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Sone

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[54] **PLASMA SMELTING FURNACE**

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[52] **U.S. Cl.** **13/1,** 13/31, 432/252

[51] **Int. Cl.** **F27b 3/00**

[58] **Field of Search** 263/10, 46; 13/31

[56] **References Cited**

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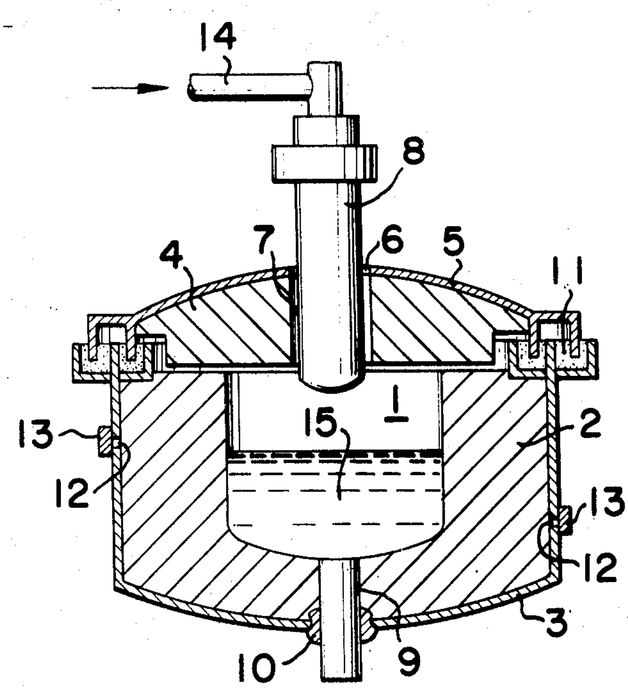
[57] **ABSTRACT**

The present invention discloses a plasma smelting furnace which is formed by enclosing the outside of a refractory which forms the smelting chamber with a metallic plate completely and the smelting chamber is sealed against the outer atmosphere, and further characterized by the fact that the air in the inner space enclosed by the metallic plate is substituted by inert gas.

5 Claims, 1 Drawing Figure



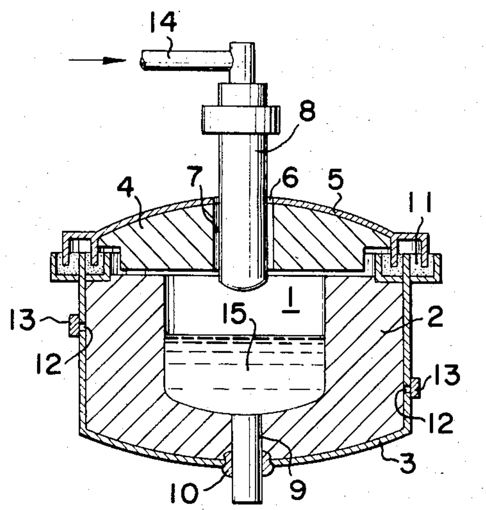

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FIG. 1

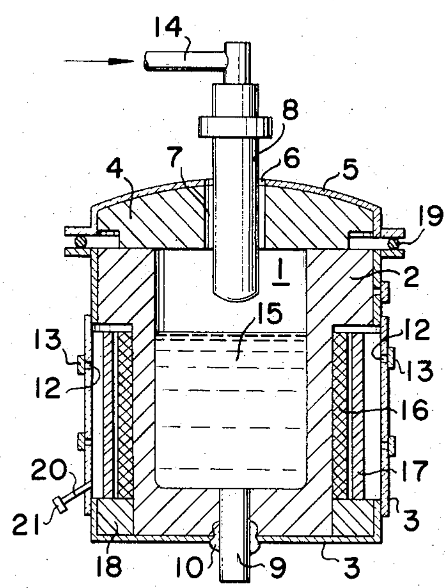
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FIG. 2

PLASMA SMELTING FURNACE

BACKGROUND OF THE INVENTION:

1. Field of the Invention:

The present invention relates to a plasma smelting furnace for melting metals by utilizing a plasma jet as the heat source, whereby the plasma gas atmosphere in the furnace is prevented from being contaminated.

2. Description of the Prior Art:

In a plasma smelting furnace for melting metals by utilizing a plasma jet as the heat source, it is necessary to prevent the atmosphere in the furnace from being contaminated with the open air by filling the furnace with the plasma gas in order to secure an advantageous effect of refining.

In plasma smelting furnace filled with plasma gas for generating a plasma jet, the pressure in the furnace as a whole becomes higher than the atmospheric pressure by 5 to 30 mm Hg. However, for example, even if the pressure in the furnace is as a whole higher than the atmospheric pressure to a certain extent, and where more than two locations for communicating the inside of the furnace with the open air are provided, the current of gas from those locations can cause introduction of atmospheric air.

Practically in a plasma smelting furnace, the plasma gas is supplied into the furnace through a plasma torch and the used plasma gas namely waste gas is exhausted through an exhaust orifice formed through the furnace proper or the furnace cover or through the gaps for exhaust formed in the circumference of the plasma torch which penetrates the furnace cover. Accordingly, in case the gas passages communicating the inside of the furnace with the open air other than these openings for exhaust are not sealed, it is very difficult to assure the effect of the plasma smelting by preventing the contamination of the atmosphere in the furnace.

Therefore, in a conventional plasma smelting furnace, efforts have been made to seal the furnace by employing an O-ring or sand at the tap hole or the furnace cover.

On the other hand, regarding the portion of the furnace proper which is heavily lined with the refractory, almost no attention has been paid for the open air leakage through the refractory lined on the furnace proper because of the fact that the refractory is the material to form a sealed wall or that the gas leakage through the refractory wall is extremely small and of the fact that the pressure in the furnace is slightly higher than the atmospheric pressure. Accordingly, there has been totally no concern as to how contamination of the atmosphere in the furnace due to such leakage of the open air can be avoided.

However, actually, the refractory which lines the furnace proper is generally a porous material so that it is not only incapable of forming a sealed wall for shielding the inside of the furnace completely from the open air but also tends to produce cracks on the refractory lining due to repetition of the expansion and contraction caused by the heating and cooling of the furnace even if it originally had a degree of sealability. In case such cracks are caused, the sealability of the refractory is lost and the gas leakage through the refractory wall cannot be avoided.

In general, in the conventional plasma smelting furnace, with a view to supporting and protecting the refractory which forms the furnace proper, the outside of the refractory is covered with the steel sheet, but this covering steel sheet is provided with a plurality of ventilating holes for drying the refractory lining which lines the furnace proper, and thus the function of sealing the furnace is carried out exclusively by the wall of the refractory. Furthermore, even in the conventional plasma smelting furnace that employs an induction electric heating including the conventional means for heating, in the portion where the induction coil is provided, the thickness of the refractory of the furnace proper is thinner, and each portion of the coil or the refractory of the inside of the coil is ordinarily supported by the coil itself, and therefore the sealed wall for shielding the inside of the furnace from the open air is formed by the refractory of the furnace proper.

Accordingly, in the conventional plasma smelting furnace, even though the tap hole or the connecting portion between the furnace proper and furnace cover is sealed, a gas passage exists between the inside of the furnace and the open air. This passage is formed by the pores of the refractory or the cracks caused on the refractory lining except the exhaust opening for the discharging of the waste gas, whereby open air enters the inside of the furnace by the gas leakage through this passage with the recognized disadvantages that the open air which enters even if it is of relatively small quantity, functions to contaminate the atmosphere of the inside of the furnace, instabilizes the generation of the plasma and reduces the heating effect of the plasma jet. The air is absorbed in the molten metal in the furnace and mixed therein to degrade the quality of the molten metal.

SUMMARY OF THE INVENTION:

The construction of the plasma smelting furnace of the present invention is based on the fact that the refractory which forms the furnace proper is porous and that during the use of the furnace, many cracks occur in the refractory lining. Therefore the whole of the furnace proper is covered completely with a metallic plate such as steel sheet and the inside of the furnace is completely sealed against the open air except the exhaust opening for discharging the waste gas. Thus the gas passage existing in the refractory lining which forms the furnace proper is completely shut off from the open air, and accordingly the atmosphere in the furnace is effectively prevented from being contaminated by entering of open air. Because of the above effective prevention, the desired effect by the plasma smelting, namely, the effective and rapid heating and maintenance of quality of the molten metal can be positively achieved.

The covering the whole of the furnace proper by a metal sheet in accordance with the present invention, can be carried out by utilizing a covering steel sheet which is generally used in the conventional plasma smelting furnace for the purpose of supporting and protecting the refractory which forms the furnace proper. In the present invention, a plurality of ventilating holes can be formed on the covering steel sheet for drying the refractory lining and therefore after the furnace is constructed and the refractory lining is sufficiently dried, a suitable cover can be mounted on the ventilating holes so that the metal wall is completely sealed by means of the covering steel sheet.

In order to further promote the plasma effect in the plasma smelting furnace of the present invention, it is desirable to substitute a suitable inert gas such as argon for the air existing between the metal sheet covering the whole of the furnace proper and the refractory of the furnace. If the air in the space between the metal sheet and refractory is replaced with the inert gas, the air from the smelting chamber is discharged and the plasma gas is filled and the plasma jet is generated, there is no cause for concern that the atmosphere in the furnace is contaminated by entrance of the air. Thus, more effective plasma effect can be obtained.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

The features and advantages of the present invention will be clearly appreciated by the following description with respect to the embodiments of the present invention by referring to the accompanied drawings.

FIG. 1 of the accompanied drawings is a sectional elevational view illustrating the metal smelting furnace of the present invention in which the plasma jet is used as the heat source; and

FIG. 2 is a sectional elevation showing the embodiment in which the present invention is applied to a metal smelting furnace that employs heating by a plasma jet and induction electric heating and stirring.

The plasma smelting furnace of the present invention as shown in FIG. 1 is formed in such a way that the circumferential side of the refractory 2 forming the crusible type smelting chamber 1 of the furnace and the total exterior surface of the bottom portion are completely covered by the covering steel sheet 3 and the top portion of the furnace is covered by the furnace cover 5 made of steel sheet which is lined with a change refractory lining 4 and a hole 6 is formed in the furnace cover 5 and the central portion of the lined refractory lining 4. The hole 6 is formed as a through hole to permit the formation of an annular gap 7 between its exterior circumferential wall and the inner wall of the hole whereby the tip portion of the plasma torch 8 inserted in the furnace is positioned at the top portion of the smelting chamber 1. At the bottom portion of the smelting chamber 1 is the furnace bottom electrode 9. At its outer end portion, the covering steel sheet 3 is penetrated and led to the outside by means of a suitable airtight insulating insulator 10. The joint between the covering steel sheet 3 and the furnace cover 5 is provided with the sand seal 11 to couple and seal the joint in an airtight manner, and if desired, a suitable number of ventilating holes 12 are bored in the covering steel sheet 3 and sealed by means of suitable detachable closing cover 13 as occasion demands the closing cover 13 is removed to effect the ventilation for drying the refractory, and also the operation of replacing the air existing between the refractory 2 and the covering steel sheet 3 with a suitable inert gas.

In order to operate the plasma smelting furnace as shown in FIG. 1, when the plasma gas is supplied into the smelting chamber 1 through the torch 8 from the air feeding tube 14 mounted on the plasma torch 8, the air existing in the smelting chamber is driven off outside of the furnace through an exhaust opening formed by the annular gap 7 around the torch 8. To fill the plasma gas in the smelting chamber 1 when the voltage for generation of the plasma is impressed between the torch 8 and the furnace bottom electrode 9, the plasma is generated and is jetted from the plasma jet to the material 15 in the smelting chamber 1 and thus the material 15 is heated and melted by the high temperature of the plasma jet.

During the operation of the furnace, the plasma gas is continuously fed into the furnace from the air feeding tube 14, and the plasma gas in the smelting chamber 1 which has been used is discharged outside of the furnace through the annular gap 7, but the smelting chamber 1 is completely sealed from the open air except for the exhaust opening formed by the annular gap 7. Thus even if the refractory 2 or the refractory lining 4 is of porous material, or the cracks are caused thereon, there is no cause for concern that the atmosphere in the furnace is contaminated as air or other undesired gas cannot enter, thus the desired plasma effect can be extremely effectively achieved.

The plasma smelting furnace of the present invention as shown in FIG. 2 is such that induction electric heating and stirring are jointly employed in the plasma smelting furnace which is shown in FIG. 1, with similar reference numerals being used for similar parts. The differences between the furnace shown in FIG. 2 to that of FIG. 1 are as follows: in the furnace of FIG. 2 the outer diameter of the lower half portion of the refractory 2 which forms the smelting chamber 1 of the furnace is reduced, and the annular coil 16 for induction heating is disposed on the outside of this reduced portion, and at the outside of the coil 16, an annular magnetic iron core 17 made of laminated iron sheets is disposed for the reduction of the leakage of the magnetic flux. The coil 16 and the magnetic iron core 17 are supported on a suitable heat resistant supporting base 18; the principal other difference is that the joined portions of the covering steel sheet 3 and the furnace cover 5 made of steel sheet are airtightly coupled and sealed by means of a heat resistant O-ring 19 instead of the sand seal. Another difference is that in order to replace the air existing in the space between the refractory 2 and covering steel sheet 3 with an inert gas such as argon, a tubular port 20 for ventilation is formed separate from the ventilating hole 12 for drying the refractory and the port 20 is closed by the closing plug 21.

The operation of the plasma smelting furnace as shown in FIG. 2 is such that the plasma jet which is generated by the plasma torch 8 is jetted to the material 15 to effect the heating of the material 15 and at the same time a suitable frequency alternating current is caused to flow to the annular coil 16 by a conventional method. The material is heated by the function of the induction current which is produced in the material and agitated but other operations are similar to those of the plasma smelting furnace as shown in FIG. 1.

In the conventional plasma smelting furnace, it has been recognized that when the furnace is just manufactured, or when the lining of the refractory is replaced, extremely good conditions result. When the lining or furnace is old not only is the generation of the plasma jet not stabilized but also a small quantity of the air enters the furnace when the refractory is exposed to the open air. By sealing the furnace cover or the tap hole of the furnace proper by means of an O ring, even though almost no crack of the refractory is recognized after the furnace is manufactured or the lining of the refractory is replaced, and when tne number of times of the use of the furnace is increased, cracks are formed on the refractory to even a slight extent, then the entering of the air into the atmosphere in the furnace is increased by at least several percent, oxygen then mixes with the molten metal to degrade the quality of the molten metal. To the contrary in the plasma smelting furnace of the present invention, not only when the furnace is new or the at the initial period of the replacement of the lining, but also even after the cracks are formed on the refractory due to the frequent use of the furnace, entering of air into the furnace from the outside is completely substantially blocked by the covering metallic sheet which encloses the furnace proper, and the mixing of the oxygen in the atmosphere in the furnace is confirmed to be dropped to less than 0.01 percent.

Table 1 shows the relationship between the sealed condition of the furnace chamber and the mixed quantity of the oxygen in the atmosphere of the furnace chamber and in the molten metal bath.

TABLE 1

Sealed condition of the furnace chamber	O_2 quantity in atmosphere (%)	O_2 quantity in molten metal bath (ppm[1])
Where the tap hole etc. other than waste gas exhaust opening is not sealed	3–15	45–70
Where the sealing cover is not used and cracks of refractory are recognized by naked eye[2]	0.2–5	35–50
Where no sealing cover is not used and cracks of refractory are not recognized by naked eye[2]	0.05–1.0	30–40
Where the sealing is effected completely by a covering metallic sheet according to the present invention	Less than 0.01	Less than 25

[1]The molten metal bath is a molten steel of high carbon chromium bearing steel (JIS:SOJ2)
[2]The cracks that can be recognized by the naked eye denote cracks of about 0.2–1 mm width and 10–50 mm length.

As will be clear from the foregoing description, according to the plasma smelting furnace of the present invention, it is possible to achieve the given effect or advantage of this plasma smelting by a simple construction in which the outside of the refractory which forms the furnace proper is enclosed completely by a metallic sheet and the gas passage between the smelting chamber other than the opening for exhausting waste gas and the open air is completely shut off; furthermore the air between the refractory and the metallic sheet as well as between refractories and/or cracks is replaced by an inert gas whereby its effect and advantage can be remarkably improved.

What is claimed is:

1. A plasma smelting furnace in which the plasma jet is used as the heat source comprising:

a. a refractory forming the smelting chamber;

b. means to completely enclose the outside of said smelting chamber to preclude the passage of gas between the smelting chamber and the open air except for an opening to exhaust the used plasma gas.

2. The furnace of claim **1** in which the space between the enclosing means and refractory is filled by an inert gas.

3. The furnace of claim **1** in which the enclosure means include a separate operable cover with sealing means between the cover and the remainder of the enclosure means.

4. The furnace of claim **2** in which the opening to exhaust the used plasma gas is a gap between the plasma jet and cover.

5. The furnace of claim **1** in which the enclosure means is a metallic sheet.

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