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(71) Applicant: **Chugai Ro Co., Ltd.**
Osaka-shi,
Osaka 5410046 (JP)

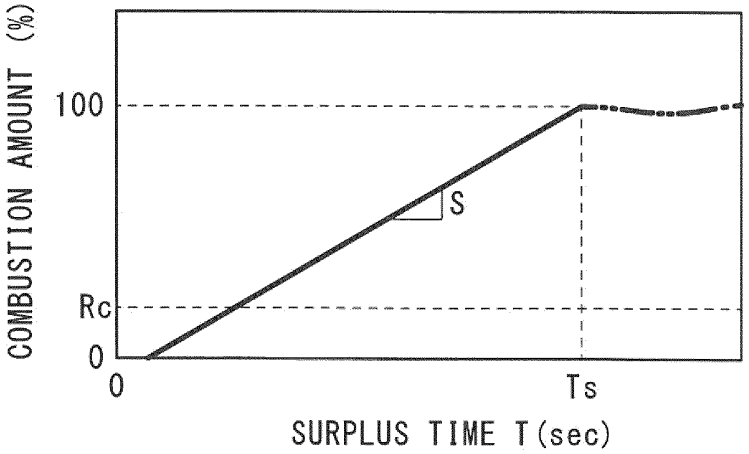
(72) Inventors:
- **NAKAGAWA, Hiroo**
. (JP)
- **HADA, Toshikazu**
. (JP)
- **HIDA, Mitsuhiro**
. (JP)

(74) Representative: **Glawe, Delfs, Moll**
Partnerschaft mbB von
Patent- und Rechtsanwälten
Postfach 26 01 62
80058 München (DE)

(54) CONTINUOUS HEATING DEVICE

(57) A continuous heating apparatus which can maintain an appropriate hating of strip material the as much as possible even if a remaining amount of looper is reduced, and which can reliably decrease the furnace temperature to a temperature equal to or less than the safety temperature controls the combustion amounts in the combustion segments respectively so that internal temperatures of the combustion segments are maintained at respectively predetermined preset temperatures if the surplus time is longer than a predetermined preset time, and varies the combustion amounts in the combustion segments respectively in a predetermined profile with respect to the surplus time if the surplus time is shorter than a predetermined preset time.

Fig. 3



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Description

FIELD OF THE INVENTION

[0001] Present invention relates to continuous heating apparatus.

BACKGROUND ART

[0002] In a heating furnace for continuously heating a strip material, a finally achieving temperature of the strip material varies depending on not only a furnace temperature but also a conveying speed for the strip material. In a continuous heating apparatus in which such heating furnace and another device, for instance a welding device for connecting strip materials having certain length to feed continuously into the heating furnace, is connected in series, as described in patent literatures 1-4, a looper which is a buffer device for absorbing a difference between conveying speeds of the heating furnace and the other device is often provided.

[0003] However, if the other device connected in series with the heating furnace has been stopped for a certain time period due to a trouble and the like, the looper can not absorb the difference of the conveying speed. And therefore, the operation of the heating furnace should be stopped. When a strip material made of martensite stainless steel is stopping in the heating furnace at a normal operating temperature, the strip material is heated to a temperature higher than the final achieving temperature so as to embrittle, and therefore a problem that the strip material fractures when restarting is caused.

[0004] For this reason, a conventional continuous heating apparatus shut down the combustion in the heating furnace, when a buffer amount of looper is small, so as to decease the furnace temperature to a safety temperature at which the strip material does not embrittle. In the time period from stopping of the combustion until the furnace temperature has decreased to the safety temperature, the conveying of the strip material can not be stopped. Therefore, the strip material passed through the heating furnace in this time period is unmarketable. Further, if the combustion is completely shut down, a restart of combustion takes long time, and therefore a problem that a down time is get longer arises.

PATENT LITERATURE

[0005]

Patent Literature 1: e JP H06-79329 A
Patent Literature 2: JP 2007-203363 A
Patent Literature 3: JP 2007-291472 A
Patent Literature 4: JP 2011-84753 A

SUMMERY OF THE INVENTION

TECHNICAL PROBLEM

[0006] In view of the above mentioned problems, an object of the present invention is to provide a continuous heating apparatus which can maintain an appropriate hating of strip material the as much as possible even if a remaining amount of looper is reduced, and which can reliably decrease the furnace temperature to a temperature equal to or less than the safety temperature.

SOLUTION TO THE PROBLEM

[0007] In order to achieve the above object, a continuous heating apparatus according to the present invention comprises a heating furnace having combustion segments in which combustion amounts can be individually controlled and which are arranged in series, for continuously heating a strip material in a manner that a conveying speed for the strip material is controlled so as to maintain a final achieving temperature of the strip material at a predetermined target temperature, and a looper which is arranged in series with the heating furnace, through which the strip material passes and which can adjust an length of the strip material accumulated inside, and characterized in that the continuous heating apparatus comprises a controller for controlling the combustion amounts in the combustion segments respectively according to a surplus time as a remaining adjustment capacity of the looper in the length of the strip material divided by the conveying speed for the strip material in the heating furnace, wherein the controller controls the combustion amounts in the combustion segments respectively so that internal temperatures of the combustion segments are maintained at respectively predetermined preset temperatures if the surplus time is longer than a predetermined preset time, and varies the combustion amounts in the combustion segments respectively in a predetermined profile with respect to the surplus time if the surplus time is shorter than a predetermined preset time.

[0008] According to this construction, when the surplus time is reduced, the speed of the strip material is reduced by an amount corresponding to a decrement of the furnace temperature due to the reduction of combustion amount. In this way, as the buffering capacity of the looper is reduced, the combustion amount is reduced so that the furnace temperature gets closer to the safety temperature at which the strip material does not fracture when stopping, as well as prevent complete shutdown of the heating furnace as much as possible so as to allow the production to be maintained.

[0009] Further, in the continuous heating apparatus according to the present invention, the combustion amount may be varied at a larger decreasing rate as higher the preset temperature is, in the profile.

[0010] According to this construction, because the combustion amount does not significantly decrease, the

total heat amount of the heating furnace can be inhibited from reducing.

[0011] Further, in the continuous heating apparatus according to the present invention, the preset time may be same for the all combustion segments.

[0012] According to this construction, a switching between the control of the combustion amount so that the furnace temperature is reached the preset temperature and the control to vary the combustion amount in the profile with respect to the surplus time is to be performed at a same time for all of the combustion segments, and therefore the switching of the control is readily made.

[0013] Further, in the continuous heating apparatus according to the present invention, the preset time may be longer as higher the preset temperature is.

[0014] According to this construction, the combustion segment with a high preset temperature starts to reduce the combustion amount earlier. Therefore, a balance between the reduction of the combustion amount due to reduction of surplus time and a function of increasing of the surplus time by decreasing of the furnace temperature can be optimized, and hence the furnace temperature can be surely decreased when stopping of the line.

[0015] Further, in the continuous heating apparatus according to the present invention, the combustion amount in the combustion segment may get closer to a certain combustion amount corresponding to a predetermined safety temperature as shorter the surplus time is, in the profile.

[0016] According to this construction, in a case where the preset temperature is lower than the safety temperature, the furnace temperature is increased according to the reduction of the surplus time. Therefore, reduction of the production volume (the conveying speed for the strip material) due to the reduction of the total heat amount of the heating furnace can be minimized.

[0017] Further, in the continuous heating apparatus according to the present invention, in a case where the surplus time is shorter than the preset time, the controller may determine the combustion amount in the combustion segments respectively with reference to the combustion amount in the combustion segment at a time that the surplus time has reached the preset time.

[0018] According to this construction, in a case where the surplus time is sufficiently long, a common furnace temperature control such as PID control is performed, and in a case where the surplus time is short, it can be switched to the control of the combustion amount without causing delay due to a heat capacity of a furnace body.

[0019] Further, in the continuous heating apparatus according to the present invention, in a case where the combustion amount in the combustion segment according to the surplus time is less than a predetermined lower limit, the controller may set the combustion amount in the combustion segment at the lower limit if an equipment connected via the looper is not completely stopped, the controller may shut down the combustion in the combustion segment if an equipment connected via the looper is completely stopped.

[0020] According to this construction, if the equipment connected via the looper is in operation, the combustions of the respective combustion segments are maintained so that the heating furnace can be readily restarted when the surplus time is increased without need for time and effort to reignite the combustion device.

ADVANCED EFFECT OF THE INVENTION

[0021] As described above, according to the present invention, the combustion amount in the heating furnace is varied in response to the surplus time that is a remaining capacity for the adjustment of the strip material by the looper divided by the conveying speed for the strip material. Therefore, the operation of the heating furnace is not stopped as much as possible, and the furnace temperature can be sufficiently decreased when the heating furnace is shut down.

BRIEF DISCRIPTION OF DRAWING

[0022]

Fig. 1 is a schematic configuration diagram of a continuous heating apparatus according to the present invention;

Fig. 2 is an illustration of preset temperatures for respective combustion segments of a heating furnace in Fig. 1;

Fig. 3 is a chart showing a relationship between a combustion amount and a surplus time of a looper;

Fig. 4 is a chart showing a relationship between a slope in Fig 3 and the preset temperature;

Fig. 5 is a chart showing a relationship between the preset time in Fig 3 and the preset temperature.

DESCRIPTION OF EMBODIMENT

[0023] Hereinafter, an embodiment of the present invention will be described with referring to the drawings.

[0024] Fig. 1 shows a configuration of a continuous heating apparatus as one embodiment of the present invention. This continuous heating apparatus comprises a welding device 1, a looper 2 and a heating furnace 3 arranged in this order, and is passed continuously by a strip material 4 through.

[0025] In the continuous heating apparatus as this embodiment, the strip material 4 is supplied in a form of a reel 5. The welding device 1 is to weld a posterior edge of a strip material 4 of a precedent reel 5 with a leading edge of a strip material 4 of a following reel 5.

[0026] The looper 2 is arranged downstream of the welding device 1. And, the looper 2 can adjust a length of the strip material 4 accumulated inside, by a movable roller 6 which is movable in a direction of an arrow in Fig. 1. Thereby, a conveying speed for the upstream strip material 4 (in the welding device 1) can be differed from

a conveying speed for the downstream strip material 4 (in the heating furnace 3).

[0027] The heating furnace 3 is arranged downstream of the looper 2 and divided into a plurality of combustion segments H1-H8, and has a controller 7 for controlling operation of the heating furnace 3. The combustion segments H1-H8 have respectively furnace temperature sensors 9 for detecting temperatures inside the furnace. The controller 7 controls combustion amounts of respective burners 8, for instance by publicly known PID control, so as to maintain the furnace temperatures of the combustion segments at preset temperatures set individually. It is noted that Fig. 2 shows also a safety temperature at which if the strip material 4 is stopped to be left inside the furnace for a long time, the strip material 4 does not embrittle, so as not to fracture under a tension force at restating.

[0028] Referring to Fig. 1 again, the heating furnace 3 further has a product temperature sensor 10 for detecting a final achieving temperature of the strip material 4 in the most downstream position, and a conveying roller 11 defining the conveying speed for the strip material 4. The controller 7 controls the speed of the conveying roller 11, for instance by the publicly known PID control, so as to maintain the final achieving temperature detected by the product temperature sensor 10 at a predetermined target temperature.

[0029] Further, the continuous heating apparatus as this embodiment has a position detector 12 for detecting a position of the movable roller 6 of the looper 2 so that the continuous heating apparatus can calculates a remaining amount of adjustable length of the strip material by the looper 2, that is the length of the strip material 4 which can be feed continuously into the heating furnace 3 in the case that the welding device 1 stops at the time. Further, the controller 7 calculates a surplus time T that is as the remaining amount of the length of the strip material 4 adjustable by the looper 2 divided by the conveying speed for the strip material in the heating furnace 3, the conveying speed being proportional to a revolving speed of the conveying roller 11.

[0030] The controller 7 compares the calculated surplus time T with preset times Ts predetermined respectively for the combustion segments. If the surplus time T is longer than the preset time Ts (e.g. 30 sec), the controller 7 performs a normal operation in which the furnace temperature of each combustion segment is maintained at preset temperatures set individually. However, if the surplus time T is shorter than the preset time Ts, the controller 7 adjusts the combustion amount in the subject combustion segment, according to the profile sown in Fig. 3, with respect to the surplus time T. The profile of the combustion amount is determined as in a percentage wherein the combustion amount of the burner 8 at the time the controller 7 has recognized the surplus time T as being equal to or less than the preset time Ts is 100% (combustion amount ratio). Thereby, the combustion amount is prevented from changing rapidly when switching to the control to determine the combustion amount in response to the surplus time T from the normal control to maintain the furnace temperature at the preset temperature, even if the relationship between the furnace temperature and the combustion amount is changed depending on outside temperature and/or humidity, of cause, the profile of an absolute value of the combustion amount may be provided.

[0031] In this embodiment, in a case where the surplus time T is equal or less than the preset time Ts, if the surplus time T is further decreased with reducing the remaining capacity in the length of the strip material 4 adjustable in the looper 2, the combustion amounts in the respective combustion segments are reduced according to the profile shown in Fig. 3. When the combustion amount is reduced, the furnace temperature is decreased and therefore the final achieving temperature tends to get lower. The controller 7 decrease the revolving speed of the conveying roller 11 so as not to decrease the final achieving temperature of the strip material 4. This control reduces conveying speed for the strip material 4 in the heating furnace 3, and therefore functions to suppress decreasing of the surplus time T.

[0032] In a case where the conveying speed for the strip material 4 in the heating furnace 3 is slower than the conveying speed for the strip material 4 in the welding device 1, the remaining capacity in the length of the strip material 4 adjustable in the looper 2 is increased so as to increase the surplus time T. If the surplus time T is increased to increase the combustion amount so that the furnace temperature is increased, the conveying speed for the strip material in the heating furnace 3 gets higher.

[0033] A variation in the furnace temperature is caused in a delayed fashion with reference to a variation in the combustion amount because of the heat capacity of the furnace body and so on. Therefore, in the preset invention, by adjusting the combustion amount in response to the surplus time T without waiting a change in the furnace temperature, the furnace temperature can be decreased to a temperature equal to or lower than the safety temperature before the remaining capacity in the length of the strip material 4 adjustable in the looper 2 falls down. To this end, the preset time T and the profile of the combustion amount should be determined so that the furnace temperature can be lowered to below the safe temperate in the combustion segment with the highest preset temperature.

[0034] In this embodiment, the combustion amount is proportional to the surplus time T, and its slope S is determined in response to the difference between the preset temperature and the safety temperature for each combustion segment as shown in Fig. 4. Specifically, the slope S of the combustion amount profile gets larger as higher the preset temperature with reference to the safety temperature is, so as to increase varying ratio of the combustion amount. In this embodiment, in a case where the preset temperature is lower than the safety temperature, the slope S is a negative value so that the combustion

amount is increased with decreasing of the surplus time T. In this case, the combustion amount predicted for a time that the surplus time T has been zero should be smaller than the combustion amount predicted to make the furnace temperature as the safety temperature. Such setting of the slope S makes the combustion amount in each combustion segment closer to the combustion amount corresponding to the safety temperature that is a combustion amount predicted to cause the furnace temperature reaching the safety temperature if the combustion amount maintained for a certain time. Thereby, the reduction of the combustion amount in total though the whole heating furnace with respect to the decreasing of surplus time T is suppressed, so as to minimize the decreasing of the conveying speed for the strip material 4. Alternatively, the slope S may be maintained in positive even if the preset temperature is lower than the safety temperature. Further, the profile is not limited to a straight like shape, and may be also defined as a curved line.

[0035] If the preset times Ts for all of the combustion segments are set at a same value, the controls of the burners 8 for all of the combustion segment are switched from the normal PID control to the control based on the surplus time Ts all together at a moment, and therefore the switching of the control is easier. However, the preset times Ts may be set at different values from one combustion segment to another. Specifically, as shown in Fig. 5, the preset time Ts preferably is set at longer time as larger the difference between the preset temperature and the safety temperature of the respective combustion segment is. In this case, the slope S of the profile of the combustion amount ratios may be a same value for the all of the combustion segments. Alternatively, particularly in a case where the structures of the combustion segment are identical, the slopes S of the profile are preferably determined so that the actual variation rates of the combustion amount in the respective combustion segments will be same, so as to equalize following capabilities in the furnace temperatures with respect to the surplus time.

[0036] While in the profile shown in Fig. 3, the combustion amount varies linearly to zero, in a case where the combustion amount is less than a lower limit value Rc corresponding to a lowest value of the combustion amount at which the combustion can be maintained in an actual burner 8, it is required to maintain the combustion amount at the lower limit value Rc or to completely shut down the combustion. If the combustion of the burner 8 is completely shut down, it needs much time and effort to ignite again. Therefore, when the combustion amount ratio according to the surplus time T is equal to or less than the lower limit value Rc, the combustion is maintained at the lower limit value Rc, and when the surplus time T has reached zero, the combustion of the burner 8 may be shut down completely simultaneously with setting the conveying speed for the strip material 4 in the heating furnace at zero. Further, in a case where the combustion amount ratio according to the surplus time T is equal to or less than the lower limit value Rc, only if the welding device 1 is completely stopping, the surplus time T is highly probable to reach zero in a short time, then the combustion of the burner 8 is completely shut down. But, if the welding device 1 is in operation even very slowly, the surplus time T is possibly increasing, then the combustion of the burner 8 may be maintained at the lower limit value Rc. Alternatively, a threshold value equal to or less than the lower limit value Rc may be defined to determine whether the combustion at the lower limit value Rc is maintained or the combustion is completely shut down, according to a magnitude relationship between the combustion amount ratio and the threshold value.

[0037] It is noted that while the welding device 1 is connected to the heating furnace 3 via the looper 2 in this embodiment, the present invention can be applied to a case where any other device is connected via the looper 2. Further, the present invention can be applied to a case where any other device is connected via looper downstream of the heating furnace. In a case where coopers are provided both upstream and downstream of the heating furnace, the surplus times may be calculated for both loopers so that the combustion amount in the heating furnace is adjusted according to the shorter one of the two surplus time.

REFERENCE SIGNS LIST

[0038]

1 welding devise
2 looper
3 heating furnace
4 strip material
5 reel
6 movable roller
7 controller
8 burner
9 furnace temperature sensor
10 product temperature sensor
11 conveying roller
12 position detector

Claims

1. A continuous heating apparatus comprising
a heating furnace having combustion segments in which combustion amounts can be individually controlled and which are arranged in series, for continuously heating a strip material in a manner that a conveying speed for the strip material is controlled so as to maintain a final achieving temperature of the strip material at a predetermined target temperature, and
a looper which is arranged in series with the heating furnace, through which the strip material passes and which can adjust an length of the strip material ac-

cumulated inside, and **characterized in that** the continuous heating apparatus comprises a controller for controlling the combustion amounts in the combustion segments respectively according to a surplus time as a remaining adjustment capacity of the looper in the length of the strip material divided by the conveying speed for the strip material in the heating furnace, wherein
the controller controls the combustion amounts in the combustion segments respectively so that internal temperatures of the combustion segments are maintained at respectively predetermined preset temperatures if the surplus time is longer than a predetermined preset time, and varies the combustion amounts in the combustion segments respectively in a predetermined profile with respect to the surplus time if the surplus time is shorter than a predetermined preset time.

2. The continuous heating apparatus according to the claim 1, wherein in the profile, the combustion amount is varied at a larger decreasing rate as higher the preset temperature is.

3. The continuous heating apparatus according to the claim 2, wherein the preset time are same for the all combustion segments.

4. The continuous heating apparatus according to the claim 1, wherein the preset time is longer as higher the preset temperature is.

5. The continuous heating apparatus according to any one of the claims 1 to 4, wherein in the profile, the combustion amount in the combustion segment gets closer to a certain combustion amount corresponding to a predetermined safety temperature as shorter the surplus time is.

6. The continuous heating apparatus according to any one of the claims 1 to 4, wherein in a case where the surplus time is shorter than the preset time, the controller determines the combustion amount of the combustion segments respectively with reference to the combustion amount of the combustion segment at a time that the surplus time has reached the preset time.

7. The continuous heating apparatus according to any one of the claims 1 to 4, wherein in a case where the combustion amount of the combustion segment according to the surplus time is less than a predetermined lower limit, the controller set the combustion amount in the combustion segment at the lower limit if an equipment connected via the looper is not completely stopped, and the controller shut down the combustion in the combustion segment if an equipment connected via the looper is completely stopped.

Fig. 1

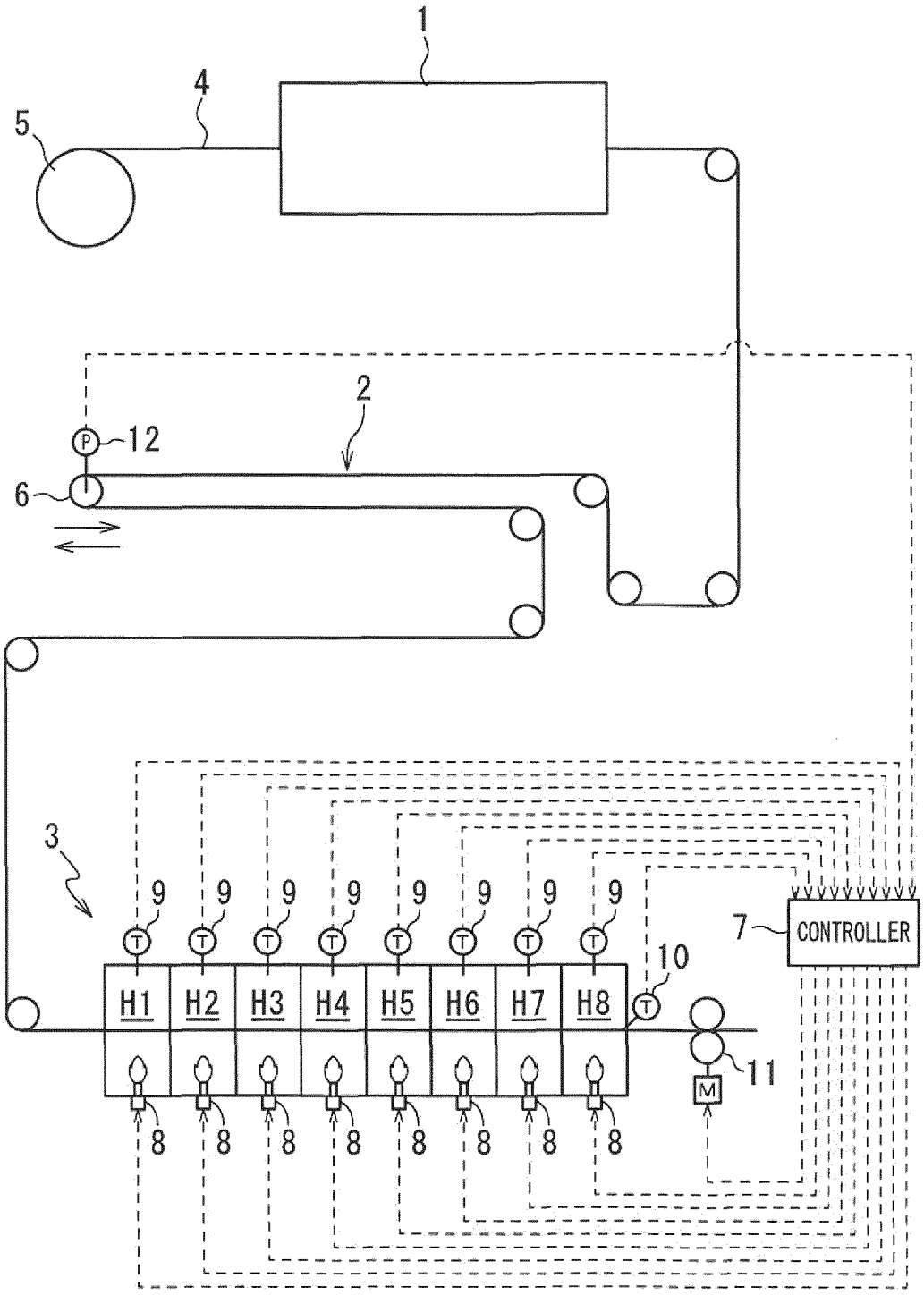
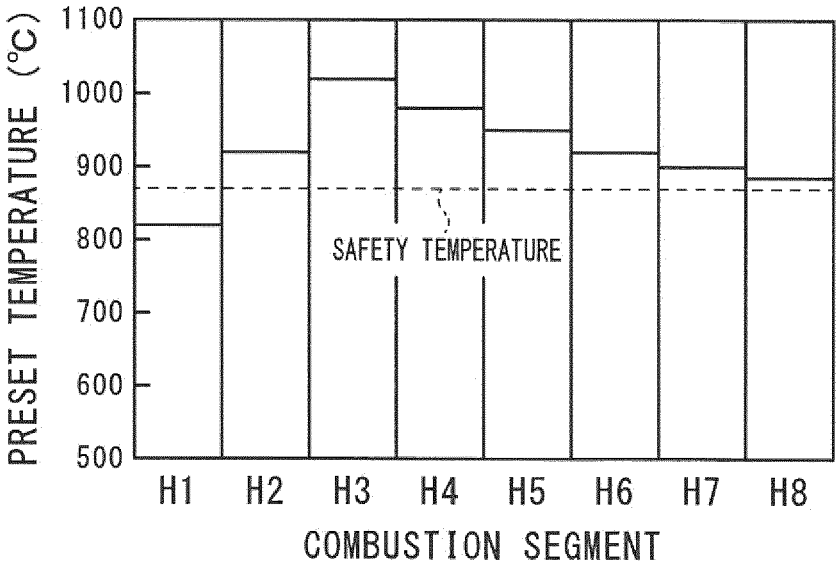


Fig. 2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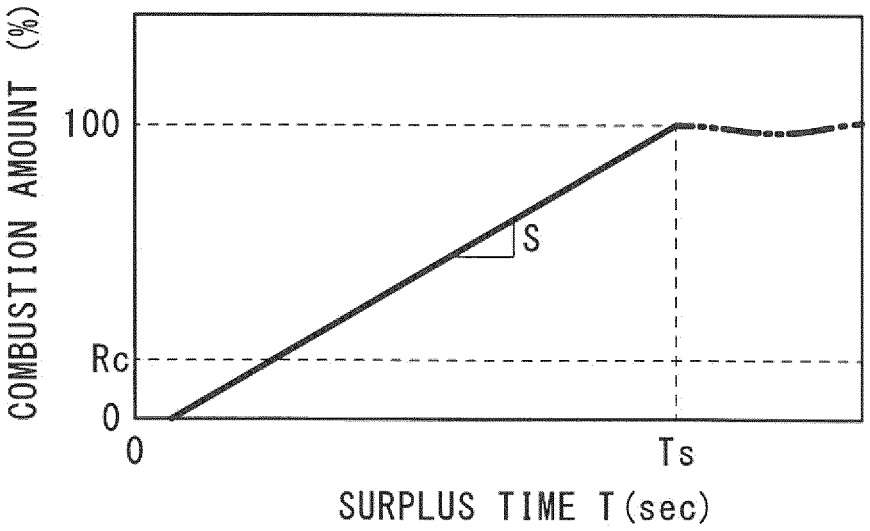
1000
900
800
700
600
500
SAFETY TEMPERATURE
H1
H2
H3
H4
H5
H6
H7
H8
COMBUSTION SEGMENT

Fig. 3


COMBUSTION AMOUNT (%)
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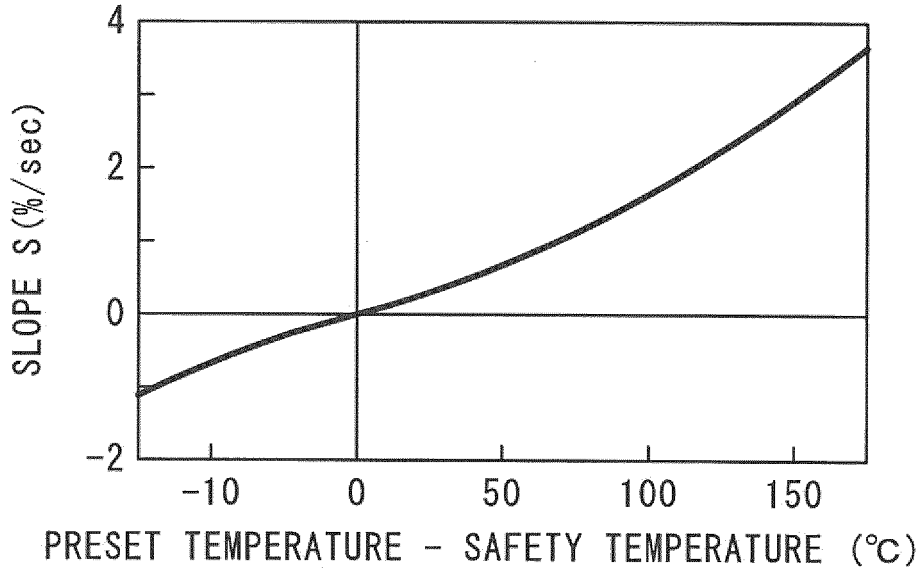
S
Rc
0
0
Ts
SURPLUS TIME T(sec)

Fig. 4


4
2
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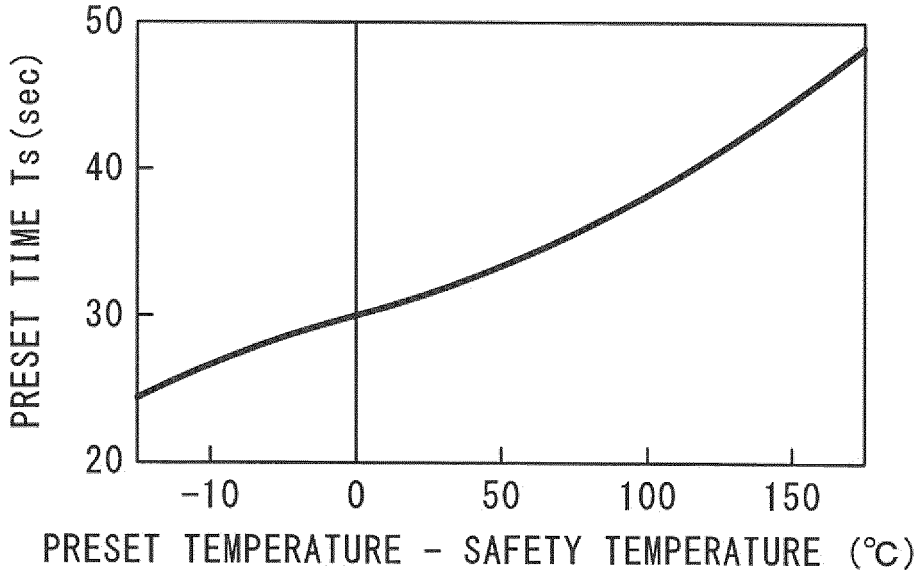
-2
SLOPE S (%/sec)
-10
0
50
100
150
PRESET TEMPERATURE - SAFETY TEMPERATURE (℃)

Fig. 5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PRESET TEMPERATURE - SAFETY TEMPERATURE (℃)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/067364

A. CLASSIFICATION OF SUBJECT MATTER
C21D9/56(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21D9/52-9/66, C21D11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-157590 A (Nippon Steel Corp.), 18 August 2011 (18.08.2011), entire text; all drawings (Family: none)	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 September, 2012 (13.09.12)	25 September, 2012 (25.09.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H0679329 A **[0005]**
- JP 2007203363 A **[0005]**
- JP 2007291472 A **[0005]**
- JP 2011084753 A **[0005]**