MEANS FOR INDUCTIVE STIRRING

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ABSTRACT
Means for inductive stirring of melt of metal or metal alloy in a ladle or furnace, comprising at least two electro-magnetic multiphase stirrers being oppositely positioned at the sides of said ladle.

2 Claims, 9 Drawing Figures
MEANS FOR INDUCTIVE STIRRING

This application is a continuation-in-part of application Ser. No. 795,086 filed Jan. 29, 1969 and now abandoned by Per Erik Hammalmund and Yngve Sundberg entitled "Means for Inductive Stirring."

BACKGROUND OF THE INVENTION

The present invention relates to a means for inductive stirring in a ladle, furnace or other container for melt of metal or metal alloy. A conventional type of multiphase inductive stirrer is designed as a cylindrical member applied outside a stainless steel or other gas-tight casing around a ladle or furnace or other metallurgical container. By selection of a low frequency in the order of magnitude of 0.1 – 10 cycles per second, the field from the stirrer can be made to penetrate the metal casing and satisfactory motoric stirring can be obtained (according to the asynchronous motor principle where a moving field pulls melt with it, as when the field from the stator in an asynchronous motor pulls the rotor round with it). It may sometimes be difficult to find room for, or for other reasons, to arrange such a cylindrical stirrer around a ladle, etc., since certain protruding parts of the ladle, etc., may make suitable positioning of the stirrer around the ladle impossible, at least near enough to this for the stirring of the melt to be effective. With a conventional cylindrical stirrer, moreover, it is impossible to make alterations in the stirring other than to alter the stirring force and direction, not the pattern.

STATEMENT OF THE INVENTION

The present invention aims at a solution of these and other similar problems and is characterized in that at least two two-phase or multi-phase electromagnetic stirrers are oppositely positioned at the sides of the ladle. Due to this arrangement stirrers can also be positioned near ladles, etc., having conical or not completely cylindrical outer surfaces, for example ladles having lifting means, furnaces with various mechanical details surrounding them, such as tilting means with extra hooks (see FIG. 4, part 16) charging means, etc., Martin furnaces, etc. By selecting the stirring direction for the different stirrers it is possible to vary the stirring direction and stirring plan.

DESCRIPTION OF THE DRAWING

The invention is further exemplified in the accompanying drawings in which,

Figs. 1 – 4 show a ladle with two stirrers and;
Fig. 5 a ladle with four stirrers;
Figs. 6, 7, 8 and 9 illustrate the stirrers with means for energizing them to produce the desired stirring patterns.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a ladle 11 containing steel melt. The ladle is provided (as seen in FIG. 4) with two lifting means 14, 15 which prevent the use of cylindrical stirrers. The ladle (or furnace) 11 may, for example, be provided with a vacuum tight lid with evacuation means or with a suitable gas tight lid with through-running electrodes (not shown) and shall be provided with stirrers which are either permanently applied to the ladle or movable in relation to this.

In the case shown two two-phase or multi-phase stirrers 12, 13 are positioned diametrically or almost diametrically at those parts of the ladle or furnace wall where the distance to the melt is short (the ratio between this distance and the height of the stirrer should be as small as possible for the stirrer to be effective.)

The stirrers 12, 13, straight or somewhat curved, can be fed with opposite phase sequence so that a stirring pattern is obtained in accordance with FIG. 1, with the same phase sequence so that the moving field moves either upwards, in which case a pattern according to FIG. 2 is obtained, or downwards, in which case a pattern according to FIG. 3 is obtained.

For example, during degassing a stirring pattern according to FIG. 2 is desired where contact between slag floating on the surface of the melt and the wall of the ladle or furnace is avoided as far as possible.

(The slag is in this case collected at the center of the surface.) When the slab is to be separated the stirring is altered to a pattern according to FIG. 1 so that separation can take place in the right-hand part in the figure of the ladle. It is sometimes desirable to have the central part of the melt free from slag, for example during temperature measurement or sampling, and in such a case the stirring pattern according to FIG. 3 may be used.

In order to accelerate homogenization of component alloy constituents it is possible to alternate between the different stirring patterns (FIGS. 1, 2 or 3).

The means according to FIGS. 1 – 3 may possibly also be supplemented by a normal bottom stirrer 21 of multiphase electromagnetic type. The phase number is often two for the stirring current, in which case each stirrer can be fed from two thyristor-controlled DC generators, but it may also be multiphase from different conventional current sources. The frequency is chosen between 0.1 – 10 cycles per second so that the magnetic field can pass easily through the metal sheath (often stainless steel) of the ladle (furnace) and bring about effective stirring.

(The stirrers may also be applied to arc furnaces, Martin furnaces, and often when the dimensions make cylindrical stirrers impossible). The stirring force can be varied, for example be kept high at the start of a stirring process and then decreased continuously or in several steps. The stirrers may also be controlled and/or fed quite independently of each other.

The ladle may sometimes be provided with more than two stirrers, for example four, placed according to FIG. 5 (see 17, 18, 19 and 20). In certain cases the stirrers in each pair may be placed not quite diametrically, for example due to various obstructions.

Means for energizing the stirrers 12 and 13 to produce the results described for FIG. 1–3 are shown in the FIGS. 6, 7 and 8.

In the FIGS. 6, 7 and 8 the stirrers 12 and 13 are again shown. Each includes Y-connected three-phase coils 22, 23 and 24 having a common connection at 25. The three coils are energized by the three-phase voltage source 26 with phases R, S, T as shown in FIG. 9. Switches 27 provide means to energize each of the coils in two alternative phase sequences.

In FIG. 6 the switch 27 for stirrer 13 is in the position shown such that the stirrer 13 is fed with the phase sequence R, S, T which will produce a magnetic field

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moving in the upward direction of the arrow A, and thus, the stirring force is in the upward direction of the arrow A. Similarly, the switch 27 for the stirrer 12 in FIG. 6 is positioned such that the coils are fed with the phase sequence R, S, T directed upwards, so that again the magnetic field and the stirrer force is in the upward direction as indicated by arrow B. Thus, the stirring pattern in FIG. 6 is as shown by the curved arrows, and therefore, is the same as that shown in FIG. 2.

In FIG. 7 the switching arrangement for the stirrer 13 is unchanged from that of FIG. 6. Therefore the direction of the magnetic field and stirring is unchanged and upward as indicated by the arrow A. However, for the stirrer 12 the switch 27 has been moved to the downward position indicated, and thus, the phase sequence R, S, T has been changed so that the magnetic field, and consequently, the direction of stirring is downwards as indicated by the arrow B. Therefore the stirring pattern is now as indicated in FIG. 1.

In FIG. 8 the switch 27 of stirrer 13 has been moved to its downward position so that the phase sequence R, S, T for the coil 13 is downward so that the movement of the magnetic field is downwards as is also the stirring motion. The switch 27 for the stirrer 12 in FIG. 8 has been unchanged from that shown in FIG. 7 so that the direction of the magnetic field and the direction of stirring for stirrer 12 is downward. Therefore in FIG. 8 the pattern of stirring is as indicated for FIG. 3.

The invention according to the above can be varied in many ways within the scope of the following claims.

What is claimed is:

1. In combination:
   a. a ladle for molten metal;
   b. at least two vertically directed multiphase electromagnetic stirrers positioned opposite each other at the sides of the ladle for controlling the movement of slag across the upper surface of the molten metal by stirring the metal as a whole alternatively in one of three alternative directions as follows:
      a. mutually different upward-downward directions of the moving fields of the stirrers to move the slag to one side of the ladle;
      b. upwardly directed directions of the moving fields of both stirrers to move the slag to the center of the ladle;
      c. downwardly directed directions of the moving fields of both stirrers to position the slag around the periphery of the ladle;
   2. The combination as in claim 1 in which at least four stirrers are positioned around the ladle, equally spaced around the periphery of the ladle.

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