(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 071 262 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.06.2009 Bulletin 2009/25

(51) Int Cl.:
F27D 19/00 *(2006.01)* ***C21D 11/00*** *(2006.01)*

(21) Application number: **08171076.6**

(22) Date of filing: **09.12.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(30) Priority: **13.12.2007 SE 0702774**

(71) Applicant: **AGA AB**
S-181 81 Lidingo (SE)

(72) Inventor: **Ekman, Tomas**
132 37, Saltsjö-Boo (SE)

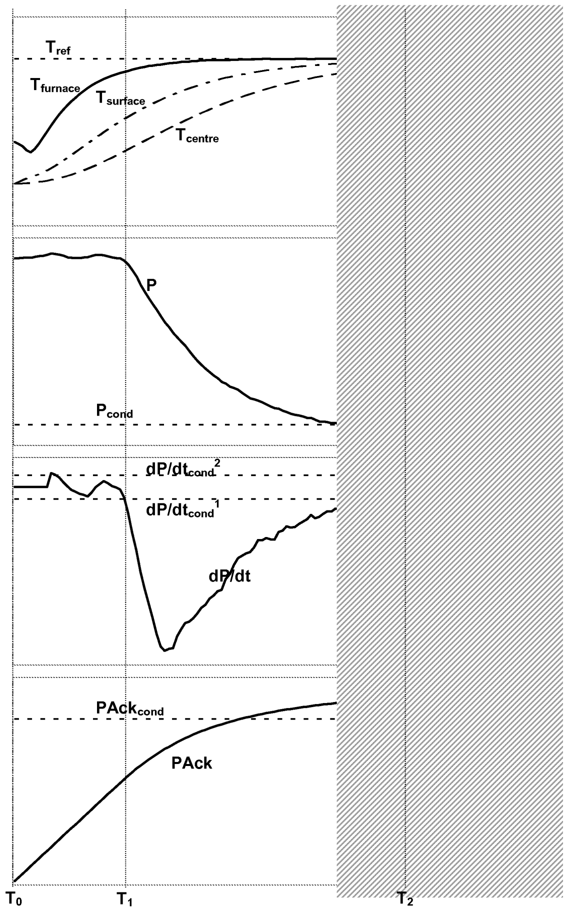
(74) Representative: **Örtenblad, Bertil Tore**
Noréns Patentbyra AB
P.O. Box 10198
100 55 Stockholm (SE)

(54) Method for heating in an industrial furnace

(57) A method for heating billets or ingots in an industrial furnace by means of at least one burner, in which furnace the heating power (P) continuously introduced into the furnace is controlled by means of a regulator whose input parameter is the temperature ($T_{furnace}$) of the furnace atmosphere, which temperature ($T_{furnace}$) is measured by means of a temperature measuring device, wherein the regulator is caused to control the heating in at least one first heating step and a subsequent second temperature equalising step.

The invention is characterised in that the instantaneous heating power (P) is measured continuously, in that the derivative of the heating power (P) with respect to time (dP/dt) is calculated continuously, and in that the heating is interrupted when a primary condition, namely that this derivative (dP/dt) falls within a predetermined interval ([$dP/dP_{cond}{}^1$, $dP/dP_{cond}{}^2$]), is met, provided that the heating at this time is in the subsequent second temperature equalising step.

Fig. 2



Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to batch heating of billets or ingots in industrial furnaces.

[0002] In such heating a final homogeneous temperature throughout the heated material is often the objective. For example, to ensure that subsequent machining is effective and to avoid damage to the material due, among other things, to shearing forces during such machining, the difference between the surface temperature of the material and the temperature at its centre must in many cases not exceed a particular predetermined value.

[0003] The required final temperature of the material can be achieved by controlling the temperature of the furnace atmosphere so that it asymptotically converges to the required final temperature. This convergence is normally controlled by means of a control regulator which controls the heating power introduced into the furnace and which uses the temperature of the furnace atmosphere as an input variable. This provides effective control of the furnace temperature for the purpose of obtaining the required final temperature in the material quickly.

[0004] However, it is difficult to know the time at which the temperature is sufficiently homogeneous throughout the heated material. The reason for this is that on the one hand the surface of the material comparatively quickly assumes approximately the same temperature as the furnace atmosphere. On the other hand, the centre temperature of the material takes a longer time to approach the temperature of the furnace atmosphere, due to heat conduction. Since no cheap and at the same time effective method of measuring the temperature in the centre of the material is known, empirically determined heating times have hitherto had to be relied upon to ensure that the temperature differences in the billet or ingot are not too large when the heating process is interrupted.

[0005] The drawback of such an approach is that a very good margin must be provided to ensure that temperature differences inside the material do not become too large, which is why the heating time often becomes unnecessarily long. The reason for this is, among other things, that the actual conducting of the process gives rise to several sources of uncertainty and that the original temperature distribution in the material is often not fully known. This results in increased energy and time consumption, with the accompanying increases in costs and environmental pollution. Moreover, suSch long heating times may result in damage to the material, e.g. due to exaggerated oxidation, which naturally increases the cost of the method and complicates it.

[0006] The present invention solves the above problems.

[0007] The present invention thus relates to a method for heating billets or ingots in an industrial furnace by means of at least one burner, in which furnace the heating power continuously introduced into the furnace is controlled by means of a regulator whose input parameter is the temperature of the furnace atmosphere, which temperature is measured by means of a temperature measuring device, wherein the regulator is caused to control the heating in at least one first heating step and a subsequent second temperature equalising step, and is characterised in that the instantaneous heating power is measured continuously, in that the derivative of the heating power with respect to time is calculated continuously, and in that the heating is interrupted when a primary condition, namely that this derivative falls within a predetermined interval, is met, provided that the heating at this time is in the subsequent second temperature equalising step.

[0008] The invention will now be described in detail with reference to an exemplary embodiment of the invention and the attached drawings, in which:

- Figure 1 shows a general view of an industrial furnace in which the method of the invention is applied; and
- Figure 2 shows a collection of four explanatory and simplified graphs which explain the method of the invention.

[0009] Figure 1 shows an industrial furnace 1 in which an ingot 2 is arranged to be heated batchwise. However, it should be realised that the method of the invention can also be used in furnaces where slabs and billets of different types are heated. The method of the invention is advantageously also used for batch heating of a plurality of ingots, billets or slabs simultaneously.

[0010] The industrial furnace 1 comprises at least one burner 3, which heats the atmosphere of the furnace 1. The burner or burners 3 may, for example, be driven by means of a gaseous or liquid fuel and air or oxygen gas as oxidant, but other operating configurations may also be used. A particularly preferred burner is a so-called oxyfuel burner whose oxidant consists of at least 80% oxygen gas.

[0011] At least one temperature measuring device 4, which measures the temperature of the furnace atmosphere and feeds it as an input parameter to a regulator 5 of the PID type (Proportional, Integral, Derivative), is also arranged in the furnace 1. This regulator 5 generates an output signal in the form of a desired heating power of the burner or burners 3. The output signal is fed to a flow regulator 6 which converts the required heating power to a certain flow of fuel and oxidant, which flow is fed from the flow regulator 6 to the burner or burners 3.

[0012] The output signal from the regulator 5 is generally less volatile than the resultant flow from the flow regulator 6, since the flow regulator 6, unlike the regulator 5, must take into consideration, among other things, the operating limitations of the burner or burners 3. The flow resulting from the flow regulator 6 thus constitutes an approximation of the ideal output signal of the regulator 5.

[0013] The burner or burners 3 heat(s) the furnace atmosphere, which in turn heats the ingot 2.

[0014] Figure 2 shows four principal and simplified, explanatory graphs in which the scale of the X-axis is identical for all four graphs and indicates the time. At the time T_0, the ingot 2 is fed into the furnace 1.

[0015] The heat treatment is divided into two steps, herein referred to as a first heating step and a second heating step, or alternatively a second temperature equalising step, respectively. During the heating step the power of the burner 3 is relatively high, the purpose of which is to heat the furnace atmosphere quickly. During the temperature equalising step, the power is continuously controlled by means of the PID regulator 5 for the purpose of achieving a sufficiently uniform temperature distribution in the ingot 2 as quickly as possible.

[0016] The top graph shows the time development for the temperature $T_{furnace}$ in the atmosphere of the furnace 1, the temperature $T_{surface}$ on the surface of the ingot 2, and the temperature T_{centre} in the centre of the ingot 2. The desired final temperature T_{ref} is also shown as a dotted horizontal line. In the present embodiment the temperature $T_{furnace}$ of the furnace atmosphere is higher than the surface temperature $T_{surface}$ of the ingot 2 when the ingot 2 is introduced into the furnace 1. Thus, the temperature $T_{furnace}$ of the furnace atmosphere initially drops as a result of the cooling effect of the ingot 2, then increases again after a certain time as a consequence of the heating power from the burner or burners 3.

[0017] The top but one graph shows the time development for the power P instantaneously discharged by the burner or burners 3, and a straight horizontal line P_{cond} that represents an interruption condition. As shown in the graph, the heating power P of the burner or burners 3 is set during the heating step to a relatively high, constant level. The purpose of this is to increase the temperature $T_{furnace}$ and the temperatures of the ingot 2 quickly before the temperature equalising step, which begins at the time T_1.

[0018] During the temperature equalising step, P is controlled by the PID regulator 5, with $T_{furnace}$ as input parameter, which in turn controls through its output signal the flow regulator 6, in turn controlling the flow of fuel and oxidant to the burner or burners 3 for the purpose of obtaining the desired final temperature T_{ref} as quickly as possible. When $T_{furnace}$ has stabilised sufficiently close to T_{ref}, it may be concluded that the surface temperature $T_{surface}$ of the ingot 2 and its centre temperature T_{centre} have also reached sufficient, and sufficiently homogeneous, temperatures.

[0019] $T_{furnace}$ is therefore measured and fed as an input parameter to the PID regulator 5, which in turn, by controlling the flow regulator 6, indirectly controls the heating power P. The purpose of this control is, in a conventional manner, to cause $T_{furnace}$ to approach the desired final temperature T_{ref} as effectively as possible.

[0020] The bottom graph shows the time development for the accumulated thermal energy PAck given by the burner or burners 3, together with a straight horizontal line $PAck_{cond}$, which represents an interruption condition.

[0021] The top graph shows that the surface temperature $T_{surface}$ of the ingot 2 and its centre temperature T_{centre} increase at different rates during the heating. Due to heat conduction, $T_{surface}$ increases more quickly than does T_{centre}. Due among other things to different furnace configurations and different dimensions of the heated material, this difference in heating is of varying preponderance. However, a common feature is that at the time T_2, when the ingot 2 is removed from the furnace 1, it is desirable for the difference between $T_{surface}$ and T_{centre} to be less than a certain predetermined value to avoid the problems described above in subsequent machining steps.

[0022] Instead of allowing the heating process to run for such a long time as to guarantee adequate temperature equalisation, the present invention solves this problem by examining the behaviour of the curve P.

[0023] Accordingly, the value P is observed continuously and its time derivative dP/dt is calculated.

[0024] The instantaneously discharged power P of the burner or burners 3 can be measured in several different ways. Firstly, P can be measured indirectly by observing the output signal of the regulator 5. In this case an ideal, desired value is obtained for P, which does not necessarily correspond to the power actually discharged instantaneously at a certain moment. On the other hand, this ideal value is a measure of the desired burner power given the current development of furnace temperature $T_{furnace}$. For reasons described in detail below, this method of measuring P in certain embodiments is therefore preferred according to the present invention. Secondly, the power P can be measured by measuring the flow from the flow regulator 6, either by means of a flow meter or by reading off the flow directly from the flow regulator 6. This alternative measuring method gives a measured value which more closely corresponds to the power actually discharged instantaneously from burner or burners 3, but on the other hand contains more noise relative to the desired power calculated by the regulator 5.

[0025] The next but bottom graph shows the time development for dP/dt, as well as two straight horizontal lines dP/dP_{cond}^1, dP/dP_{cond}^2, which together represent an interruption condition. As will be realised from the combination of the next but top and next but bottom graphs, dP/dt is initially approximately zero in the present exemplary embodiment, then passes from the first heating step and into the PID control phase, i.e. the second heating step, via a not necessarily continuous transition at the time T_1. During this phase the derivative dP/dt will vary according to the PID control of P.

[0026] Surprisingly, it has been found that empirically based conditions for dP/dt can be formulated, thus making it possible to estimate, very accurately, the time T_2 at which the heating process can be interrupted and the ingot 2 can be removed from the furnace 1 for subsequent machining steps without heating ingot 2 for an unnecessarily long time, whilst at the same time achieving sufficient temperature homogeneity in the ingot 2.

[0027] Correspondingly, time T_2 is selected according to the present invention as the time at which a primary condition is met, in other words the time at which dP/dt falls within a certain predetermined interval $[dP/dP_{cond}^1, dP/dP_{cond}^2]$, determined on the basis of experience and dependent on a number of factors such as the dimensions and shape of the heated material, the furnace type, the number of burners, the characteristics of the regulator 5 and the flow regulator 6, desired maximum temperature difference between $T_{surface}$ and T_{centre} and so on. The interval $[dP/dP_{cond}^1, dP/dP_{cond}^2]$ is preferably symmetrical around dP/dt = 0.

[0028] To prevent the heating process from being interrupted too early, it must also be ensured that the method has reached the temperature equalising second heating step. According to an exemplary embodiment this can be done by ensuring that two secondary conditions are met simultaneously.

[0029] A first secondary condition is that the absolute value of P must be below a certain first predetermined value P_{cond}. It is preferable for this first predetermined value P_{cond} to be selected so that it is below the value of P during the initial phase or an early phase, between T_0 and T_1, to prevent the heating process from being interrupted already during the first heating step.

[0030] A second secondary condition is that the total thermal energy supplied, PAck, must exceed a certain second predetermined value $PAck_{cond}$. This second predetermined value $PAck_{cond}$ is selected to prevent premature interruption of the heating process, preferably so that it exceeds the minimum quantity of energy which is theoretically required to heat the ingot 2 to the desired final temperature distribution with the desired minimum temperature homogeneity and with a heating efficiency suitable for the system.

[0031] It is realised that the purpose of the second secondary condition is to prevent premature interruption of the heating process and that this purpose is achieved by not allowing such interruption to take place before a minimum quantity of thermal energy has been supplied. Approximate and/or indirect measures of PAck can thus be used to determine whether the second secondary condition has been met or not. For example, the time from the beginning of the heating process may be measured, and given that P, as a function of time, is approximately known, this time can be used as an approximate and indirect measure of PAck. Similarly, many other metrics can be used to determine, approximately and/or indirectly, whether the second secondary condition has been met, for example the position of fuel valves, measured fuel pressures, etc.

[0032] The total thermal energy supplied, PAck, is preferably measured indirectly by measuring the total quantity of fuel introduced into the furnace 1 since heating began.

[0033] When both secondary conditions are met, it is certain that the heating method is in the temperature equalising phase between T_1 and T_2, i.e. in the second temperature equalising step. During this phase, the furnace 1 is in a form of dynamic thermal equilibrium. The temperature of the furnace wall has thus been largely stabilised, as has the degree of thermal losses through the wall. In principle, the flue gases maintain a constant temperature and flow. In practice it is mainly the ingot 2 that changes temperature during this temperature equalising phase. In other words, the dependence between P and T_{centre} is relatively direct, which is why the PID control of P has a relatively clear, and delayed, effect on the variation of T_{centre}. Conversely, because the PID control is a predictable process under uniform conditions, the variation in P induced by the PID control will depend on the variation over time in T_{centre}, and also on the instantaneous value of T_{centre}. Because of these relations, it has been found that it is possible to use the value of dP/dt to predict when the value of T_{centre} will exceed a certain value.

[0034] This can be realised by considering a somewhat simplified expression of the total power supplied P_{tot} expressed as a function of the surface area A of a heated ingot, the thermal conductivity of the heated material λ, the distance ΔD between the surface of the material and its centre, and the temperature difference ΔT between the surface and the centre, and at the above described dynamic equilibrium, i.e. when the surface temperature of the heated material has reached the final temperature in the furnace:

$$P_{tot} = P_{material} + P_{losses} = \frac{A\lambda\Delta T}{\Delta D} + P_{losses},$$

in which $P_{material}$ and P_{losses}, respectively, are those proportions of the total power supplied that are transferred to the material in the form of thermal energy and that disappear from the system in form of losses, respectively.

[0035] In the case of dynamic equilibrium, P_{losses} is built up from two components. Firstly, losses occur in the form of thermal energy in the outgoing flue gases. These are approximately linear as a function of P_{tot}. Secondly, other losses occur which are approximately constant over time where there is dynamic equilibrium, since the temperature conditions are approximately constant over time in the furnace, besides inside the heated material itself, as described above.

[0036] Furthermore, A, λ and ΔD are approximately constant throughout the heating process, which is why $P_{material}$

is essentially a function of ΔT. In fact, it has been found that in the case of the dynamic equilibrium described above, the derivative of $P_{material}$ with respect to time is approximately a linear function of ΔT, referred to below as $F(\Delta T)$.

[0037] In other words, the following applies under dynamic equilibrium:

$$\frac{dP_{tot}}{dt} = \frac{dP_{material}}{dt} + \frac{dP_{losses}}{dt} \approx F(\Delta T) + k_1 \frac{dP_{tot}}{dt} \Rightarrow \frac{dP_{tot}}{dt} \approx k_2 \Delta T \Rightarrow T_{centre} \approx T_{surface} - \frac{1}{k_2}\frac{dP_{tot}}{dt},$$

in which k_1 and k_2 are constants and since $F(\Delta T)$ is an approximately linear function. Since $T_{surface}$ is known and constant when the dynamic equilibrium described above prevails, the time derivative of P_{tot} can thus be used to approximately calculate the temperature T_{centre} in the centre of the heated material.

[0038] Finally, since the specific operating conditions may vary somewhat, it has been found that it is easier to use empirically based interruption conditions than mathematically calculated conditions. The above derivation is therefore intended mainly to explain the principle behind the present invention.

[0039] In Figure 2, the dotted surface illustrates the area in which both secondary conditions are met. At the time T_2 the primary condition is also met, and the heating may thus be interrupted.

[0040] Because of the operating conditions, that actually vary, and the generally varying conditions that prevail during heating of material in industrial furnaces, the PID control of P will have a relatively high variance. As described above, this variance will be somewhat higher if P is measured at the flow regulator 6 rather than at the regulator 5.

[0041] In other words, P will generally vary as a relatively smooth function as the negative derivative increases during the period between T_1 and T_2, but with a noise component of varying intensity. Whenever applicable, this noise component can be filtered off by averaging P over a number of measuring points that depends on the current application, preferably at least 10 measuring points. It is also possible, and preferable, to have the number of points used in the formation of the mean value vary as a function of how high the variance of P currently is. Thus, more points are used in the formation of the mean value at high instantaneous variance, and reversely fewer points at low instantaneous variance. For example, the variance may be lower during the beginning of the temperature equalising second heating step and higher during its final stage. For the sake of clarity, and to give an example, a mean value has been formed over 10 historical measuring points for P in the next but bottom graph of dP/dt.

[0042] Moreover, there may be greater justification, for example, in forming a mean value over more points if P is measured at the flow regulator 6. The flow of fuel and oxidant controlled by the flow regulator 6 contains a further noise component relative to the output signal generated by the regulator 5, as described above. One reason for this is that the flow regulator 6 controls the burner or burners 3, in certain applications, to heat the furnace 1 by an on/off procedure. This may, for example, depend on the fact that the burner or burners 3 has (have) a minimum power which exceeds the heating power prescribed by the PID regulator 5, which heating power is to be discharged to the furnace atmosphere at a certain given occasion. In this case, for example, the flow regulator 6 controls the burner or burners 3 to be switched on for a certain period of time after which it (they) are switched off and then repeat(s) this process so that the mean power emitted will be that prescribed by the PID regulator 5 during each given period of time. This method is called pulse width modulation.

[0043] It is also possible for the flow regulator 6 to use constant times for the switched-on/switched-off position, respectively, and instead to vary the power of the burner or burners 3 during the switched-on position, thereby achieving the same correct average heating power. This is called pulse height modulation.

[0044] Other modulation techniques are also possible, for example a combination of pulse width modulation and pulse height modulation, to achieve an average instantaneous heating power which corresponds to that prescribed by the PID regulator 5 during a certain given period of time.

[0045] When such a modulation is used, combined with measurement of P at the flow regulator 6, it is also possible, advantageously, to average the curve P over a number of measuring points in order to arrive at a corresponding continuous function from which dP/dt can be determined. In the same manner as above, at least 10 measuring points are preferably used for the mean value formation, but it is also preferable to vary the number of measuring points as a function of the variance of P. For example, the modulation will very likely be greater or more prevalent during the final stage of the heating process, when T_{centre} approaches its desired final temperature.

[0046] In the present exemplary embodiment, the regulator 5 is of the PID type, but it should be realised that also other types of regulators can be used when applying the method of the present invention. In such cases the criteria of the present invention for interrupting the heating may need to be modified to suit the prevailing conditions. For example, it may also be necessary to examine the second derivative with respect to time of the heating power curve in the case where a regulator used can bring about a build-up of the furnace temperature, where the derivative of the heating power is zero once or several times before the furnace temperature eventually approaches its final value.

[0047] The present invention thus provides a method that enables a heating process to be interrupted with greater certainty in an industrial furnace when there is sufficient temperature uniformity in the material, without the need to continue the heating process for an unnecessarily long period, with the associated drawbacks in terms of long heating times, high energy costs and material damage. Moreover, the investment cost for applying the present invention to existing industrial furnaces is low, because sensors or corresponding devices required to measure or observe emitted power and furnace temperature are often already installed. In these cases it is therefore sufficient to implement the actual interruption condition, which can be achieved at relatively low cost.

[0048] Exemplary embodiments have been described above. However, the invention may be varied without departing from the concept of the invention. The present invention must not therefore be considered to be limited by these exemplary embodiments but can be varied within the scope of the attached claims.

Claims

1. A method for heating billets or ingots (2) in an industrial furnace (1) by means of at least one burner (3), in which furnace (1) the heating power (P) continuously introduced into the furnace (1) is controlled by means of a regulator (5) whose input parameter is the temperature ($T_{furnace}$) of the furnace atmosphere, which temperature ($T_{furnace}$) is measured by means of a temperature measuring device (4), wherein the regulator (5) is caused to control the heating in at least one first heating step and a subsequent second temperature equalising step, **characterised in that** the instantaneous heating power (P) is measured continuously, **in that** the derivative of the heating power (P) with respect to time (dP/dt) is calculated continuously, and **in that** the heating is interrupted when a primary condition, namely that this derivative (dP/dt) falls within a predetermined interval ($[dP/dP_{cond}^1, dP/dP_{cond}^2]$), is met, provided that the heating at this time is in the subsequent second temperature equalising step.

2. A method according to Claim 1, **characterised in that** the heating is considered to be in the subsequent second temperature equalising step if both a first secondary condition, namely that the absolute instantaneous heating power (P) is below a first predetermined value (P_{cond}), and a second secondary condition, namely that the total thermal energy (PAck) introduced into the furnace (1) since the beginning of the heating exceeds a second predetermined value ($PAck_{cond}$), are met at the same time as the said primary condition.

3. A method according to Claim 1 or 2, **characterised in that** the instantaneous heating power (P) at any time is determined indirectly by continuously measuring the quantity of fuel per unit time introduced into the industrial furnace (1).

4. A method according to Claim 1 or 2, **characterised in that** the instantaneous heating power (P) at any time is determined as an ideal and desired heating power calculated by the regulator (5).

5. A method according to Claim 1 or 2, **characterised in that** the regulator (5) is caused to control a flow regulator (6), which in turn is caused to control the heating power supplied to the industrial furnace (1), and **in that** the instantaneous heating power (P) is determined at any time as the heating power modulated by the flow regulator (6).

6. A method according to Claims 2, 3, 4 or 5, **characterised in that** the first predetermined value (P_{cond}) consists of the heating power emitted into the furnace (1) during an early stage, or a lower value.

7. A method according to any one of Claims 2 - 6, **characterised in that** the second predetermined value ($PAck_{cond}$) consists of the theoretical energy which is at least required to heat the material (2) to the required final temperature distribution or higher with a heating efficiency suitable for the system.

8. A method according to any one of the preceding claims, **characterised in that** the variance over time of the heating power (P) is caused to be reduced by means of a first mean value formation over several consecutive measuring points, before calculation of the derivative of the heating power with respect to time (dP/dt).

9. A method according to any one of the preceding claims, **characterised in that** when pulse width modulation, pulse height modulation or combinations of these are used to control the heating power (P) introduced continuously into the furnace (1), a corresponding continuous heating power function is calculated by means of a second mean value formation over several consecutive measuring points of the heating power (P), and **in that** the corresponding continuous heating power function is used to calculate the derivative (dP/dt).

10. A method according to Claim 8 or 9, **characterised in that** the first and/or second mean value formation over several consecutive measuring points make(s) use of at least 10 consecutive points.

11. A method according to Claim 8 or 9, **characterised in that** the first and/or second mean value formation over several consecutive measuring points make(s) use of a number of consecutive points where the number of points varies depending on the instantaneous variance of the heating power over time.

12. A method according to any one of the preceding claims, **characterised in that** the interval ($[dP/dP_{cond}{}^1, dP/dP_{cond}{}^2]$) is symmetrical around 0.

13. A method according to any one of the preceding claims, **characterised in that** the burner (3) is an oxyfuel burner.

Fig. 1

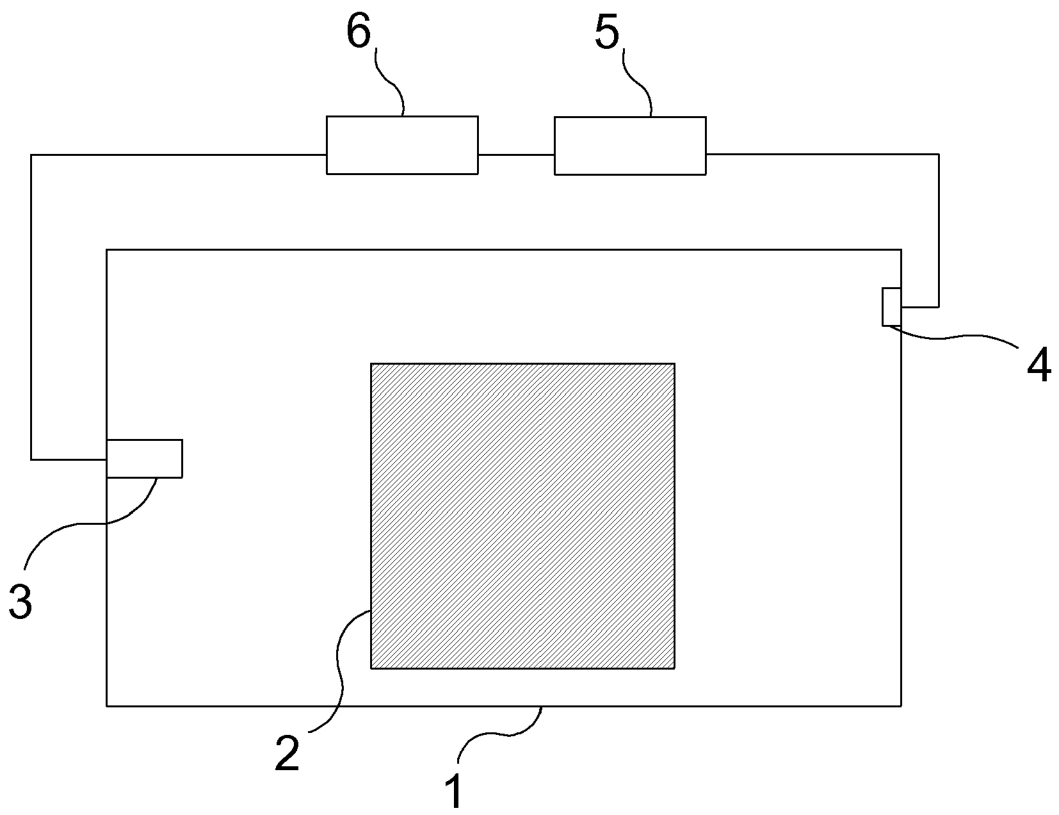
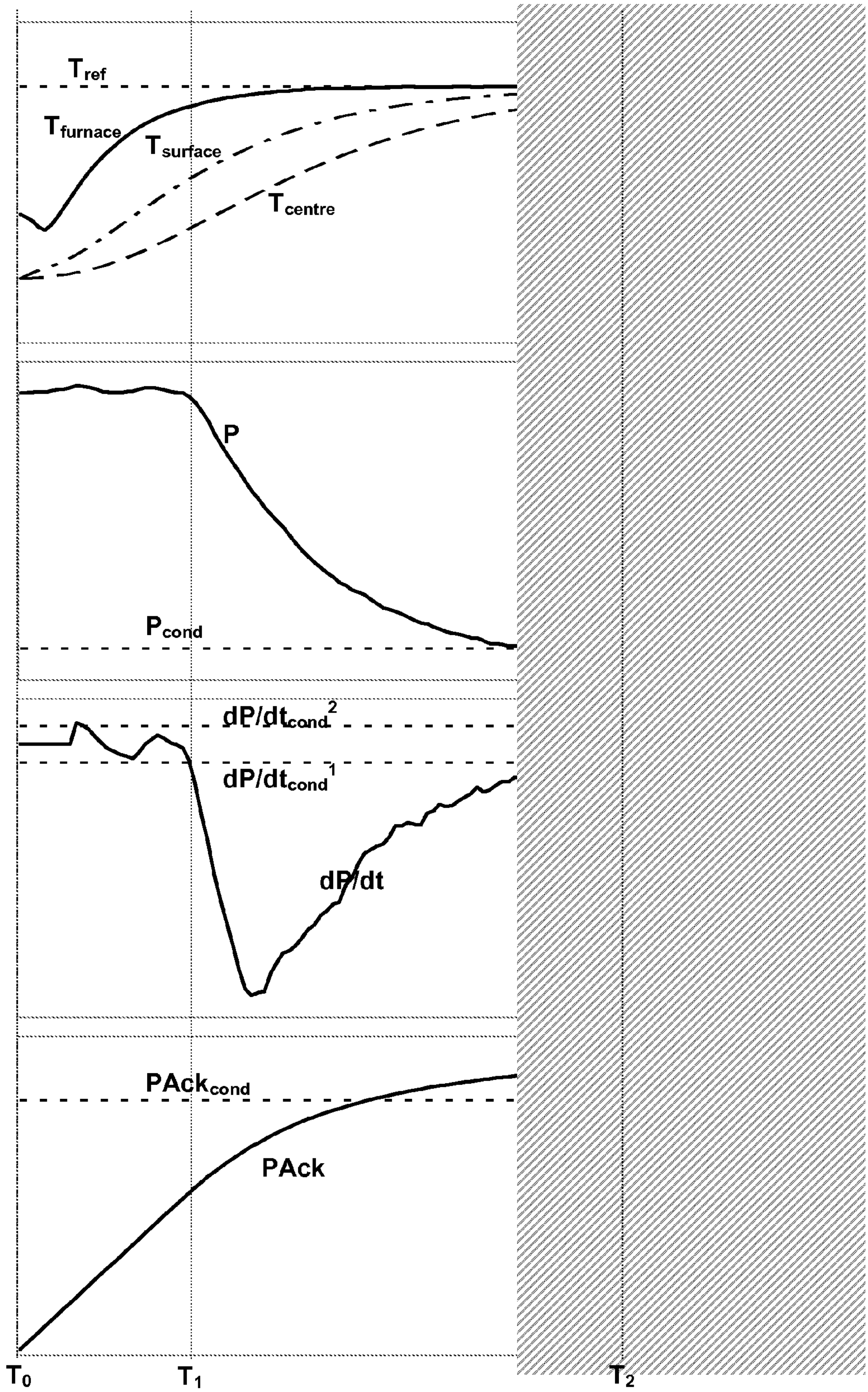


Fig. 2


T_ref
T_furnace
T_surface
T_centre
P
P_cond
dP/dt_cond 2
dP/dt_cond 1
dP/dt
PAck_cond
PAck
T0
T1
T2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 17 1076

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2 788 175 A (RUDOLF BOUREK ET AL) 9 April 1957 (1957-04-09) * the whole document * * figure 2 *	1-13	INV. F27D19/00 C21D11/00
A	DE 28 08 771 A1 (HOESCH WERKE AG) 6 September 1979 (1979-09-06) * figures 1,2 *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)
F27D
C21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 March 2009	Peis, Stefano

2

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 17 1076

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-03-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2788175 A	09-04-1957	NONE	
DE 2808771 A1	06-09-1979	BE 874480 A1	27-08-1979
		BR 7901100 A	20-11-1979
		CA 1118074 A1	09-02-1982
		FR 2418816 A1	28-09-1979
		GB 2015710 A	12-09-1979
		IT 1113473 B	20-01-1986
		JP 1238998 C	13-11-1984
		JP 54123508 A	25-09-1979
		JP 59013575 B	30-03-1984
		SE 7813098 A	02-09-1979
		US 4225306 A	30-09-1980

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82