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(57) The invention relates to a continuous heating furnace control. In order to achieve even heating of material 3 as it passes through the furnace, taking account of irregularities in passage, in material dimensions, and in the hearth lining the furnace is controlled according to the invention by taking over the length of the furnace one or more items of furnace firing data, e.g. temperature as at 10 or fuel and air consumption, progressively converting the measurements taken into signals representative of the temperature change of the pieces of material and the temperature of each piece of heat material located on the length of the furnace as actual temperature. The actual temperature profile so produced is compared with various desired temperatures predetermined locally over the length of the furnace (a reference temperature profile) and in the zones in which a deviation is found, the furnace firing 5, 6 is adjusted to minimize variations therefrom.

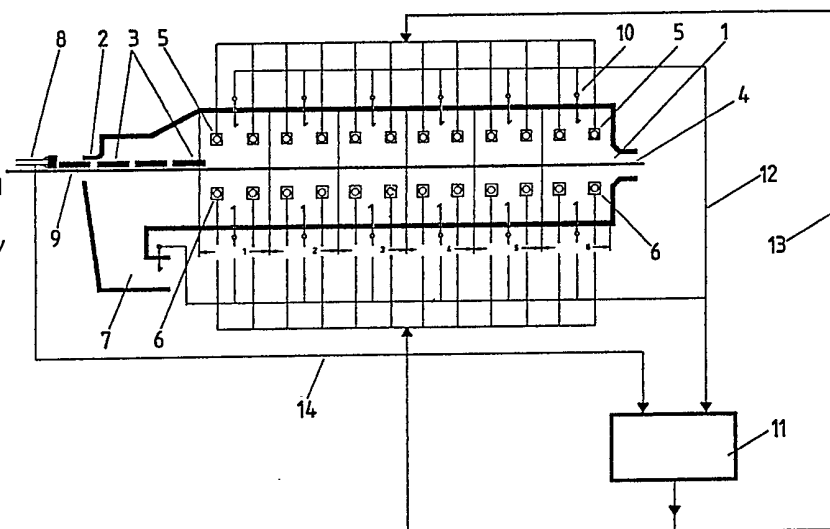


Fig. 1

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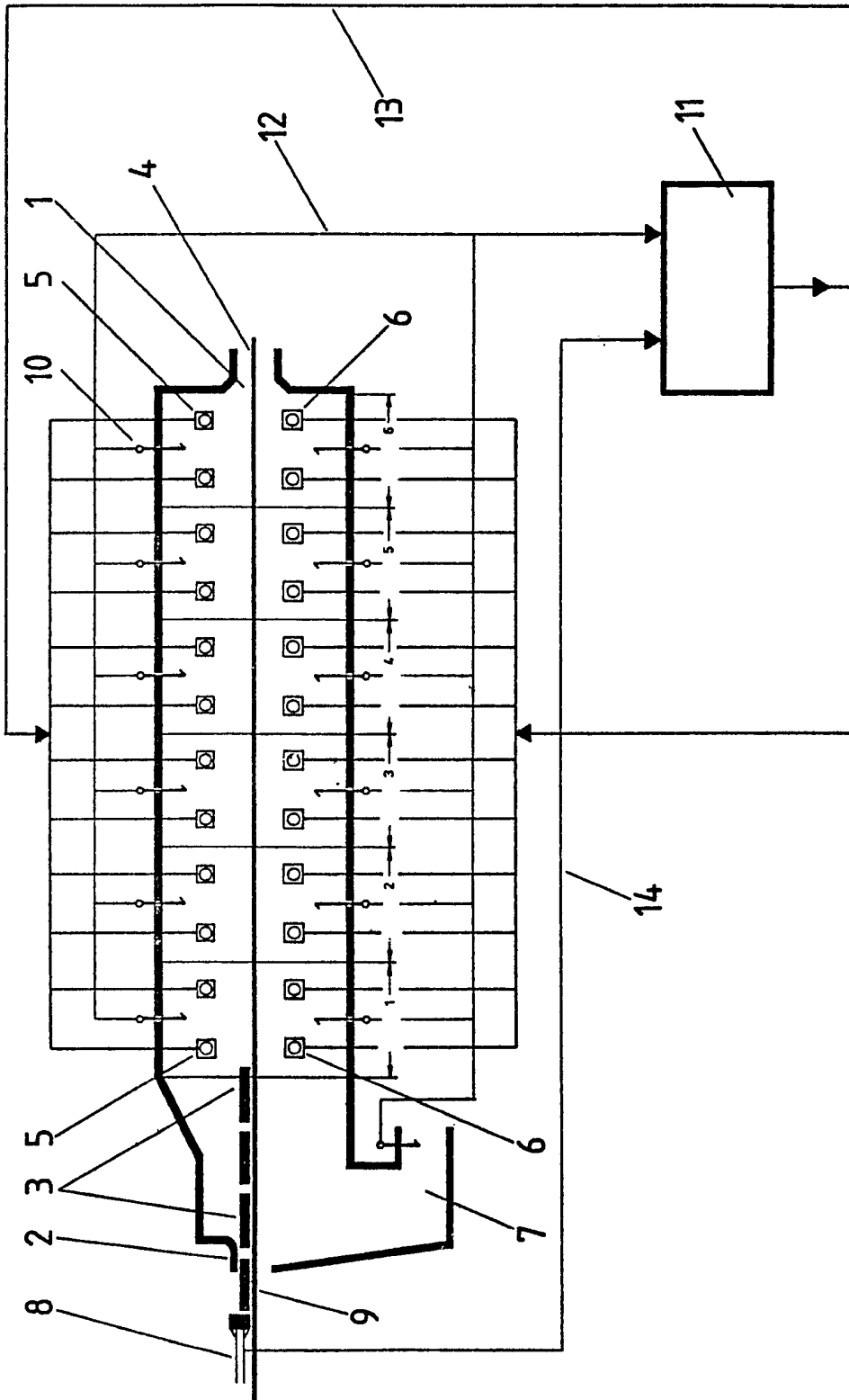


Fig. 1

SPECIFICATION

Heating furnace control

5 The invention relates to the control of heating furnaces. Particularly, it concerns continuous such control enabling material passing through the furnace to gain heat in accordance with a predetermined pattern. The invention has especial
10 application in the iron and steel industry.

Controls to date for continuous heating furnaces are designed such that material to be heated runs evenly through the furnace, the hearth of which is evenly lined. When the furnace material has different dimensions and/or gaps are to be found between the individual throughput sections of pieces of material, then the even heating of the material is disturbed. For example, temperature transitions can be detected on the heat material in the vicinity
20 of the gaps. Also, a variable quality of the heat material can cause an uneven heating. Substantial deviations of the heat material temperature also occur if for example, as a result of an interruption in operation in the manufacturing area prior to or
25 following on from the furnace, the speed of passage has to be altered, or if the speed of passage alters several times.

The invention addresses the problem of evenly heating material of material passing through a
30 heating furnace, even at variable throughputs, while also taking account of irregularities in the lining of the furnace hearth. To this end, the invention provides a method of controlling the operation of a heating furnace as material to be heated
35 passes therethrough, comprising the furnace firing over the length of the path of material through the furnace to produce values representative of the temperature of the material and changes therein along said path; comparing such values with a reference temperature profile; and regulating the firing of the furnace as necessary to minimize
40 variations of such values from the reference temperature profile. The monitoring step will normally comprise ascertaining furnace firing data and cyclically converting measurements from such data into
45 said representative values.

The furnace firing may be monitored in the method of the invention by measuring the temperature of the furnace atmosphere along the path of
50 material through the furnace. In an alternative, the quantities of fuel, typically gas, and air consumed can be measured.

Regulation of the furnace firing is preferably accomplished in zones defined along the path of material through the furnace. A typical furnace
55 suitable for control according to the invention has a plurality of burners arranged along the path. At least one, preferably at least two, burners on either side of the path may be used to define each such
60 zone.

The direct measurement of the temperature of the heat material in a furnace is not normally possible, particularly in the iron and steel industry. In a method of the invention several measured values
65 are determined cyclically several times over the

length length of the furnace, which values are able to continuously specify the temperature increase of individual pieces of material in the heating path.

70 The mathematical methods of calculation for this are known. They derive from Fourier's differential equation, which is able to be solved at least iteratively for the conditions of a particular industrial furnace with the aid of electronic data processing machines. Thus for each cycle values are ascertainable for the temperature increase, and through accumulation of the values for each piece of material from the input into the furnace data regarding its representative temperature (actual temperature) and position in the furnace (control zone) can be
80 obtained.

According to the invention, the actual temperature of the heat material determined according to the above technique is compared with a desired temperature profile, which defines in each case
85 predetermined temperatures locally over the furnace length. On the basis of the difference between desired and actual values and as a function of the extent of this difference, the furnace is regulated in zones. Of course, if the control zone is
90 longer than the individual piece of heat material, the furnace is not controlled for each piece individually, but rather only in zones.

The present invention is found to effectively achieve even heating of material passing unevenly
95 through a furnace as well as accommodating a variably dense hearth lining. The firing of the furnace can be adapted independently, according to the throughput speed, and/or according to the dimensions of the material or pieces thereof passing therethrough. The invention enables a higher degree of efficiency than previously possible to be achieved in terms of heating technique and as a consequence, a substantial saving in energy. Further, the savings in energy consumption fully justify the expenditure for the control mechanism.

100 An embodiment of the invention is now described by way of example and with reference to the accompanying drawing which shows diagrammatically, a side view of a continuous heating furnace adapted for control according to the
110 invention.

The thickly drawn line 1 represents the fireproof casing of the furnace chamber with the inlet 2 and the outlet 4 for material 3 to be heated. The furnace is equipped in each case with a row of burners 5 in the upper furnace and burners 6 in the lower furnace. Each pair of burners 5 in the upper furnace and burners 6 in the lower furnace define a regulating zone. The furnace shown has six regulating zones. The burners 5, 6 supply the furnace with combustible gas and air. The flow of exhaust gas runs contrary to the transportation of heat material to the exhaust outlet at 7.

115 The material 3 to be treated enters through the inlet 2 into the furnace. The material 3, contrary to the drawing, lies compactly in the furnace and is thus transported by means of a slab pusher 8 on the hearth 9 through the furnace to the outlet 4.

120 The furnace is equipped with a sensor 10 for the temperature measurement of the furnace atmosphere
130

phere in each regulating section. In the embodiment shown, a sensor is available for each regulating zone in both the lower and upper furnaces. The drawing also shows a calculator or computer 11, a
5 temperature recording line 12, a burner control line 13 and a line 14 for the transfer to the calculator 11 of data concerning the material 3 and the throughput speed thereof.

The computer 11 is programmed with reference
10 temperature profiles for certain materials, throughput speeds, etc. In response to signals received along lines 12, 14 it adjusts the operation of the burners 5, 6 along lines 13 to maintain the actual temperature profile of material 3 in the furnace to
15 a desired shape, and thus achieves the desired heating level for material passing through the furnace.

CLAIMS

20

1. A method of controlling the operation of a heating furnace as material to be heated passes therethrough, comprising monitoring the furnace firing over the length of the path of material
25 through the furnace to produce values representative of the temperature of the material and changes therein along said path; comparing such values with a reference temperature profile; and regulating the firing of the furnace as necessary to
30 minimize variations of such values from the reference temperature profile.

2. A method according to Claim wherein the monitoring step comprises ascertaining furnace firing data and cyclically converting measurements
35 from such data into said representative values.

3. A method according to Claim 1 or Claim 2 wherein the regulation of the furnace firing is in zones defined along the path of material through the furnace.

40 4. A method according to Claim 3 wherein the furnace comprises a plurality of burners arranged along the path of material therethrough, at least one burner on either side of the path defining a said zone.

45 5. A method according to Claim 4 wherein at least two burners on either side of the path define a said zone.

6. A method according to any preceding claim wherein the furnace firing is monitored by measuring the temperature of the furnace atmosphere
50 along the path of material through the furnace.

7. A method according to any of Claims 1 to 5 wherein the furnace firing is monitored by measuring the quantities of fuel and air consumed along
55 the path of material through the furnace.

8. A method according to any preceding claim wherein material to be heated is passing continuously through the furnace.

9. A method of controlling the operation of a heating furnace substantially as described herein with reference to the accompanying drawing.

10. Continuous heating furnace control wherein several times cyclically over the length of the furnace one or more items of data concerning the furnace firing are ascertained, measured values are

progressively converted cyclically into the temperature change of the pieces of heat material and the temperature of each piece of heat material situated on the length of the furnace is determined as the
70 actual temperature, the actual temperature is compared with various desired temperatures preset locally over the length of the furnace and in the zones in which a deviation is found, an alteration to the furnace firing takes place.

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