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(54) **Vacuum treating steels.**

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Description

The present invention relates to the processing of steels and other electroconductive metals.

The presence of dissolved gases, including hydrogen, oxygen and nitrogen, in metals, for example, steels can cause several undesirable effects, such as, internal ruptures or flaking, embrittlement, void formation and inclusions. It is desirable, therefore, to remove the dissolved gases prior to solidification of the metal and vacuum often is employed for such purpose. The molten metal is housed in a large chamber and is agitated to facilitate removal of the gases by vacuum applied to the chamber. This prior art operation, however, is somewhat unsatisfactory, in that a molten metal to be treated must be tapped from a furnace with sufficient temperature to withstand heat losses during treatment, and efficient removal of the gas is not achieved.

In accordance with the present invention, a novel method and apparatus of degassing metals is provided (compare present claims 1 and 7). Particularly preferred embodiments of present invention are defined in the dependent claims 2 to 6 and 8 to 10. The invention is particularly applicable to the treatment of molten steel and will be described mainly with reference thereto, but the invention is also applicable to any other electron-conductive metal. In the present invention, molten steel is drawn from a bath into a vertical column by the vacuum, a high frequency coil surrounds the vertical column and a high frequency alternating electrical current is passed through the coil to provide an electrical field which compresses and contracts the vertical steel rod away from its confining walls. In this way the whole of the outer surface of the rod is exposed to vacuum and gas is drawn from the considerable surface area of the thin steel rod exposed to the vacuum. The vacuum is then shut off, permitting the rod of degassed steel to return to the bath. The process then is repeated until all the gases have been removed. While being subjected to vacuum, the molten steel column is also inductively superheated by the eddy currents induced in the molten steel.

In addition to effecting efficient removal of dissolved gases from the molten steel, heat losses from the molten steel are minimized, since no conductive losses occur through contact with the confining walls and heat is added to the steel rod through the induced eddy currents.

As a result of the minimization of heat losses during treatment, the temperature at which the molten metal needs to be tapped from the furnace can be lower than in the prior art, typically about 1600°C for the present invention in comparison with about 1650°C for the prior art.

Although only a portion of the molten steel is treated at one time, the high efficency of gas removal from the large surface area of the thin steel rod enables the dissolved gas content of the steel to be depleted to a very low level in a manageable number of passes. Depending upon the volume of molten steel to be vacuum treated, a single treatment unit may be employed or a plurality of such treatment units may be used.

The invention is described further, by way of illustration, which reference to the accompanying drawings, in which:

Figure 1 of the drawings is a sectional view illustrating one embodiment of an apparatus for effecting vacuum treating of steel in accordance with one embodiment of the invention; and

Figure 2 is a close-up view of a portion of the apparatus of Figure 1.

Referring to the drawings, a steel-treating apparatus 10 comprises a pot 12 containing a bath 14 of molten stel to be treated. The bath may be stirred by any convenient procedure, for example, argon gas stirring or electromagnetic stirring.

A vacuum application unit 16 is used to effect treatment of the steel. The unit comprises a support member 18 which overlies the top of the pot 12 to enclose the molten steel bath 14. A hollow tube 22 extends through the support member 18 and dips into the bath 14. The tube 22 may be constructed of any convenient non-electrically-conducting and non-magnetic material, such as heat resistant refractory material.

The hollow tube at its upper end communicates with a vacuum line 24 whereby vacuum may be applied to the interior of the tube 22. An electrical coil 26 is wound around the exterior of the tube 22 and is connected to a source of high frequency alternating current (not shown).

While a single vacuum application unit 16 is illustrated for treatment of the molten steel bath 14, a plurality of such units 16 may be employed, the number depending on the volume of molten steel to be treated.

In operation, vacuum is applied to the interior of the tube 22 by vacuum line 24, causing a rod of molten steel 28 to be drawn up into the hollow tube 22. A high frequency alternating current, preferably at a frequency of about 25 to about 50 kHz, is passed through the coil 26. The resulting magnetic field establishes eddy currents in the molten steel red 28 which adds superheat and counteracts heat losses. The eddy currents also result in a repellant magnetic field which causes the molten steel rod 28 to contract radially inwardly and to become detached from the inner wall of the tube 22, as shown in the detailed close up of Figure 2.

Since the molten steel rod 28 is detached from the inside wall of the tube 22, the whole of the exterior surface of the steel rod 28 over the length of the coil 26 is exposed to the vacuum applied by the vacuum tube 24. The narrow diameter of the rod 28 and the large surface area of the rod which is exposed to the vacuum permit dissolved gases to be readily and substantially completely removed from the steel rod 28.

Once the vacuum treatment of the molten steel rod 28 is complete, the vacuum is shut off, permitting the vacuum treated rod 28 to return to the bath 14. When a plurality of vacuum application units 16 is used, the vacuum may be applied and released simultaneously to all or a selected number of the tubes 22 or may be applied and released sequentially to the tubes 22.

The procedure described above then is repeated a sufficient number of times to treat all the molten steel in the bath 14. In the vacuum treatment process, hydrogen, oxygen and nitrogen are removed, while carbon also is removed as a reaction product of carbon and oxygen.

The vacuum may have any desired value to achieve the drawing of the steel rod 28 into the tube 22 and to withdraw the dissolved gases from the molten steel rod. Usually, a vacuum of about 10 to about 300 torrs (about 13.3 to about 400 mbar) is used.

The number of cycles necessary to effect complete treatment depends on the overall volume of the molten metal, the diameter of the tube 22 and the value of the vacuum. Usually about 30 to 50 cycles is sufficient, with each cycle being about 30 to 60 seconds in duration.

The procedure of the invention enables dissolved gases to be removed from molten steel or other electroconductive metals efficiently and rapidly in an energy-efficient manner. The present invention thereby overcomes the problems of prior art procedures for vacuum treating of such metals.

In summary of this disclosure, the present invention provides a novel method and apparatus for vacuum treating of steel or other electroconductive metal to remove dissolved gases therefrom, which involves exposure of a large surface area of narrow thickness of the molten metal to the action of vacuum while simultaneously heating the metal.

Claims

1. A method for the vacuum treating of a molten electroconductive metal, such as steel consisting in applying vacuum to a tube dipping into a molten bath of an electroconductive metal to draw the molten metal into the tube and to form an elongate rod of the molten metal within the tube, and electromagnetically radially-inwardly compressing the elongate rod, so as the detach the elongate rod from the internal wall of the tube and to expose the external surface to the electromagnetically-compressed rod to the vacuum, therby to withdraw dissolved gases from the molten metal rod.

2. The method claimed in claim 1, characterized in that the electromagnetic compression is effected by forming an electric coil about the external surface of the tube and passing a high frequency alternating current through the coil.

3. The method claimed in claim 1, characterized by (a) prior to the vacuum application step, providing the molten bath of steel in a container, and inserting the tube into the molten bath so as to dip into the molten metal bath and to extend substantially vertically upwardly therefrom, and (b) following the electromagnetic compression of the molten metal rod and when the exposure of the external surface of the electromagnetically-compressed rod to the vacuum has been effected for a desired period of time, releasing the vacuum from the tube to permit the resulting vacuum-treated rod to fall back into the molten bath.

4. The method claimed in claim 3, characterized by being carried out repetitively for a desired number of cycles to permit substantially complete withdrawal of dissolved gases from all the metal in the molten bath.

5. The method claimed in claim 4, characterized by stirring the molten bath during the repetitive operations.

6. The method claimed in any one of claims 1 to 5, characterized in that a plurality of tubes are dipped into the molten bath to each of which vacuum is applied and the elongate rod in each tube is electromagnetically-compressed.

7. An apparatus for the vacuum treating of an electroconductive metal, having (a) an elongate tube (22) of heat-resistant non-electrically-conducting and non-magnetic material, having an internal bore and having one end adapted to be dipped into a molten bath (14) of electroconductive metal to be treated and the other adapted for the attachment of a vacuum line (24) thereto for application of vacuum to the bore; (b) a support member (18) through which the tube (22) projects a distance sufficient to dip into the bath (14) of molten metal when the support member (18) engages a pot (12) containing the bath (14) of molten metal and located adjacent one end of the tube (22); and (c) an electrical coil (26) wound about the external surface of the tube (22) in the region of the length of the tube (22) between the support member (18) and the other end of the tube (22).

8. The apparatus claimed in claim 7, characterized by means (24) for applying vacuum to the bore at the other end of the tube (22).

9. The apparatus claimed in claim 7 or 8, characterized by means for passing high frequency alternating current through the electrical coil (26).

10. The apparatus claimed in any one of claims 7 to 9, characterized in that the tube (22) is constructed of heat-resistant refractory material.

Patentansprüche

1. Verfahren zur Vakuumbehandlung einer Schmelze eines elektrisch leitenden Metalls wie beispielsweise Stahl, das darin besteht, daß ein Vakuum an ein Rohr gelegt wird, das taucht, um die Metallschmelze in das Rohr zu ziehen und einen langgesstreckten Stab der Metallschmelze im Rohr zu bilden, und daß der langgestreckte Stab elektromagnetisch radial nach innen zusammengedrückt wird, um den langgestreckten Stab von der Innenwand des Rohres zu lösen und die Außenfläche des elektromagnetisch zusammengedrückten Stabes dem Vakumm auszusetzen, damit dadurch gelöste Gase von dem Metallschmelzenstab abgezogen werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das elektronmagnetische Zusammendrücken dadurch bewirkt wird, daß eine elektrische Spule um die Aussenfläche des Rohres herum ausgebildet und ein Wechselstrom mit hoher Frequenz durch die Spule geleitet wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß a) vor dem anlegen des Vakumms das Stahleschmelzbad in einem Behälter vorgesehen wird und das Rohr in das Metallschmelzbad so eingeführt wird, daß es in das Metallschmelzbad eintaucht und davon im wesentlichen vertikal nach oben verläuft, und b) anschließend an das elektromagnetische Zusammendrücken des Metallschmelzenstabes und dann, wenn die Außenfläche des elektromagnetisch zusammengedrückten Stabes über ein gewünschtes Zeitintervall dem Vakuum ausgesetzt ist, das Vakuum vom Rohr abgenommen wird, damit der sich ergebende vakuumbehendelte Stab in das Schmelzbad zurückfallen kann.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß es wiederholt in einer gewüschten Anzähl von Zyklen ausgeführt wird, um im wesentlichen vollständig die gelösten Gase von dem gesamten Metall im Schmelzbad abziehen zu können.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß das Schmelzbad während der wiederholten Arbeitsvorgänge gerührt wird.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß eine Vielzahl von Rohren in das Schmelzbad getaucht wird, en jedem von denen ein Vakuum angelegt wird, und der langgestreckte Stab in jedem Rohr elektromagnetisch zusemmengedrückt wird.

7. Vorrischtung zur Vakuumbehandlung eines elektrisch leitenden Metalls mit a) einem langgestreckten Rohr (22) aus einem warm-festen, elektrisch nicht leitenden und nicht magnetischen Material, das eine Innenbohrung aufweist und mit einem Ende in ein Schmelzbad (14) des zu behandelnden elektrisch leitenden Metalls getaucht werden kann, während das andere Ende an einer Vakuumkeitung (24) angebracht werden kann, um ein vakuum an die Bohrung zu legen b) einem Halteelement (18), durch das das Rohr (22) um eine Strecke vorsteht, die ausreicht, em es in das Bad (14) der Metallschmelze zu tauchen, wenn das Halteelement (18) mit einem Topf (12) in Eingriff kommt, der das Bad (14) der Metallschmelze enthält und neben einem Ende des Rohres (22) angeordnet ist, und c) einer elektrischen Spule (26), die um die Außenfläche des Rohres (22) im Bereich der Länge des Rohres (22) zwschen dem Halteelement (18) und dem anderen Ende des Rohres (22) gewickelt ist.

8. Vorrichtung nach Anspruch 7, gekennzeichnet durch Einrichtungen (24) zum Angelen eines Vakumms an die Bohrung am anderen Ende des Rohres (22).

9. Vorrichtung nach Aspruch 7 oder 8, gekennzeichnet durch Einrichtungen zum Leiten eines hochfrequenten Wechslestromes durch die elektrische Spule (26).

10. Vorrichtung nach einem der Anspüche 7 bis 9, dadurch gekennzeichnet, daß das Rohr (22) aus einem warm-festen, feuerfesten Material besteht.

Revendications

1. Un procédé de traitment par le vide d'un métal électroconducteur à l'état fondu, tel que l'acier, consistent à appliquer le vide à un tube trempant dans un bain d'un métel conducteur à l'état fondu pour aspirer le métal fondu à l'intérieur de tube et à comprimer électromagnétiquement, radialement vers l'intérieur, le tige allongée afin de détacher la tige allongée de la paroi interne du tube et d'exposer la surface externe de la tige comprimée électromagnétiqument à l'action du vide, pour extraire les gaz dissous de la tige de métal fondu.

2. Le procédé selon le revendication 1, caractérisé en ce que le compression électromagnétique est réalisée par formation d'une bobine électrique autour de la surface externe du tube et passage d'un courant alternatif haute fréquence à travers la bobine.

3. Le procédé selon le revendication 1, caractérisé en ce que (a) avant l'étape d'application du vide, on place le bain d'acier fondu dans un récipient, et on insére le tube dans le bain de métal fondu de façon qu'il trempe dans le bain de métal feondu et se prolonge substantiellement verticalement vers le haut depuis ce bain, et (b) aprés la compression électromagnétique de la tige de métal fondu et lorsque l'exposition à l'action du vide de la surface externe de la tige comprimée électromagnétiquement a été effectuée pendant une période de tempts désirée, on casse le vide du tube pour permettre à la tige traitée par le vide résultante de retomber dans le bain fondu.

4. Le procédé selon la revendication 3, caractérisé en ce qu l'on répète le traitement pendant un nombre de cycles désiré pour permettre l'extraction substantiellement compléte des gaz dissous de la totalite du métal dans le bain fondu.

5. Le procédé selon la revendication 3, caractérisé en ce qu l'on agite le bain fondu durant les opérations répétitives.

6. Le procédé selon l'une quelconque des revendications 1 à 5, caractérisé en ce que plusieurs tubes sont trempés dans le bain fondu, le vide est appliqué à chacun de ces tubes, et la tige allongée dans chaque tube est comprimée électromagnétiquement.

7. Un appareil pour le traitement par le vide d'un métal électroconducteur, comprenant (a) un tube allongé (22) en un matériau thermiqument résistant, non-conducteur électrique et non-magnétique, ayant un alésage interne et une extrémité destinée à trempée dans un bain fondu (14) de métal électroconducteur a traiter tandis que l'autre extrémité est agencée pour la fixation d'une conduite de vide (24) pour l'application du vide à l'alésage; (b) un élément de support (18) à travers lequel le tube (22) fait saillie d'une distance suffisante pour tremper dans le bain (14) de

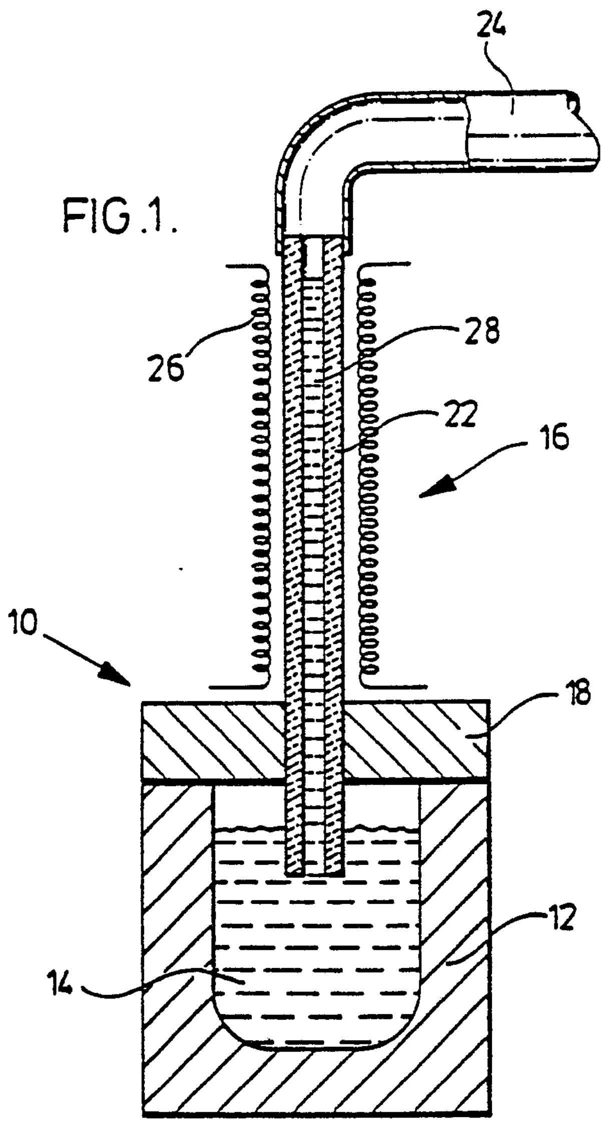
métal fondu lorsque l'élément de support (18) est monté un creuset (12) contenant le bain (14) de métal fondu et disposé au voisinage d'une extrémité du tube (22); et (c) une bobine électrique (26) enroulée autour de la surface externe du tube (22) dans la région de la lougueur du tube (22) comprise entre l'élément de support (18) et l'autre extrémité du tube (22).

8. L'appareil selon la revendication 7, caractérisé par un dispositif (24) pour appliquer le vide à l'alésage à l'autre extrémité du tube (22).

9. L'appareil selon la revendication 7 ou 8, caractérisé par un dispositif pour faire passer un courant alternatif haute fréquence à travers le bobine électrique (26).

10. L'appareil selon l'une de revendications 7 à 9, caractérisé en ce que le tube (22) est construit en un matériau réfractaire thermiquement résistant.

FIG.1.



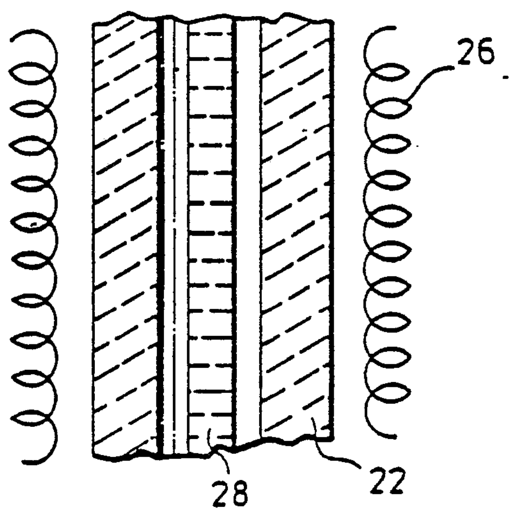


FIG.2.