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

(11) **EP 3 124 863 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.02.2017 Bulletin 2017/05

(21) Application number: **15767749.3**

(22) Date of filing: **25.03.2015**

(51) Int Cl.:
F23G 5/00 *(2006.01)* ***F23G 5/50*** *(2006.01)*

(86) International application number:
PCT/JP2015/059218

(87) International publication number:
WO 2015/147091 (01.10.2015 Gazette 2015/39)

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

(30) Priority: **26.03.2014 JP 2014064555**

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(54) **SURFACE MELTING FURNACE AND METHOD FOR OPERATING SURFACE MELTING FURNACE**

(57) A surface melting furnace includes a furnace chamber 4, a treatment-target supply mechanism 8, and a plurality of sensors Hs and Ts. The furnace chamber 4 has a slag port 3a on its furnace bottom 3. The treatment-target supply mechanism 8 is configured to supply a treatment target to the furnace chamber 4. The sensors Hs and Ts are configured to perform measurement at different measurement locations for estimation of a profile of the molten surface of the treatment target, whereby the surface melting furnace enables the profile of the molten surface to be estimated over a large area. The treatment target supplied to the furnace chamber 4 by the treatment-target supply mechanism 8 is configured to melt from the surface and flow down to the slag port 3 a.

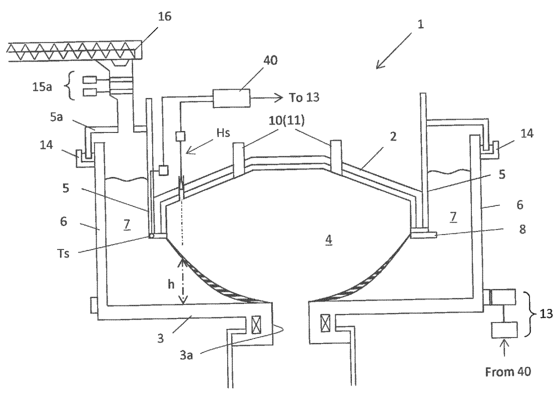

Fig.1

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Description

[TECHNICAL FIELD]

[0001] The present invention relates to a surface melting furnace and a method for operating the surface melting furnace.

[BACKGROUND ART]

[0002] Surface melting furnaces include furnace chambers having slag ports and treatment-target supply mechanisms that supply treatment targets to the furnace chambers. The surface melting furnaces are configured such that the treatment targets, which are supplied to the furnace chambers by the treatment-target supply mechanisms, melt from the surface and flow down to the slag ports.

[0003] There is a need for adjusting supply quantities of the treatment targets by the treatment-target supply mechanisms so that target throughput of the treatment targets subjected to melt treatment by the surface melting furnaces will be achieved. To meet this need, the supply quantities of the treatment targets and melting conditions have been adjusted so that the supply quantities will agree with the target throughput by measuring in advance the supply quantities of the treatment targets, measuring quantities of molten slag after the treatment, and determining whether the treatment targets are in short supply or in oversupply on the basis of the ratios of the quantities of the slag to the supply quantities of the treatment targets for a certain time period of several hours to about half a day.

[0004] However, the determination described above takes some time because delays of several hours exist between the supply quantities of the treatment targets measured before melting and the quantities of the slag measured after melting. Thus, there have chronically been situations in which appropriate profiles of the molten surfaces cannot be maintained. The situations are caused by delays of determinations of both short-supply states, in which the profiles of the molten surfaces of the treatment targets retreat from the slag ports to the treatment-target-supply-mechanism side, and oversupply states, in which the profiles of the molten surfaces of the treatment targets move on toward the slag ports to cause the treatment targets to be thickly accumulated.

[0005] The retreat of the profiles of the molten surfaces from the slag ports accelerates consumption of refractory materials on furnace bottoms and the like and causes a problem in that the lives of the refractory materials in the furnaces are shortened. The moving on of the profiles of the molten surfaces toward the slag ports causes a disadvantageous situation in which unmolten treatment targets roll down steep slopes formed by thick accumulation toward the slag ports, and are discharged through the slag ports.

[0006] For this reason, melting furnaces having sufficient extra capacities have been currently designed and operated so that the treatment targets can be molten with the target throughput in the short-supply states rather than in the oversupply states in order to prevent the unmolten treatment targets from being discharged through the slag ports.

[0007] Patent document 1 discloses methods for controlling molten surfaces. In order to enable stable melt treatment by maintaining the molten surfaces of treatment targets in appropriate positions, the methods include irradiating the molten surfaces of treatment targets with optical beams having emission wavelengths shorter than the short-wavelength ends of emission spectra in intensities equal to or higher than predetermined intensities in melting furnaces, detecting the positions with photodetectors capable of detecting beam spot positions of the optical beams on the molten surfaces, and determining whether the positions of the molten surfaces are appropriate on the basis of the detection results of the positions.

[0008] These methods for controlling molten surfaces are configured to reduce supply quantities per unit hour of the treatment targets to areas for melt treatment when the positions of the molten surfaces are determined to be ahead of the appropriate positions. In contrast, the methods are configured to increase the supply quantities per unit hour of the treatment targets to the areas for melt treatment when the positions are determined to have retreated.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0009] [Patent document 1] Japanese Unexamined Patent Application Publication No. H11-325434

SUMMARY OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0010] However, the surface melting furnaces disclosed in Patent document 1 have used highly expensive lasers having emission wavelengths in the ultraviolet range as light sources. For this reason, the light sources cannot be disposed in large numbers, and it has been difficult to estimate the profiles of the molten surfaces over large areas.

[0011] In view of the problems described above, the present invention has an object to provide a surface melting furnace in which a profile of a molten surface can be estimated over a large area, and a method for operating the surface melting furnace.

MEANS FOR SOLVING THE PROBLEMS

[0012] To achieve the object above, a first characteristic configuration of a surface melting furnace according to the present invention is, as set forth in claim 1 in the document of claims, that a surface melting furnace includes a furnace chamber, a treatment-target supply mechanism, and a plurality of sensors. The furnace chamber has a slag port. The treatment-target supply mechanism is configured to supply a treatment target to the furnace chamber. The sensors are configured to perform measurement at different measurement locations for estimation of a profile of the molten surface of the treatment target. The treatment target supplied to the furnace chamber by the treatment-target supply mechanism is configured to melt from the surface and flow down to the slag port.

[0013] The configuration above enables the profile of the molten surface to be appropriately estimated on the basis of information obtained by performing measurement at the different measurement locations with the sensors. Thus, whether the molten surface is in an appropriate state can be determined appropriately.

[0014] A second characteristic configuration of the same is, as set forth in claim 2 in the same document, that one of the sensors may include a temperature sensor configured to detect a temperature of a supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber by the treatment-target supply mechanism, in addition to the first characteristic configuration described above.

[0015] Retreat of the molten surface of the treatment target causes the supplied portion to be easily affected by the furnace-chamber temperature, and the temperature of the supplied portion increases. Moving on of the molten surface of the treatment target causes the supplied portion to be less likely to be affected by the furnace-chamber temperature, and the temperature of the supplied portion decreases. Thus, whether the molten surface is in a retreat phase or in a moving-on phase can be determined on the basis of temperature information of the supplied portion measured by the temperature sensor. This information is therefore valuable measurement information for estimation of the profile of the molten surface.

[0016] A third characteristic configuration of the same is, as set forth in claim 3 in the same document, that the sensors may be disposed in different positions along a path from a supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber by the treatment-target supply mechanism, to the slag port, in addition to the first or the second characteristic configuration described above.

[0017] With the configuration above, measurement is performed on a plurality of positions on the molten surface measured along the path from the supplied portion to the slag port. The profile of the molten surface from the supplied portion to the slag port can be estimated on the basis of this measurement information, and whether the molten surface is moving on or retreating can be appropriately recognized.

[0018] A fourth characteristic configuration of the same is, as set forth in claim 4 in the same document, that one of the sensors may include a non-contact sensor configured to detect a surface height of the treatment target, in addition to any one of the first to the third characteristic configurations described above.

[0019] The non-contact sensor detects the surface height of the treatment target from above the treatment target, and thus at least one point on the molten surface can be directly measured.

[0020] A fifth characteristic configuration of the same is, as set forth in claim 5 in the same document, that the surface melting furnace may further include a treatment-target supply controller, in addition to any one of the first to the fourth characteristic configurations described above. The treatment-target supply controller may be configured to estimate the profile of the molten surface of the treatment target on the basis of output of the sensors. The treatment-target supply controller may also be configured to control at least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism on the basis of the profile estimated.

[0021] The treatment-target supply controller estimates the profile of the molten surface of the treatment target and determines whether the molten surface is in the retreat phase or in the moving-on phase. If the molten surface is determined to be in the retreat phase, the supply quantity of the treatment target is adjusted to increase toward a target supply quantity that has been determined so that an appropriate profile of the molten surface will be achieved. If the molten surface is determined to be in the moving-on phase, the supply quantity of the treatment target is adjusted to decrease toward a target supply quantity that has been determined so that an appropriate profile of the molten surface will be achieved.

[0022] A sixth characteristic configuration of the same is, as set forth in claim 6 in the same document, that the surface melting furnace may further include a treatment-target supply controller, in addition to any one of the first to the fourth characteristic configurations described above. The treatment-target supply controller may be configured to estimate the profile of the molten surface of the treatment target on the basis of output of the sensors. The treatment-target supply controller may also be configured to control at least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism to adjust the supply quantity to a target supply quantity on the basis of a result of the estimating. The treatment-target supply controller may also be configured to correct the target supply quantity to adjust a cumulative supply quantity of the treatment target in a predetermined time period to a target cumulative supply quantity.

[0023] The fifth characteristic configuration described above adjusts the supply quantity of the treatment target so that an appropriate profile of the molten surface will be achieved, but cannot guarantee that the result of the adjustment achieves the target throughput of the surface melting furnace. However, since the treatment-target supply controller of the sixth characteristic configuration corrects the target supply quantity to adjust the cumulative supply quantity of the treatment target in a predetermined time period to the target cumulative supply quantity, the target throughput of the surface melting furnace can be achieved.

[0024] A seventh characteristic configuration of the same is, as set forth in claim 7 in the same document, that an inner cylinder and an outer cylinder may be disposed concentrically, in addition to any one of the first to the sixth characteristic configurations described above. The inner cylinder may be integrally formed around a furnace ceiling. The outer cylinder may be integrally formed around a furnace bottom of the furnace chamber. The gap between the inner cylinder and the outer cylinder may constitute a treatment-target container. The treatment-target supply mechanism may be configured to supply the treatment target to the furnace chamber by relative rotation of the inner cylinder and the outer cylinder.

[0025] In a rotary surface melting furnace, the treatment target is annularly supplied to the furnace chamber by relative rotation of the inner cylinder and the outer cylinder. If a plurality of sensors that perform measurement at different measurement locations for estimation of the profile of the molten surface of the treatment target are disposed on this surface melting furnace, at least one sensor can give a plurality of pieces of measurement data along the circumferential direction while the melting furnace makes one revolution. The three-dimensional profile of the molten surface can be estimated from the pieces of measurement data, and the profile of the molten surface can be estimated more accurately.

[0026] A characteristic configuration of a method for operating a surface melting furnace is, as set forth in claim 8 in the same document, that a method for operating a surface melting furnace includes estimating a profile of a molten surface of a treatment target on the basis of output of a plurality of sensors on the surface melting furnace. The surface melting furnace includes a furnace chamber and a treatment-target supply mechanism. The furnace chamber has a slag port. The treatment-target supply mechanism is configured to supply the treatment target to the furnace chamber. The treatment target supplied to the furnace chamber by the treatment-target supply mechanism is configured to melt from the surface and flow down to the slag port. At least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism is controlled to adjust the supply quantity to a target supply quantity on the basis of a result of the estimating. The target supply quantity is corrected to adjust a cumulative supply quantity of the treatment target in a predetermined time period to a target cumulative supply quantity.

[0027] Since the target supply quantity is corrected to adjust the cumulative supply quantity of the treatment target in a predetermined time period to the target cumulative supply quantity, the profile of the molten surface is adjusted appropriately, and the target throughput of the surface melting furnace can be achieved.

EFFECTS OF INVENTION

[0028] As described above, the present invention has enabled provision of a surface melting furnace in which a profile of a molten surface can be estimated over a large area, and provision of a method for operating the surface melting furnace.

BRIEF DESCRIPTION OF DRAWINGS

[0029]

[Fig. 1] Fig. 1 is an illustrative diagram of a rotary surface melting furnace according to the present invention.

[Fig. 2] Fig. 2 is an illustrative diagram of the rotary surface melting furnace in which a molten surface has retreated.

[Fig. 3] Fig. 3 is an illustrative diagram of the rotary surface melting furnace in which the molten surface has moved on.

[Fig. 4] Fig. 4 is an illustrative diagram illustrating a layout of sensors.

[Fig. 5] Fig. 5 is an illustrative diagram of a plurality of sensors that measure heights of the molten surface.

[Fig. 6] Fig. 6 is an illustrative diagram of a control table based on the sensors.

[Fig. 7] Fig. 7 shows another embodiment and is an illustrative diagram of a plurality of sensors that measure heights of the molten surface.

[Fig. 8] Fig. 8 shows still another embodiment and is an illustrative diagram of a plurality of sensors that measure heights of the molten surface.

[Fig. 9] Fig. 9 shows still another embodiment and is an illustrative diagram of a plurality of sensors that measure heights of the molten surface.

[Fig. 10] Fig. 10 shows still another embodiment and is an illustrative diagram of a plurality of sensors that measure heights of the molten surface.

[Fig. 11] Fig. 11A and Fig. 11B are illustrative diagrams of main part of a surface melting furnace according to still another embodiment.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0030] The following describes embodiments of a surface melting furnace and a method for operating the surface melting furnace according to the present invention. Fig. 1 shows a rotary surface melting furnace 1 that is an embodiment of the surface melting furnace. The surface melting furnace 1 is a furnace for melt-treating waste such as incineration ash and sewage sludge. The surface melting furnace 1 includes a furnace chamber 4, a treatment-target container 7 around the furnace chamber 4, a treatment-target supply mechanism 8 that supplies the treatment target from the treatment-target container 7 to the furnace chamber 4, and other components. On the approximately center of a furnace ceiling 2 of the furnace chamber 4, two combustion burners 10 provided with air supply mechanisms 11 are disposed. The furnace chamber 4 has a slag port 3a on its furnace bottom 3.

[0031] An inner cylinder 5 integrally formed with the furnace ceiling 2 around the furnace ceiling 2 and an outer cylinder 6 integrally formed with the furnace bottom 3 around the furnace bottom 3 are disposed concentrically. The gap between the inner cylinder 5 and the outer cylinder 6 is configured to constitute the treatment-target container 7.

[0032] The lower part of the outer cylinder 6 has a portion for coupling a drive mechanism 13. The inner cylinder 5 and the outer cylinder 6 are configured to rotate relative to each other due to rotation of the outer cylinder 6 caused by the drive mechanism 13. A plurality of cutout blades 8, which are components of the treatment-target supply mechanism, are disposed on the lower part of the inner cylinder 5 along the circumferential direction.

[0033] The cutout blades 8 are constituted of plate-like sloping blades that guide the treatment target, which is moving in the tangential direction on the lower part of the inner cylinder 5 due to the rotation of the outer cylinder 6, to the furnace chamber 4. The cutout blades 8 due to the relative rotation of the inner cylinder 5 and the outer cylinder 6 annularly supplies the treatment target contained in the treatment-target container 7 to the furnace chamber 4, and the treatment target forms a bowl shape in the furnace chamber.

[0034] A water-sealing mechanism 14 water-seals a boundary between the outer cylinder 6 and an edge of a cover 5a extending from the upper part of the inner cylinder 5 toward the outer cylinder 6. A hopper 15 provided with a double damper mechanism 15a is disposed above the cover 5a. A screw conveyor mechanism 16 puts the treatment target into the treatment-target container 7. The furnace ceiling 2, the furnace bottom 3, the inner cylinder 5, and the outer cylinder 6 are constituted of refractory walls in which refractory bricks or other materials are stacked. A water-cooling jacket is disposed to cover the refractory walls of the furnace ceiling 2 and a portion adjacent to the slag port of the furnace bottom 3.

[0035] A water tank that catches molten slag produced by melting the treatment target is disposed below the slag port 3a. A flue is formed to laterally extend immediately below the slag port 3a. Exhaust-gas treatment equipment such as a secondary combustion device, a waste-heat boiler, an air preheater, a cooling tower, a bag filter, a scrubber, and a white-smoke preventing device are disposed along the flue. Purified exhaust gas is emitted from a chimney.

[0036] The treatment targets to be melt-treated include incineration residues and incineration fly ash from waste incinerators as well as animal and plant residues such as sewage sludge, livestock excreta, and food waste and combustible waste such as pulverized municipal solid waste.

[0037] When starting up the rotary surface melting furnace 1, the combustion burners 10 are ignited to preheat the furnace chamber 4 to a temperature equal to or higher than 1,000°C. After that, the outer cylinder 6 is rotated via the drive mechanism 13, and melting of the treatment target is started. The combustion burners 10 are then allowed to continue to combust, and the temperatures of the furnace chamber and the molten surface reach about 1,300°C. When the treatment target is combustible waste, the combustion burners 10 are stopped. The treatment target is then allowed to spontaneously combust, and the melting is continued with the temperature of the furnace chamber being 1,300°C.

[0038] The treatment target put into the furnace chamber 4 by the cutout blades 8 melts at about 1,300°C and flows to the slag port 3a. Combustion gas is induced toward the chimney by an induced draft fan on the downstream side of the flue, cooled and purified in the exhaust-gas treatment equipment described above, and emitted from the chimney. Combustion air to be supplied from the air supply mechanisms 11 into the furnace is preheated to about 200°C by warm water of the boiler and the air preheater using the exhaust gas.

[0039] Fig. 1 shows a state in which the profile of the molten surface is being appropriately melt-treated. Fig. 2 shows a state in which the profile of the molten surface has retreated. Fig. 3 shows a state in which the profile of the molten surface has moved on. In the drawings, the hatched areas represent the molten surface.

[0040] The retreat of the profile of the molten surface from the slag port 3a accelerates consumption of the refractory material on the furnace bottom 3 and the like, and the life of the refractory material in the furnace is shortened. The moving on of the profile of the molten surface toward the slag port 3a causes a disadvantageous situation in which an unmolten treatment target rolls down a steep slope formed by thick accumulation toward the slag port 3a, and is discharged through the slag port.

[0041] Thus, the rotary surface melting furnace 1 includes a plurality of sensors Ts and Hs that perform measurement at different measurement locations for estimation of the profile of the molten surface of the treatment target. The profile of the molten surface is estimated on the basis of information obtained by performing measurement at the different measurement locations with the sensors Ts and Hs. A treatment-target supply controller 40 is included that determines appropriately whether the molten surface is in an appropriate state on the basis of this profile and adjusts the input of the treatment target into the furnace. The sensors may be the same kind of sensors but are preferably a combination of different kinds of sensors. The "same kind of sensors" means sensors based on the same detection principle.

[0042] One of the sensors is constituted of a non-contact sensor Hs configured to detect a surface height of the treatment target through the furnace ceiling 2 covering the furnace chamber 4. The non-contact sensor Hs faces the treatment target through the furnace ceiling 2 and detects the height h of the molten surface, and thus at least one point on the molten surface can be directly measured. The "height h of the molten surface" means the height from the furnace bottom 3 to the surface of the treatment target.

[0043] A sensor preferably used as the non-contact sensor Hs is an electromagnetic-wave sensor that emits microwaves from a trumpet-shaped antenna toward the treatment target and measures the height h of the molten surface on the basis of the reflection time. In addition, a photodetector that emits laser light toward the treatment target and measures the height h of the molten surface on the basis of the reflection time can be used as the non-contact sensor Hs. The measurement can be performed also with wavelengths in the infrared range because infrared light from the treatment target can be removed with a filter if at least light for measurement has been modulated.

[0044] If the treatment target is combustible waste, it is preferable to irradiate the surface of the molten object having just been cut and put into the furnace by the cutout blades 8 with the wave for measurement. The temperature in the furnace facilitates thermal decomposition of the treatment target, and changes in the volume of the treatment target become remarkable. Changing states of the treatment target are thus monitored easily.

[0045] As shown in Fig. 5, a profile with an angle θ of elevation connecting the edge of the slag port 3 a with the lower end of the inner cylinder 5 is preliminarily assumed to be a standard molten-surface profile, for example. The profile is determined to be appropriate if the height h of the molten surface is a height h2 of the molten surface corresponding to the standard molten-surface profile, determined to be in the retreat phase if the height is h1 lower than the height h2, and determined to be in the moving-on phase if the height is h3 higher than the height h2. In addition, the degree of the moving-on or the retreat phase is recognized on the basis of the magnitude of the difference value between the height h of the molten surface at that time and the height h2 of the molten surface corresponding to the standard molten-surface profile.

[0046] One of the sensors is constituted of a temperature sensor Ts configured to detect the temperature of a supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber 4 by the cutout blades 8. As shown in Fig. 2, retreat of the molten surface of the treatment target causes the supplied portion to be easily affected by the furnace-chamber temperature, and the temperature of the supplied portion increases. As shown in Fig. 3, moving on of the molten surface of the treatment target causes the supplied portion to be less likely to be affected by the furnace-chamber temperature, and the temperature of the supplied portion decreases. Accordingly, although it is difficult to detect the moving-on phase of the molten surface of the treatment target, the retreat phase can be accurately detected on the basis of increase in temperature detected by the temperature sensor Ts. As the temperature sensor, a sheathed thermocouple is disposed on the treatment-target container 7 side of the lower edge of the inner cylinder 5.

[0047] In other words, whether the molten surface has transitioned to the retreat phase or is in the moving-on phase can be determined on the basis of temperature information of the supplied portion measured by the temperature sensor Ts. This information is therefore valuable measurement information for estimation of the profile of the molten surface. Particularly in the retreat phase, the information also serves as an indicator related to damage of the refractory material in a portion adjacent to the supplied portion and is valuable measurement information.

[0048] As shown in Fig. 4, the non-contact sensor Hs is disposed on one location on the peripheral edge of the furnace ceiling 2 that has a circular shape in the plan view, and the temperature sensors Ts are disposed on eight locations regularly in the circumferential direction. The non-contact sensor Hs measures the height h of the molten surface at the same location each time the outer cylinder 6 makes one revolution. For example, if the outer cylinder 6 and the furnace bottom 3 make one revolution per one hour, each height h of the molten surface can be recognized on a one-hour cycle. The profile of the molten surface can be estimated on the basis of the height h of the molten surface and the temperature detected by the temperature sensors Ts.

[0049] The temperature sensors Ts are disposed on eight locations in Fig. 4, but at least one temperature sensor Ts disposed on one location enables the profile to be estimated. In other words, the profile can be estimated even if any of the temperature sensors Ts on eight locations break down, although the accuracy decreases. It is most preferable for estimation of the profile that the non-contact sensor Hs and one of the temperature sensors Ts be aligned in the radial direction from the supplied portion to the slag port.

[0050] The treatment-target supply controller 40 estimates the profile of the molten surface of the treatment target on the basis of output of the sensors Hs and Ts. At least a supply quantity of the treatment target to be supplied to the furnace chamber by the cutout blades 8 is controlled to adjust the supply quantity to a target supply quantity on the basis of a result of the estimating.

[0051] For example, if the molten surface is determined to be in the retreat phase, the supply quantity of the treatment target is adjusted to increase toward the target supply quantity that has been determined so that an appropriate profile of the molten surface will be achieved. If the molten surface is determined to be in the moving-on phase, the supply quantity of the treatment target is adjusted to decrease toward a target supply quantity that has been determined so that an appropriate profile of the molten surface will be achieved.

[0052] Fig. 6 shows table information used for controlling the rotational speed of the outer cylinder 6 on the basis of the output of the sensors Hs and Ts to adjust the supply quantity of the treatment target into the furnace. The treatment-target supply controller 40 controls the drive mechanism 13 on the basis of the table data and the output of the sensors Hs and Ts.

[0053] For example, if the molten surface level rises and the temperature of the lower part of the inner cylinder 5 decreases, the profile of the molten surface is determined to be in the moving-on phase, and the supply quantity of the treatment target is reduced. If the molten surface level is lowered and the temperature of the lower part of the inner cylinder 5 increases, the profile of the molten surface is determined to be in the retreat phase, and the supply quantity of the treatment target is increased. The target supply quantity at this time is preliminarily set as a standard supply quantity for each area of the table data. The standard supply quantity set for the table data is preferably configured to be consecutively modified on the basis of data obtained in the moving-on or the retreat phase of the molten surface during operation.

[0054] In addition, the treatment-target supply controller 40 is configured to correct the target supply quantity to adjust the cumulative supply quantity of the treatment target in a predetermined time period to the target cumulative supply quantity. For example, the target supply quantity is corrected to increase if the actual throughput is lower than the target throughput of the treatment target, and the target supply quantity is corrected to decrease if the actual throughput is higher than the target throughput of the treatment target, on the basis of measurement information of the supply quantity of the treatment target obtained while the profile of the molten surface is maintained in an appropriate state by the control described above.

[0055] If the actual throughput is lower than the target throughput of the treatment target, the throughput can be increased by increasing the thermal dose from the combustion burners 10 or by increasing the combustion air. If the actual throughput is higher than the target throughput of the treatment target, the throughput can be decreased by decreasing the thermal dose from the combustion burners 10 or by decreasing the combustion air.

[0056] Since such control corrects the target supply quantity to adjust the cumulative supply quantity of the treatment target in a predetermined time period to the target cumulative supply quantity, the target throughput of the surface melting furnace in the predetermined time period can be achieved.

[0057] In other words, the profile of the molten surface can be estimated on the basis of information obtained by performing measurement at the different measurement locations with the sensors Hs and Ts. With this profile of the molten surface, whether the molten surface is in an appropriate state can be determined appropriately.

[0058] In other words, the method for operating the surface melting furnace according to the present invention estimates the profile of the molten surface of the treatment target on the basis of the output of the sensors Hs and Ts disposed on the surface melting furnace 1. At least the supply quantity of the treatment target to be supplied to the furnace chamber 4 by the treatment-target supply mechanism 8 is controlled to modify the profile and adjust the supply quantity to the target supply quantity on the basis of the profile estimated. In addition, the target supply quantity is configured to be corrected so that the cumulative supply quantity of the treatment target in a predetermined time period will achieve the target cumulative supply quantity, in other words, the throughput in the predetermined time period will achieve the target.

[0059] As shown in Fig. 7, the non-contact sensor Hs is preferably constituted of a plurality of sensors and disposed in different positions along a path from the supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber 4 by the treatment-target supply mechanism 8, to the slag port 3a. Direct measurement is performed on a plurality of positions on the molten surface along the path from the supplied portion to the slag port 3a. The profile of the molten surface from the supplied portion to the slag port can be thus accurately estimated, and whether the molten surface is moving on or retreating can be appropriately recognized.

[0060] Fig. 8 shows another embodiment in which the non-contact sensors Hs are disposed in different positions along the circumferential direction of the furnace ceiling 2 so that the positions of the non-contact sensors Hs will be different from each other in the radial direction. Such a configuration enables how largely the height of the molten surface measured on the outer side in the radial direction at a point in time changes toward the slag port 3a afterward to be recognized during one revolution of the molten surface.

[0061] Fig. 9 shows an embodiment in which a plurality of temperature sensors Ts are disposed. A first temperature sensor Tsa is disposed on the treatment-target container 7 side of the lower part of the inner cylinder 5, and a second temperature sensor Tsb is disposed on the furnace chamber 4 side. By including the second temperature sensor Tsb, a dead zone of the first temperature sensor Tsa when the profile of the molten surface has transitioned to the moving-on side can be compensated. Also in this case, a plurality of pairs are disposed at predetermined intervals in the circumferential direction as in Fig. 4.

[0062] In addition, the state of the molten surface may be configured to be recognized by measuring the temperature distribution in an area from the slag port 3 a along the radial direction with a third temperature sensor Tsc and a fourth temperature sensor Tsd disposed in the refractory material constituting the furnace bottom 3. Also in this case, a plurality of temperature sensors may be disposed in the radial direction, and a plurality of pairs may be disposed at predetermined intervals in the circumferential direction.

[0063] Disposing the temperature sensors in the radial direction enables the profile of the molten surface to be determined even when the non-contact sensor is broken or not disposed, although the accuracy decreases. The combination of the temperature sensors and the non-contact sensor is a combination of different kinds of sensors. Thus, the sensors are less likely to break down at the same time even under the same conditions. The combination is better in that a minimal profile can be estimated because at least one kind of the sensors functions appropriately.

[0064] Fig. 10 shows still another aspect of the non-contact sensor Hs. Light for measurement emitted from a light source L is used for rotational scanning by a first mirror M1 and is configured to be reflected toward the molten surface by a plurality of second reflecting mirrors M2 disposed on the peripheral edge of the furnace ceiling. Disposing a light receiving element that detects reflected light in the light source L enables the distance between the light source and the molten surface to be measured. The distance to the furnace bottom 3 has been preliminarily measured, and the height of the molten surface can be calculated from the difference between the distances.

[0065] The configuration described above enables the heights of the molten surface in a plurality of positions to be measured with the single light source L and the light receiving element. In addition, configuring a third reflecting mirror M3 on a different distance in the radial direction to be removable from the optical path enables the heights of the molten surface on a plurality of points in different areas along the radial direction to be measured.

[0066] Fig. 10 shows the configuration applied to a photodetector, but such a configuration can be applied to a distance sensor using microwaves. A configuration may be made such that a plurality of waveguides that transmit the electromagnetic waves are radially disposed from around a center point, a metal reflector corresponding to the first mirror is rotated at the center point to transmit the electromagnetic waves within each of the waveguides, and the molten surface is irradiated with electromagnetic waves by metal reflectors corresponding to the second mirrors. The configuration may be made such that coaxial cables are coupled to a plurality of trumpet-shaped antennas instead of the waveguides, and a path made by each of the coaxial cables is selected by a switch.

[0067] In the embodiments described above, the configuration in which the treatment-target supply mechanism includes the cutout blades 8 has been described. When the treatment target is fluid, however, the treatment target can be supplied by rotation of the outer cylinder 6 without the cutout blades 8. The treatment-target supply mechanism can be constituted of the outer cylinder 6, the drive mechanism 13 that rotates the outer cylinder 6, and other components.

[0068] In the embodiments described above, the case in which the surface melting furnace is the rotary surface melting furnace 1 has been described as an example. The surface melting furnace according to the present invention is, however, not limited to the rotary surface melting furnace 1 and can be applied to other types of surface melting furnaces, needless to say.

[0069] For example, the present invention can be applied to a surface melting furnace 1 having the slag port 3a at the center of the furnace bottom 3 and including a plurality of push-in mechanisms 30 for inputting the treatment target disposed around the furnace bottom 3, as shown in Fig. 11A. This surface melting furnace is a type of surface melting furnace in which both the outer cylinder 6 constituted integrally with the furnace bottom 3 and the inner cylinder 5 constituted integrally with the furnace ceiling 2 are secured, and the push-in mechanisms 30 supply the treatment target into the furnace.

[0070] As shown in Fig. 11B, the present invention can be applied to a surface melting furnace 1 having the slag port 3a at the edge of the furnace bottom 3 and including a plurality of push-in mechanisms 30 for inputting the treatment target disposed on the opposite side. In any of these embodiments, the treatment-target supply mechanism is the push-in mechanisms 30.

[0071] In other words, the present invention is only required to be a surface melting furnace including a plurality of sensors that perform measurement at different measurement locations for estimation of the profile of the molten surface of a treatment target.

[0072] The embodiments described above are only examples of the present invention. A specific configuration of each component can be modified and designed as appropriate as long as the operations and effects of the present invention can be obtained.

DESCRIPTION OF SYMBOLS

[0073]

- 1: Surface melting furnace
- 2: Furnace ceiling
- 3: Furnace bottom
- 3a: Slag port
- 4: Furnace chamber
- 5: Inner cylinder
- 6: Outer cylinder
- 8: Treatment-target supply mechanism
- 40: Treatment-target supply controller
- Hs: Non-contact sensor
- Ts: Temperature sensor

Claims

1. A surface melting furnace comprising:

a furnace chamber having a slag port;
a treatment-target supply mechanism configured to supply a treatment target to the furnace chamber; and
a plurality of sensors configured to perform measurement at different measurement locations for estimation of a profile of a molten surface of the treatment target,
wherein the treatment target supplied to the furnace chamber by the treatment-target supply mechanism is configured to melt from a surface and flow down to the slag port.

2. The surface melting furnace according to claim 1, wherein one of the sensors comprises a temperature sensor configured to detect a temperature of a supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber by the treatment-target supply mechanism.

3. The surface melting furnace according to claim 1 or 2,
wherein the plurality of sensors are disposed in different positions along a path from a supplied portion of the treatment target, the supplied portion just having been supplied to the furnace chamber by the treatment-target supply mechanism, to the slag port.

4. The surface melting furnace according to any one of claims 1 to 3,
wherein one of the sensors comprises a non-contact sensor configured to detect a surface height of the treatment target.

5. The surface melting furnace according to any one of claims 1 to 4, the surface melting furnace further comprises a treatment-target supply controller configured to:

estimate the profile of the molten surface of the treatment target based on output of the plurality of sensors; and
control at least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism based on the profile estimated.

6. The surface melting furnace according to any one of claims 1 to 4, the surface melting furnace further comprises a treatment-target supply controller configured to:

estimate the profile of the molten surface of the treatment target based on output of the plurality of sensors;
control at least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism to adjust the supply quantity to a target supply quantity based on a result of the estimating; and
correct the target supply quantity to adjust a cumulative supply quantity of the treatment target in a predetermined time period to a target cumulative supply quantity.

7. The surface melting furnace according to any one of claims 1 to 6,
wherein an inner cylinder integrally formed around a furnace ceiling and an outer cylinder integrally formed around a furnace bottom of the furnace chamber are disposed concentrically,
wherein a gap between the inner cylinder and the outer cylinder constitutes a treatment-target container, and
wherein the treatment-target supply mechanism is configured to supply the treatment target to the furnace chamber by relative rotation of the inner cylinder and the outer cylinder.

8. A method for operating a surface melting furnace, the surface melting furnace comprising:

a furnace chamber having a slag port; and
a treatment-target supply mechanism configured to supply a treatment target to the furnace chamber,
wherein the treatment target supplied to the furnace chamber by the treatment-target supply mechanism is configured to melt from a surface and flow down to the slag port,
the method comprising:

estimating a profile of a molten surface of the treatment target based on output of a plurality of sensors on the surface melting furnace;
controlling at least a supply quantity of the treatment target to be supplied to the furnace chamber by the treatment-target supply mechanism to adjust the supply quantity to a target supply quantity based on an result of the estimating; and
correcting the target supply quantity to adjust a cumulative supply quantity of the treatment target in a predetermined time period to a target cumulative supply quantity.

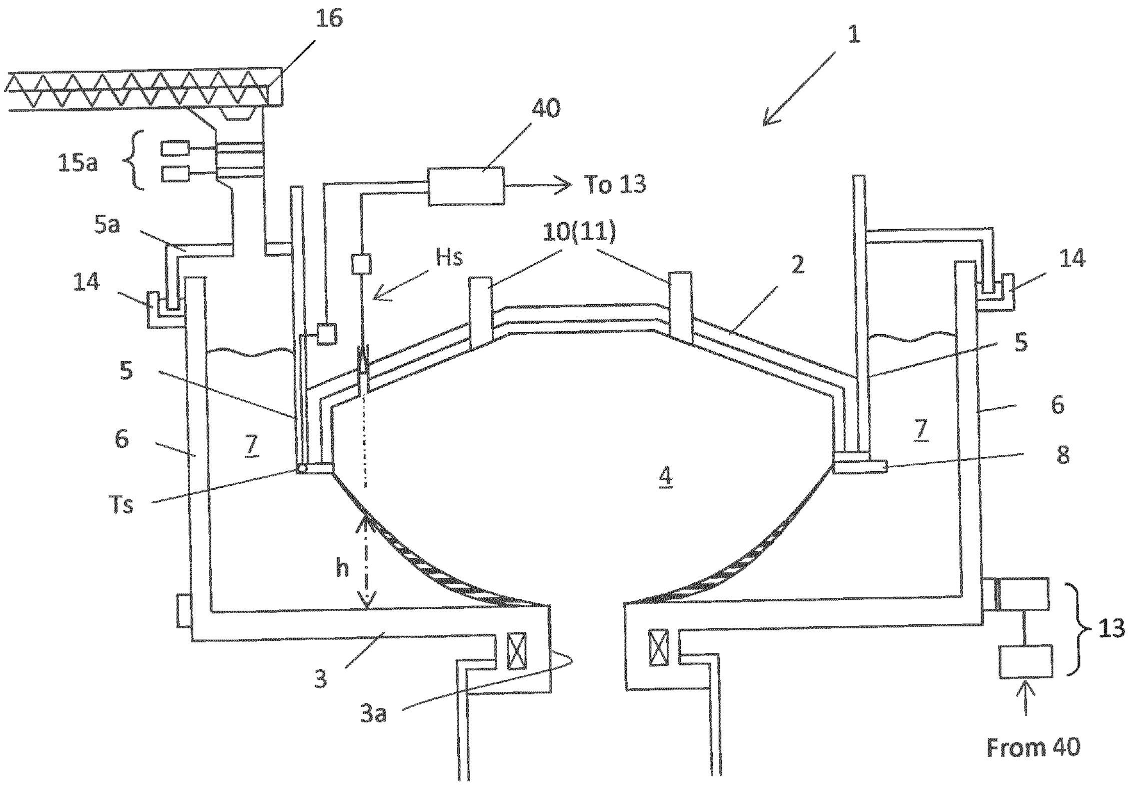

Fig.1

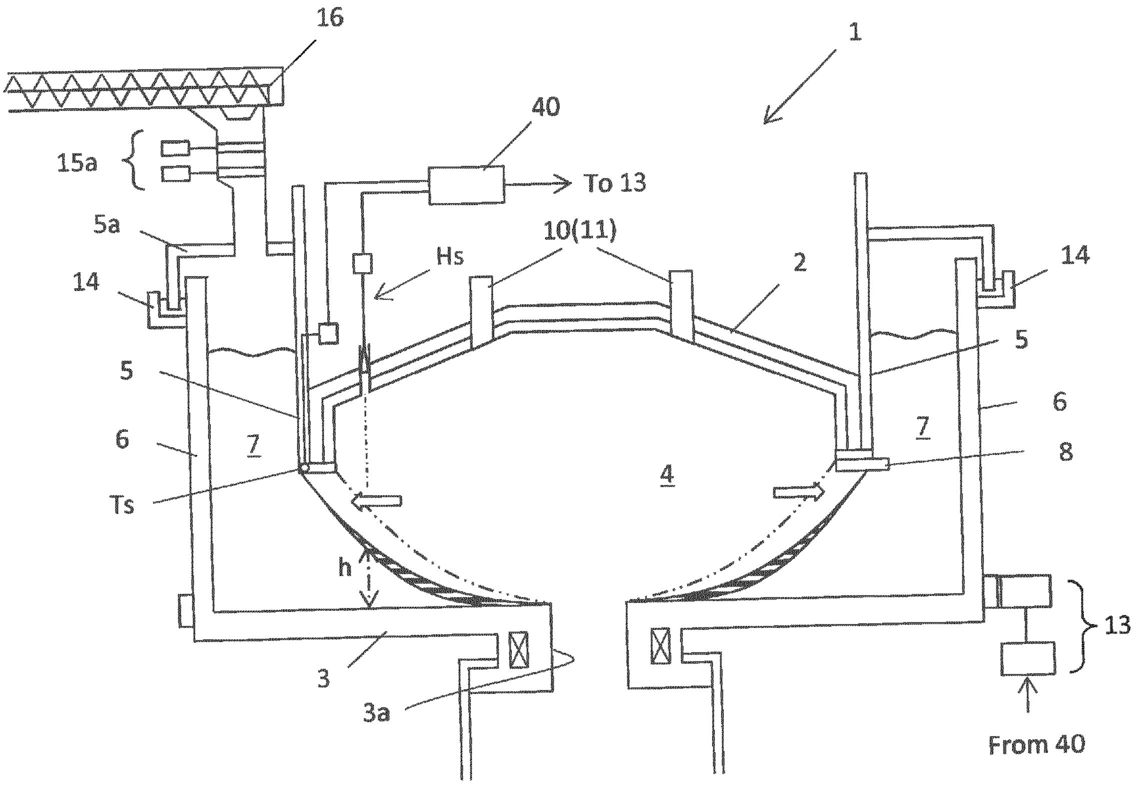

Fig.2

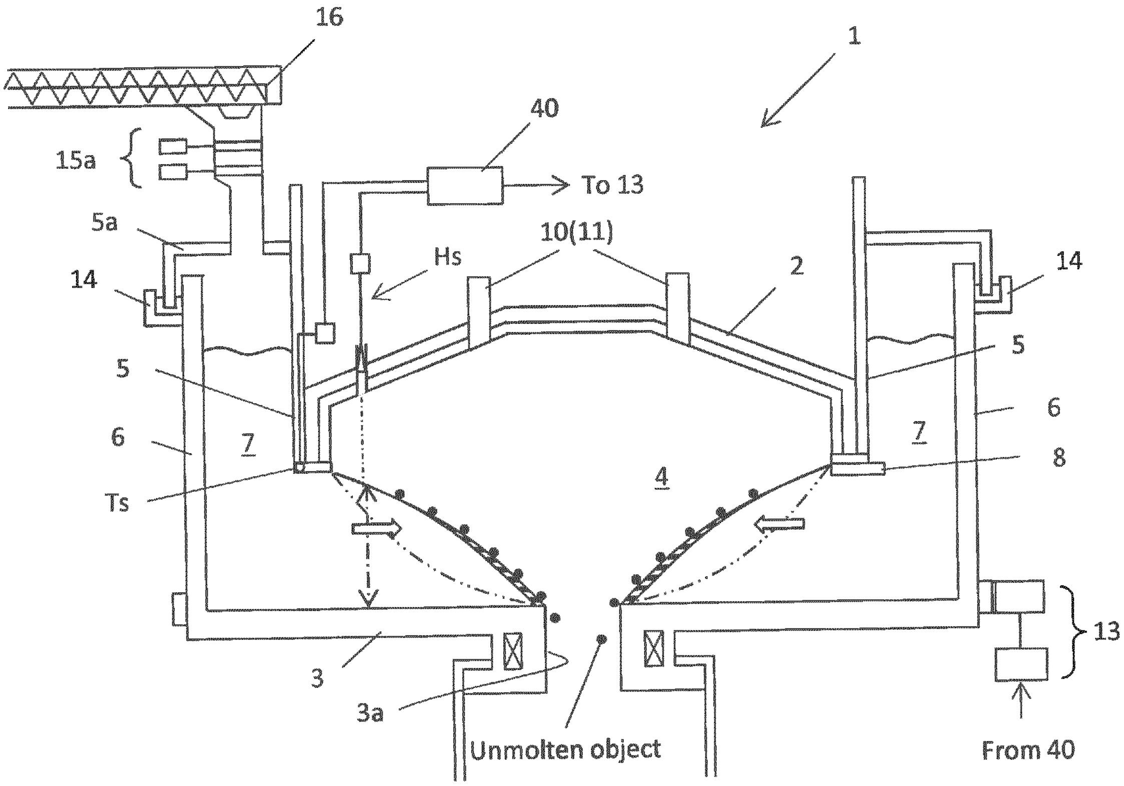
16
1
40
15a
To 13
5a
10(11)
Hs
14
2
14
5
5
6
7
6
7
8
4
Ts
13
3
3a
Unmolten object
From 40

Fig.3

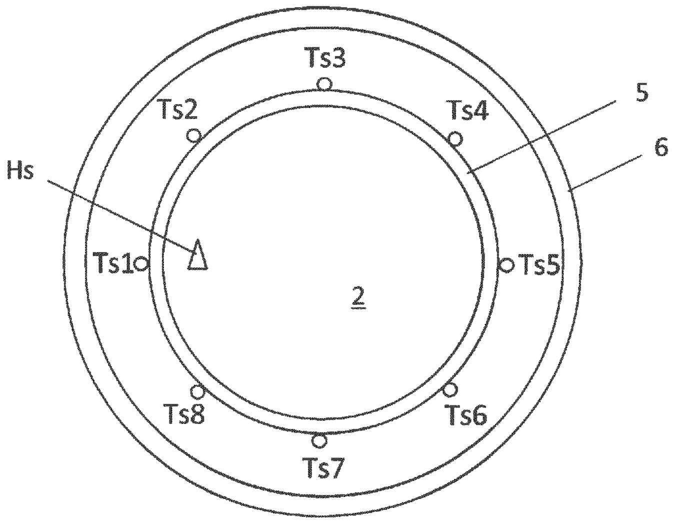

Fig.4

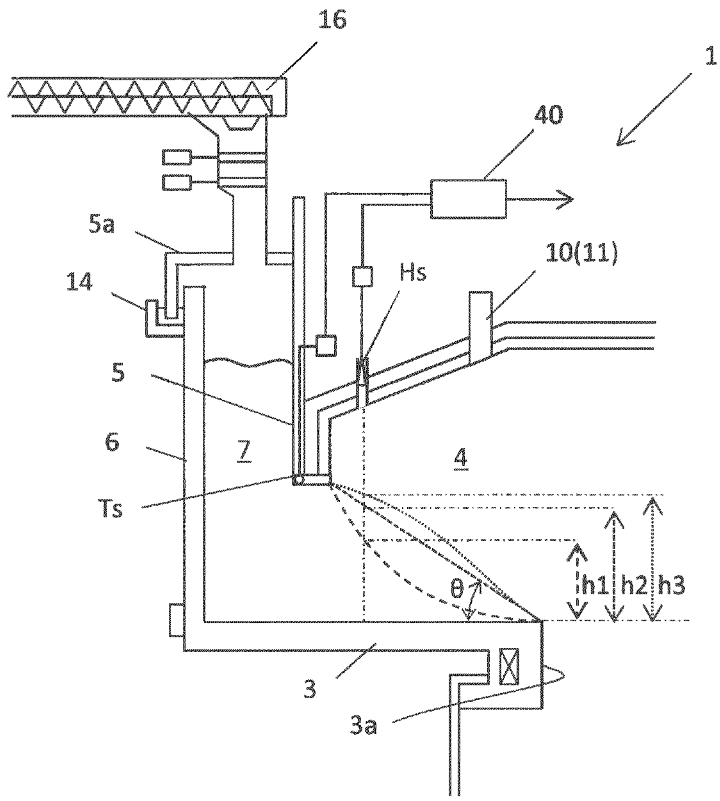

Fig.5

		Molten surface level		
		Lowered	No change	Rise
Temperature of lower part of inner cylinder	Lowered	—	Reduce supply quantity Increase melting quantity	Reduce supply quantity Increase melting quantity
	No change	Increase supply quantity Reduce melting quantity	Maintain status quo	Reduce supply quantity Increase melting quantity
	Rise	Increase supply quantity Reduce melting quantity	Increase supply quantity Reduce melting quantity	—

Fig.6

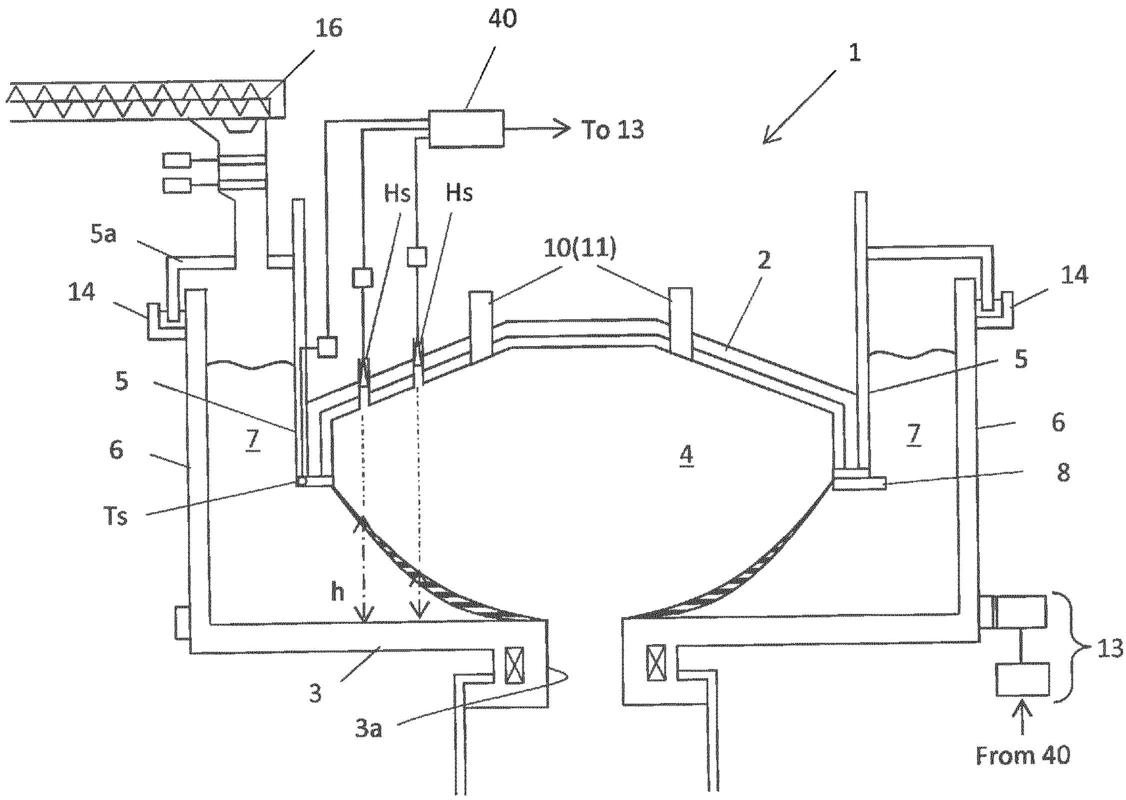

Fig.7

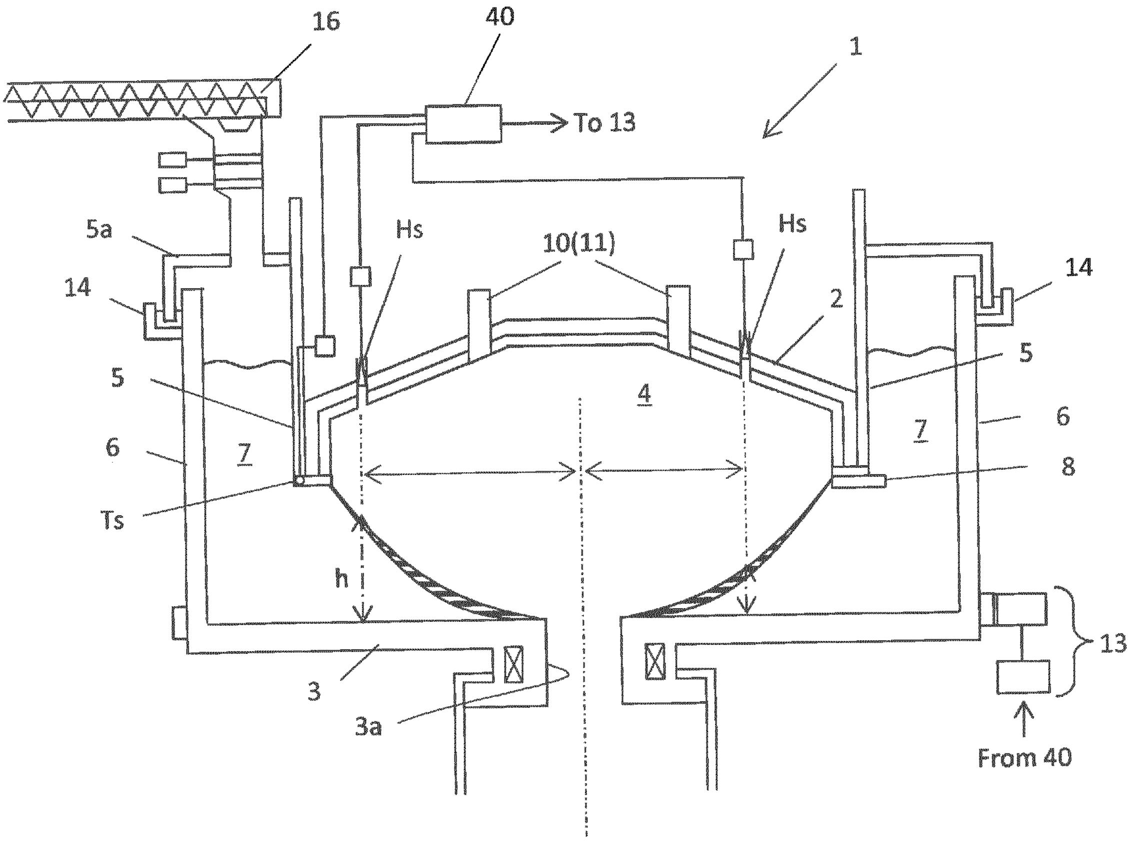

Fig.8

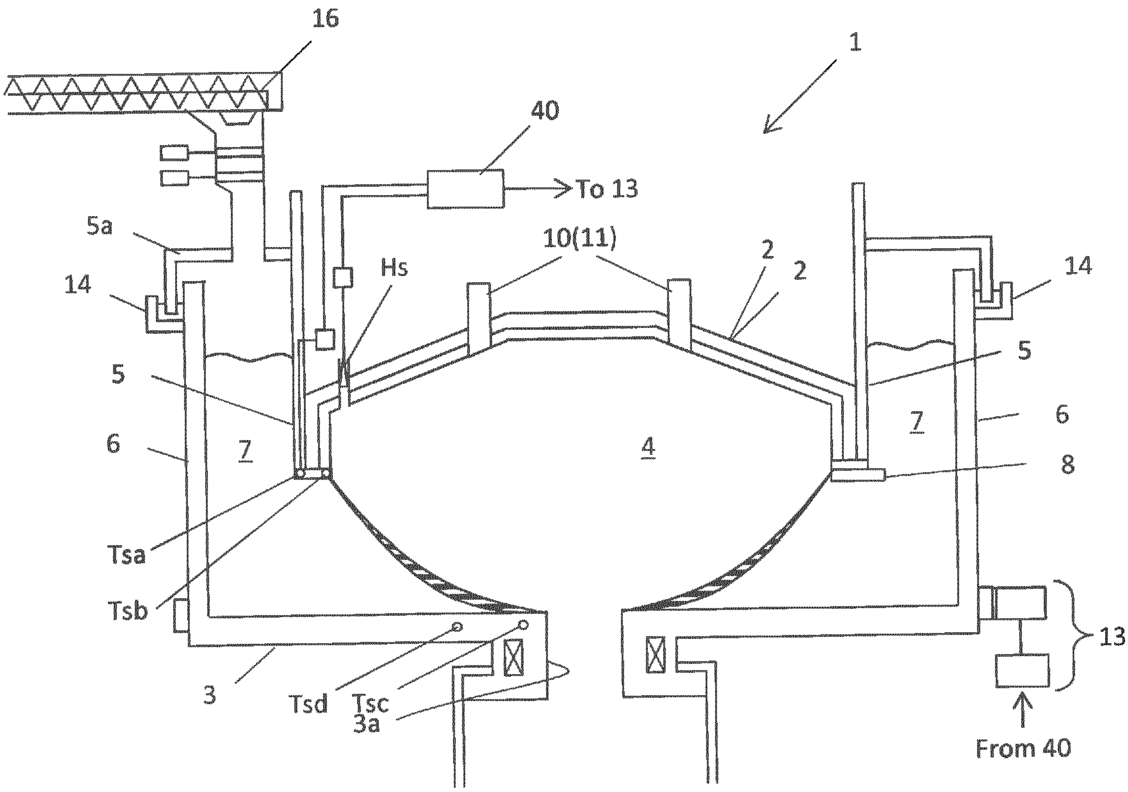
16
1
40
To 13
5a
10(11)
2
2
14
Hs
14
5
5
6
7
4
7
6
8
Tsa
Tsb
13
3
Tsd
Tsc
3a
From 40

Fig.9

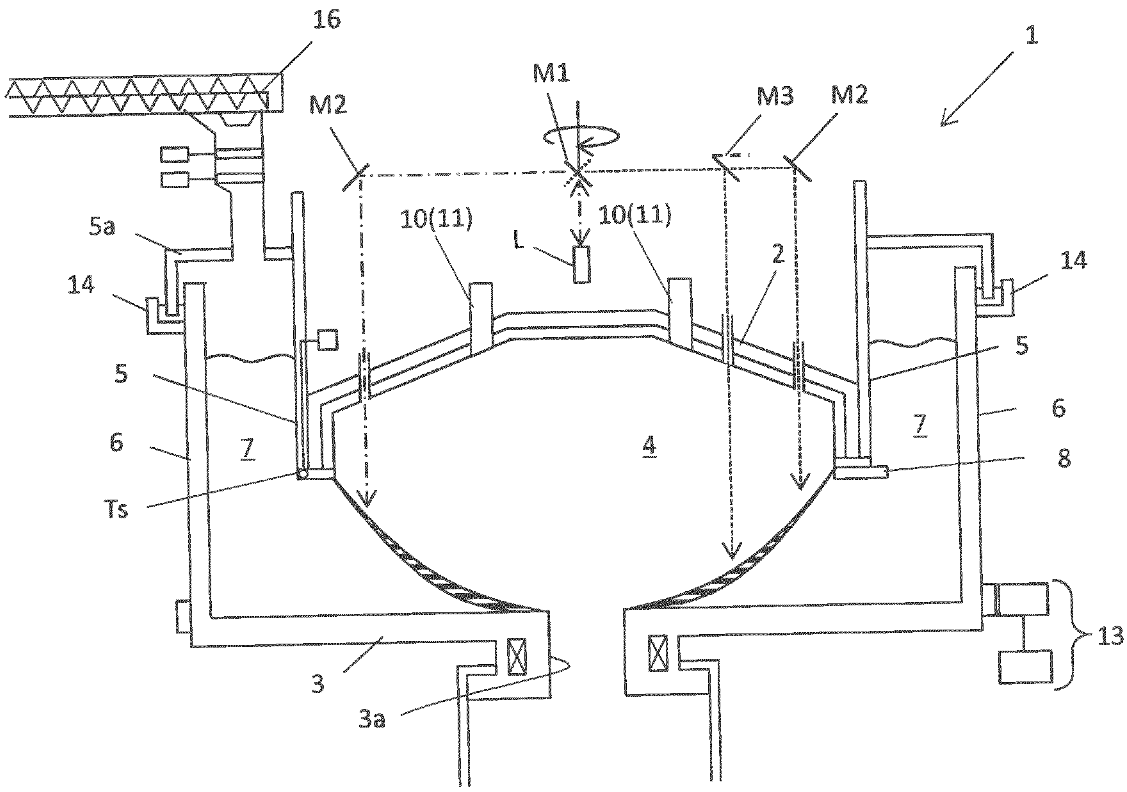

Fig.10

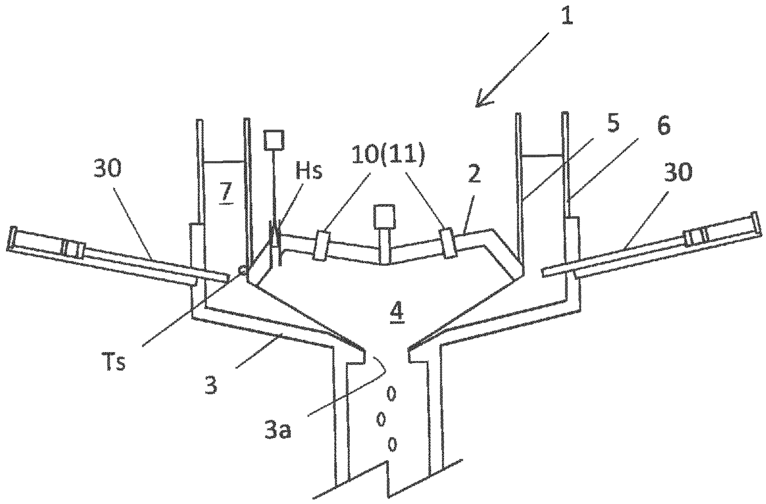

Fig.11A

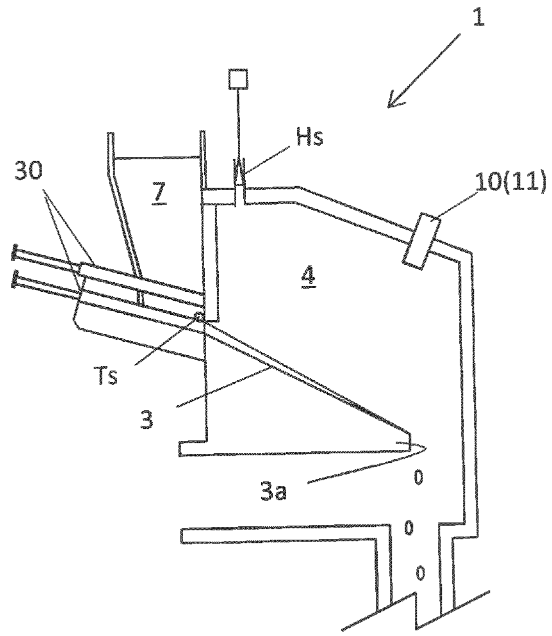

Fig.11B

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/059218

A. CLASSIFICATION OF SUBJECT MATTER
F23G5/00(2006.01)i, *F23G5/50*(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)
F23G5/00, F23G5/50

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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.
X Y	JP 2001-263638 A (Kubota Corp.), 26 September 2001 (26.09.2001), paragraphs [0003], [0032] to [0039], [0042]; fig. 1 to 4 (Family: none)	1,3-8 2
Y	JP 1-234710 A (Kubota Tekko Kabushiki Kaisha), 20 September 1989 (20.09.1989), page 2, upper left column, lines 1 to 7; fig. 5 (Family: none)	2

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2015 (26.05.15)	09 June 2015 (09.06.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP H11325434 A **[0009]**