d'eau de l'atmosphère du four, dans une plage prédéterminée. 55
8. Dispositif selon la Revendication 7, dans lequel les moyens de mise en réaction comprennent une unité

de désoxygénation catalytique de gaz.

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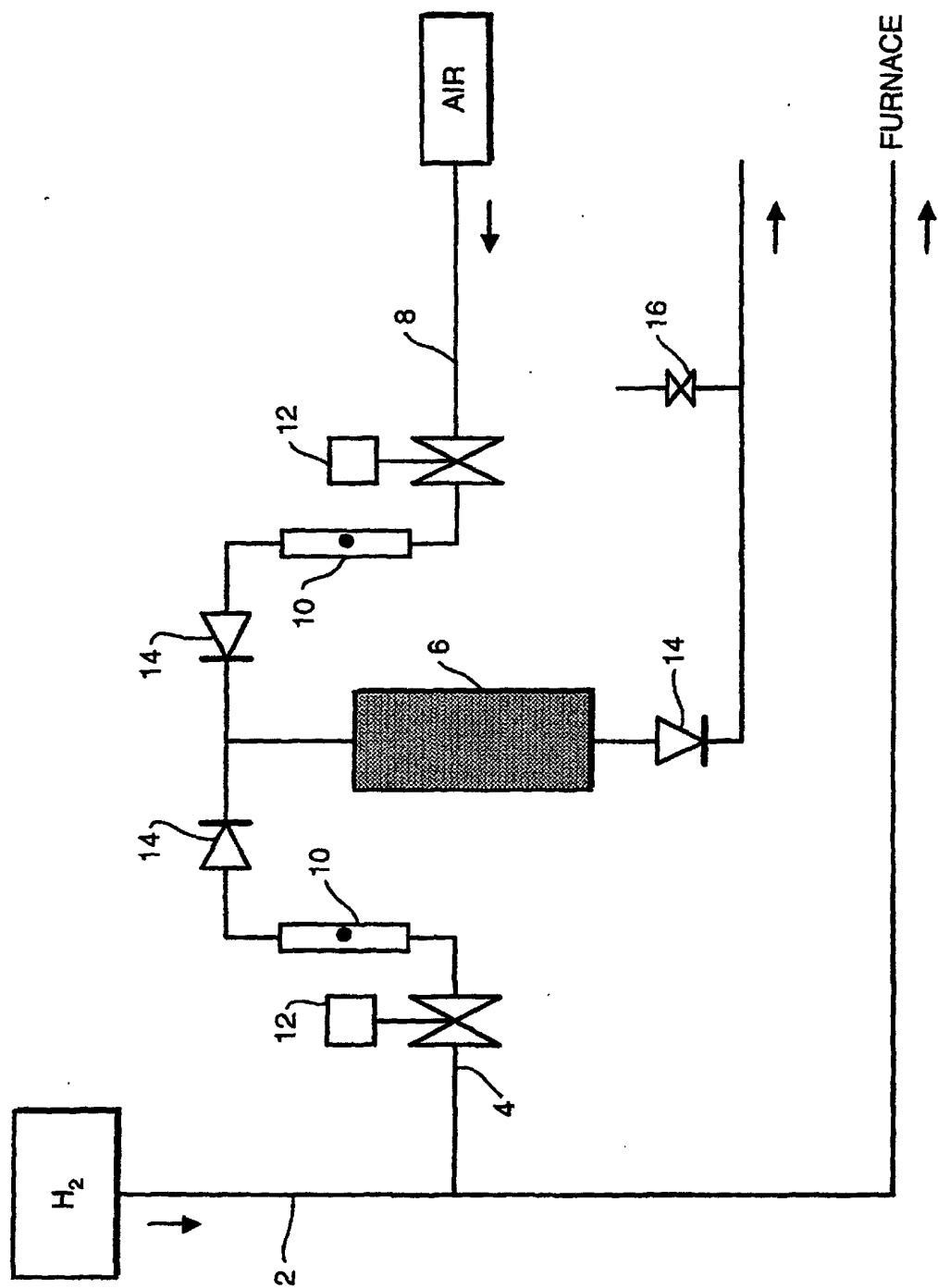


FIG.1