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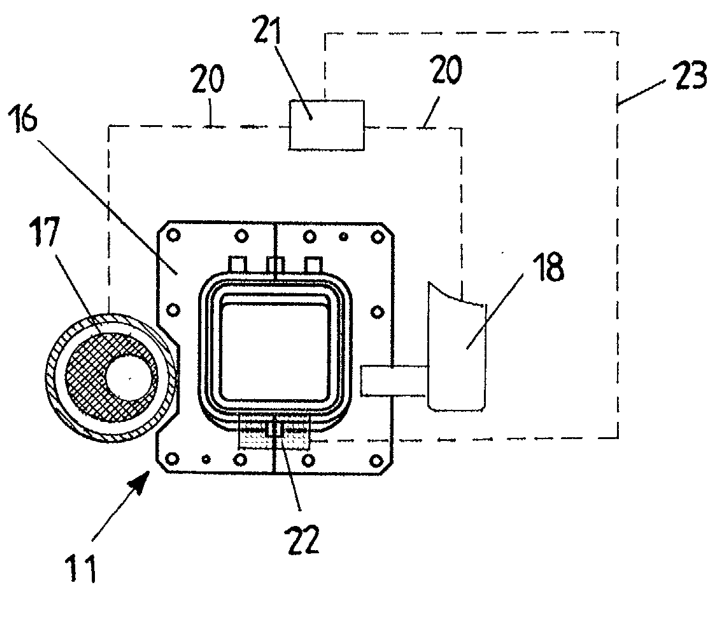
(54) **Method and device for controlling the level of steel in a continuous casting mold**

(57) A method for controlling the level of steel in continuous casting in an ingot mold, wherein there are provided a radioactive detector (17, 18) and a thermal detector (22) in the proximity of a level (19) of the steel fed to an ingot mold (13) by a casting duct (15) wherein in a first initial step for regulating the continuous casting method, the radioactive detector (17, 18) is actuated at a high speed of detection of changes in the level (19) of steel, and in a second step at steady condition, as soon as the start up transient has finished, the high-precision steel level (19) thermal detector (22) is actuated.

Fig.3



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Description

[0001] The present invention relates to a method and a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets.

[0002] It is known that the method for producing steel in continuous casting, first created for producing basic steels, has progressively developed to a more advanced quality.

[0003] For example, billets currently produced with this method are required to exhibit almost absolute surface and sub-surface integrity, which can only be obtained by non-linear (parabolic and derivative) taper ingot molds and with the precise control of functional parameters.

[0004] Among these essential parameters, the control of steel level in an ingot mold is certainly important. This applies to both what relates to the absolute value (that is, the exact detection of the meniscus position) and to what relates to the stability of such value, the first one since it determines the initial size of the skin being moulded and the consequent conditions of cooling of the billet, and the second one since it is a potential cause of inclusions caused by covering dust in the steel thus produced.

[0005] To this purpose, a number of methods for detecting the steel level in an ingot mold have been produced so far, but each of them exhibits a series of inaccuracies that makes them not sufficiently reliable. Gross errors even occur in known methods, above all if applied to small sized ingot molds (that is, having a side up to 160 mm).

[0006] With reference to the above prior art, it can be noted that the methods used so far can be summarised as radioactive, optical, magnetic and thermal methods.

[0007] The method based on a radioactive level measurement is the most widespread. This method reads the variation in a radioactive flow darkened by the level of steel present in the ingot mold.

[0008] It must be underlined that a recent survey conducted on a continuous casting machine for billets has shown a considerable inaccuracy in the determination of the absolute value of the steel level. This occurs due to the uneven formation of solidified slag between the steel meniscus and the same ingot mold wall. Such slag screen radioactive rays and alter the actual value of steel level even by 30/40 mm.

[0009] Moreover, it should not be forgotten that this method exhibits a high speed of detection of the variations in the steel level, which is associated to the low accuracy in the determination of such level value.

[0010] The second method, of the optical type, acts by reading the level of light emitted by the meniscus surface or the light of a luminous beam reflected by the covering dust.

[0011] This method is almost exclusively used in free casting since it detects the upper portion of what is present in the ingot mold and is not capable of distinguishing between steel, slag or covering dust.

[0012] Moreover, such behaviour turns dust thickness errors into coarse errors of evaluation of the level of the same steel.

[0013] In any case, it should not be forgotten that the optical method maintains a high speed of detection of variations in the steel level. However, it should also be underlined that there is an absolute inaccuracy in the level determination due to the above difficulties.

[0014] The third method, of the magnetic type, essentially consists in a sensor (a coil) detecting the variations of magnetic "resonance" surrounding it. This method is mainly used for controlling the steel level in continuous casting for thick slabs or blooms since it is much affected by the variations of magnetic permeability of the ingot mold copper as temperature changes.

[0015] This type of problem requires the sensor to be arranged at a considerable distance from the ingot mold walls; this particular prediction is not feasible in continuous casting for billets, for reasons of size, due to their very small size.

[0016] In any case, it can be said that the magnetic method exhibits a high speed of detection of variations in the steel level, beside a good accuracy in the level determination. On the other hand, the magnetic detection method cannot be used for producing small sections (for example, smaller than 160 mm) and has a very high purchase cost.

[0017] Finally, the fourth known measurement method is that called thermal method, and is based on the fact that the thermal spectrum on the ingot mold wall is function of the steel level. Thus, in this detection method, the level of the same steel is read in an indirect manner through the detection of the ingot mold wall temperature.

[0018] Such temperature measurement occurs through the use of micro-thermocouples inserted into the copper wall of the ingot mold, or through the detection of the magnetic permeability variation induced in copper by the different temperature.

[0019] Unfortunately, the thermal nature of the method causes a response delay and the resulting hysteresis is the reasons why the same method is generally not used in particular cases.

[0020] In any case, the thermal method exhibits an excellent accuracy in the determination of the level (if read in precise conditions) but exhibits the defect of having absolute unreliability in the dynamic detection of level variations.

[0021] All of the above causes serious problems to obtain a measurement of steel level meeting all requirements to have an optimum control over the continuous casting method. This is even more felt in particular for the production of small section billets mentioned above.

[0022] Thus, a general object of the present invention is to find a different solution to the technical problem mentioned above.

[0023] Another object is to realise a method and a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, which should be adapted for carrying out the above task, even though being easy to operate.

[0024] These objects according to the present invention are achieved by realising a method and a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, as illustrated in the attached independent claims.

[0025] Further important features and details of the present invention are illustrated in the dependent claims.

[0026] The features and advantages of a method and a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, according to the present invention, will appear more clearly from the following detailed description of an embodiment made by way of a nonlimiting example with reference to the attached drawings. In such drawings:

- figure 1 is a first side elevation section view of an ingot mold for billets to which a device for controlling the level of steel according to the present invention is attached;
- figure 2 is a second side elevation section view of the device of figure 1;
- figure 3 is a top plan view of the device shown in figures 1 and 2.

[0027] With general reference to the various figures, there is shown a schematic view of a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, according to the present invention, indicated with reference numeral 11. Such device 11 is arranged in the proximity of an outside wall 12 of a copper ingot mold 13 with square section, around which a water conveyor 14 is arranged for cooling it during the steel continuous casting operations. Steel is fed through a casting duct 15 directly connected to a tundish (not shown) that allows realising a series of sequences in the desired number.

[0028] Moreover, for example, such water conveyor 14 is provided with a flanging 16 at which device 11 according to the present invention is arranged.

[0029] Device 11 comprises a radioactive detector and a thermal detector. In particular, it can be noted that the radioactive detector comprises a radioactive source 17, for example realised with cobalt 60, and a scintillator 18, among which a radioactive flow sets up. Such flow remains constant until it is darkened by a level 19 of steel present in the ingot mold entering from the casting duct 15. Thereby, there occurs a variation of a radioactive flow that indicates the variation of position of level 19 of steel into the ingot mold 13.

[0030] A special connection line 20 is connected to a central processor 21 that receives the variation signal and commands a limitation or an increase of steel feeding from the casting duct 15 to maintain the level 19 of steel constant.

[0031] Device 11 of the invention for controlling the level of steel in continuous casting in an ingot mold also comprises a thermal detector, globally indicated with reference numeral 22, also connected to the central processor 21 through its own connection line 23.

[0032] Such thermal detector 22 checks the thermal spectrum on wall 12 of ingot mold 13 based on the level 19 of steel. Such measurement of temperature is carried out, for example, through the detection - by the thermal detector 22 - of the variation of magnetic permeability induced in the copper wall 12 of ingot mold 13.

[0033] Such combination of radioactive detectors 17, 18 and thermal detector 22 allows correcting all technical problems of the prior art.

[0034] In fact, by using the two radioactive detectors 17, 18 and the thermal detector 22 at the same time, the resulting assembly exhibits much better features than those of known devices.

[0035] Moreover, such device allows realising a new and original method for controlling the level of steel in continuous casting ion an ingot mold, in particular for small sized billets.

[0036] In fact, after a first initial step for regulating the continuous casting method in an ingot mold 13 for billets, the radioactive detector 17, 18 is actuated at a high speed of detection of changes in the level 19 of steel. In fact, in this first step a broad detection of the level that sets up is sufficient since, among the other things, the solidified slag is minimal.

[0037] This type of detection allows a quick, effective and quite precise start up of the casting operation.

[0038] In a second step at steady condition, as soon as the start up transient has finished, the thermal detector 22 is actuated, which signals the steel level 19 to processor 21.

[0039] Such thermal detector 22 detects with the utmost accuracy the steel level 19, once the temperature of copper of wall 12 of ingot mold 13 has reached the predetermined level.

[0040] In this way, the control of the level of steel in an ingot mold for small sized billets is optimised.

[0041] In fact, the first detector 17, 18 exhibits a high dynamic response capability (about 0,10 seconds) whereas the second detector 22 is highly accurate when reading the level (excluding the transients).

[0042] It is thus confirmed that the new method for controlling the level consists of the radioactive system, which operates in a traditional manner during the automatic start up step and during the initial regulation step. Afterwards, the level value detected by the thermal system (suitably filtered in time to ensure the utmost accuracy) corrects the value assumed by the radioactive system according to its priority, adjusting it to the new condition. In this way, the correction of quick variations of the level relies on the quick response of the radioactive system, which starts the regulation based on the reference determined by the thermal system as absolute value.

[0043] It has thus been noted that a method and a device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, according to the present invention, achieve the objects mentioned above.

[0044] The method and the device for controlling the level of steel in continuous casting in an ingot mold, in particular for small sized billets, of the present invention thus conceived, can be subject to several changes and variants, all falling within the scope of the same invention.

[0045] Moreover, in the practice, the materials and units used, as well as their size and components, can be of any type according to the technical requirements.

Claims

1. Method for controlling the level of steel in continuous casting in an ingot mold, wherein there are provided a radioactive detector (17, 18) and a thermal detector (22) in the proximity of a level (19) of the steel fed to an ingot mold (13) by a casting duct (15) wherein in a first initial step for regulating the continuous casting method, said radioactive detector (17, 18) is actuated at a high speed of detection of changes in the level (19) of steel, and in a second step at steady condition, as soon as the start up transient has finished, said high-precision steel level (19) thermal detector (22) is actuated.

2. Method according to claim 1, **characterised in that** said radioactive detector (17, 18) detects a variation of a radioactive flow for signalling the variation of position of said steel level (19) into said ingot mold (13).

3. Method according to claim 1, **characterised in that** said thermal detector (22) detects the variation of temperature of the copper of a wall (12) of said ingot mold (13).

4. Method according to claims 1-3, **characterised in that** a central processor (21) receives variation signals from said detectors (17, 18; 22) and commands a limitation or an increase of steel feeding from said casting duct (15) to maintain said level (19) of steel constant.

5. Device for controlling the level of steel in continuous casting in an ingot mold, arranged at an upper portion of an ingot mold (13) in the proximity of a level (19) of the steel fed to an ingot mold (13) by a casting duct (15), **characterised in that** it comprises a radioactive detector (17, 18) and a thermal detector (22) arranged in the proximity of said level (19) of said steel fed, wherein said radioactive detector (17, 18) and thermal detector (22) are connected to a central processor (21) that receives variation signals of said level and commands a limitation or an increase of steel feeding from said casting duct (15) to maintain said level (19) of steel constant.

6. Device according to claim 5, **characterised in that** said radioactive detector (17, 18) comprises a radioactive source (17) and a scintillator (18) between which a radioactive flow sets up, which passes through said level (19) of steel.

7. Device according to claim 5, **characterised in that** said thermal detector (22) is installed to detect the temperature of said wall (12) of said ingot mold (13).

Fig.1

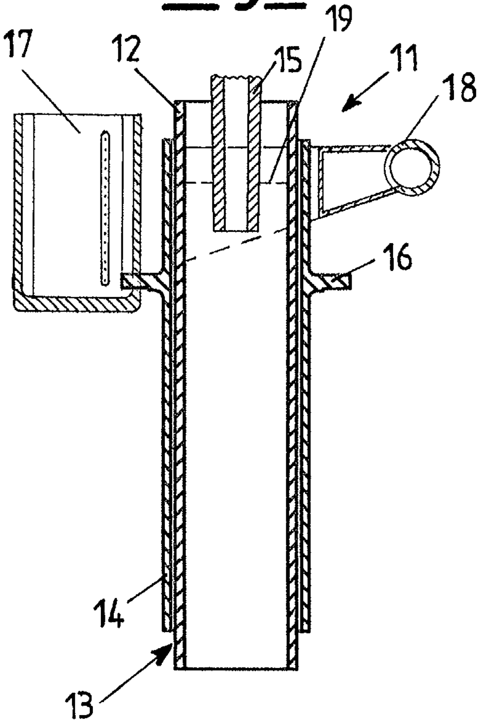

Fig.2

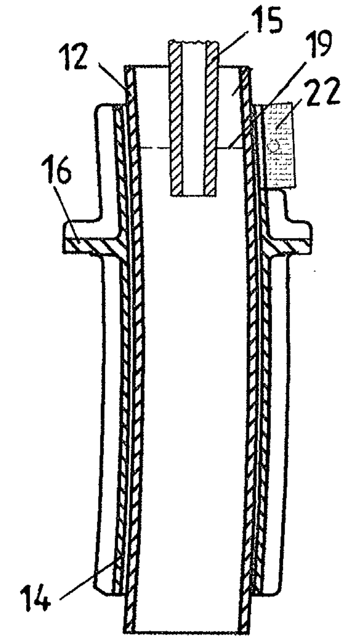

Fig.3