



(11)

EP 2 868 405 A1

(12)

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

(43) Date of publication:
06.05.2015 Bulletin 2015/19

(51) Int Cl.:
B22D 11/16 (2006.01)

(21) Application number: **12879691.9**

(86) International application number:
PCT/KR2012/011552

(22) Date of filing: **27.12.2012**

(87) International publication number:
WO 2014/003269 (03.01.2014 Gazette 2014/01)

(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

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(30) Priority: **28.06.2012 KR 20120069876**

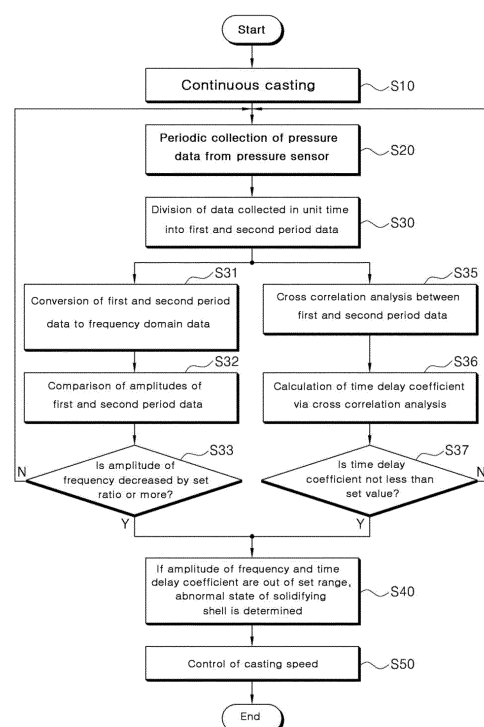
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(54) **BREAKOUT PREVENTION METHOD IN CONTINUOUS CASTING**

(57) Disclosed is a method for preventing a breakout of molten steel in a solidifying shell in a mold in continuous casting. The method includes periodic collection of pressure data of a cylinder of a mold oscillator, division of the pressure data into first and second period data, conversion of respective period data to frequency-domain data, analysis of power spectra of the converted data, calculation of a time delay coefficient associated with a delay in signal via a cross correlation analysis between the first and second period data, and control of the casting speed according to results of power spectra analysis and cross correlation analysis.

[Drawings 4]



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Description**Technical Field**

5 [0001] The present invention relates, in general, to a breakout prevention method in continuous casting and, more particularly, to a breakout prevention method in continuous casting, which prevents a breakout of molten steel contained within the solidifying shell in a mold by collecting, from a pressure sensor, pressure signals generated during the oscillation of the mold in continuous casting and analyzing them.

10 **Background Art**

[0002] Generally, a continuous casting machine is equipment that produces a metal section by casting molten steel, which is produced in a steelmaking furnace and supplied to a continuous casting mold via a ladle and then a tundish, into the specified size of castings.

15 [0003] A continuous casting machine includes a ladle that stores molten steel, a tundish, a mold that first cools and forms the molten steel drained from the tundish into a metal section having a specified shape, and a plurality of pinch rolls connected with the mold so as to move the metal section.

[0004] In operation, the molten steel supplied into the mold from the ladle through the tundish is cast into the metal section with specified width, thickness, and shape, and the metal section is conveyed by the pinch rolls and is cut into metal products such as slabs, blooms, billets or the like.

20 [0005] As a related art technology, a segment breakout prevention method and apparatus for continuous casting are disclosed in Korean Patent No. 10-0705245 (registered on April 9, 2007).

Disclosure

25

Technical Problem

[0006] Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and an object of the present invention is to provide a breakout prevention method in continuous casting, which can predict and cope with a possibility of a breakout of molten steel in a solidifying shell in a mold by way of analysis of the size and time delay of a change in pressure using a pressure sensor mounted on a cylinder of a hydraulic mold-oscillator in order to prevent the breakout of molten steel in the solidifying shell in the mold.

30 [0007] Technical problems to be solved by the present invention are not limited to the above-mentioned problem, and other problems will be definitely understood by a skilled person in the art to which the present invention pertains, from the following description.

35

Technical Solution

[0008] In order to accomplish the above object(s), the present invention provides a method for preventing a breakout of molten steel in a solidifying shell in a mold in continuous casting, the method including: periodically collecting time-domain pressure data about a change in pressure of a cylinder of a mold oscillator from a pressure sensor mounted onto the cylinder; dividing the pressure data into first and second period data, converting respective period data to frequency-domain data, and analyzing power spectra of the converted data; calculating a time delay coefficient associated with a delay in signal by analyzing pressure data collected in a unit time with respect to a cross correlation between the first and second period data; and comparing amplitudes of respective frequencies of the first and second period data obtained via the analysis of the power spectra with each other, and controlling a casting speed when the amplitude of the frequency of present time period data in the first and second period data is reduced from that of previous time period data in the first and second period data by a reference ratio or more and the calculated time delay coefficient is not less than a reference value.

50 [0009] The reference ratio for the amplitudes of the frequencies may be 7% or more, and the reference value for the time delay coefficient may be 5 or more.

[0010] The first period data may have at least 10 samples of pressure data collected at 1 second intervals from 1 second to 10 seconds before the present time, and the second period data may have at least 10 samples of pressure data collected at 1 second intervals from the present time to 9 seconds before the present time.

55 [0011] When all of the amplitude of the frequency and the time delay coefficient deviate from set ranges, the casting speed is reduced to prevent the breakout.

Advantageous Effects

[0012] According to the present invention, pressure of a mold cylinder is compared and determined based on a certain reference, thereby providing an effect of easy prediction of a breakout occurring in the solidifying shell.

[0013] Further, the casting speed is controlled while reflecting the possibility of a breakout during the continuous casting, thereby providing an effect of prevention of a breakout in the solidifying shell.

Description of Drawings

[0014]

FIG. 1 is a conceptual view of a continuous casting machine associated with an embodiment of the present invention, showing a flow of molten steel.

FIG. 2 is a conceptual view of the distribution of molten steel M in a mold and surroundings.

FIG. 3 is a view of a breakout prevention apparatus in a continuous casting mold according to an embodiment of the present invention.

FIG. 4 is a flowchart showing a breakout prevention procedure in continuous casting according to an embodiment of the present invention.

FIG. 5 is a view showing analysis periods of pressure signals according to an embodiment of the present invention.

FIG. 6 is a graph showing analysis of power spectra according to an embodiment of the present invention.

FIG. 7 is a graph showing cross correlation analysis according to an embodiment of the present invention.

Best Mode

[0015] Reference should now be made to the drawings, in which the same reference numerals are used throughout the different drawings to designate the same or similar components. Further, when conventional functions and components may make the gist of the present invention unclear, a detailed description of those elements will be omitted.

[0016] FIG. 1 is a conceptual view of a continuous casting machine associated with an embodiment of the present invention, showing a flow of molten steel.

[0017] Continuous casting is a casting process that continuously produces metal sections or steel ingots while solidifying molten steel in a base-open mold. Continuous casting is used to produce an elongated product having a simple sectional shape such as a square, a rectangle, a circle or the like, and other products including slab, bloom, and billet for subsequent rolling.

[0018] The continuous casting machine has a vertical type, a vertical-curved type, or the like. FIG. 1 shows a vertical-curved type continuous casting machine.

[0019] Referring to FIG. 1, the continuous casting machine may include a ladle 10, a tundish 20, a mold 30, a secondary cooling zone 60 and 65, and pinch rolls 70.

[0020] The tundish 20 is a container that receives molten steel from the ladle 10 and supplies it to the mold 30. In the tundish 20, the control of feed speed of molten steel drained into the mold 30, the distribution of the molten steel to respective molds 30, the storage of the molten steel, the separation of slag and non-metallic inclusion, and the like take place.

[0021] The mold 30 is generally a water-cooled copper mold in which the molten steel is primarily cooled. The mold 30 has a hollow portion whose both sides are opened and in which molten steel is stored. The mold 30 has a pair of long-side walls and a pair of short-side walls to connect the long-side walls in order to produce a metal section. Here, the short-side wall has an area smaller than that of the long-side wall. The walls of the mold, mainly the short-side walls, are moved closer to or away from each other, forming a specified level of taper. This taper is set to compensate for contraction of molten steel M in the mold 30 due to its solidification. The degree at which the molten steel M is solidified varies depending on carbon content according to the kind of steel, kind of powders (for intensive cooling or slow cooling), casting speed or the like.

[0022] The mold 30 serves to maintain the shape of a metal section to be drawn from the mold and to form a hard solidifying shell 81 so as to prevent molten steel contained in the solidifying shell from spilling out of the solidifying shell. The water-cooling method includes a method using a copper plate, a method using a copper block having a water-cooling groove therein, a method using an assembled copper pipe having a water-cooling groove therein, and the like.

[0023] The mold 30 oscillates vertically by an oscillator 40 to prevent the molten steel sticking to the walls of the mold. A lubricant is used to reduce the friction between the mold 30 and the solidifying shell 81 during the oscillation of the mold and to prevent the burning thereof. The lubricant includes oil to be sprayed onto an object, and powders to be added onto the surface of molten steel in the mold 30. The powders are added to the molten steel to form slag, and function to prevent oxidation/nitrification of the molten steel in the mold 30 and to absorb non-metallic inclusion floating

on the surface of the molten steel, as well as to lubricate the mold 30 and the solidifying shell 81. A powder feeder 50 is installed to supply the powders into the mold 30. An outlet of the powder feeder 50 is directed towards an inlet of the mold 30.

[0024] The secondary cooling zone 60 and 65 serves to additionally cool the primarily cooled molten steel in the mold 30. The primarily cooled molten steel is supported by support rolls 60 so that the solidifying shell is not deformed, and is cooled directly by a sprayer 65 for spraying water. The solidification of the metal section is mostly carried out by the secondary cooling.

[0025] A drawing apparatus employs a multi-drive manner in which sets of pinch rolls 70 are used to draw the metal section without being slid. The pinch rolls 70 draw a solidified leading end of the molten steel in the casting direction so that the molten steel passing through the mold 30 can travel continuously in the casting direction.

[0026] In this continuous casting machine configured as such, molten steel M contained in the ladle 10 is drained into the tundish 20. To this end, a shroud nozzle 15 is provided to the ladle 10 to extend towards the tundish 20. The shroud nozzle 15 extends and is submerged into the molten steel in the tundish to prevent oxidation/nitrification of the molten steel M due to exposure to air.

[0027] The molten steel M contained in the tundish 20 is drained into the mold 30 through a submerged entry nozzle 25 extending into the mold 30. The submerged entry nozzle 25 is arranged, passing through the center of the mold 30, thereby allowing the molten steel M to be symmetrically discharged from opposite outlets at an end side of the nozzle 25 towards the inside of the mold. Start of discharge of the molten steel M through the submerged entry nozzle 25, the discharge speed of the molten steel, and interruption of the discharge of the molten steel are determined by a stopper 21 installed in the tundish 20 correspondingly to the submerged entry nozzle 25. Specifically, the stopper 21 can be vertically moved along the inside of the submerged entry nozzle 25 so that it can open and close an inlet of the submerged entry nozzle 25. Unlike the manner using the stopper, the discharge of the molten steel M may be controlled by using a slide gate. The slide gate is configured such that a plate slidably moves in the horizontal direction in the tundish 20 in order to control the amount of molten steel M to be discharged through the submerged entry nozzle 25.

[0028] The molten steel M in the mold 30 starts solidifying from the portion in contact with wall sections of the mold 30. This is because heat exchange between the edge surfaces of the molten steel M and the water-cooled mold 30 is easier, than between middle portion of the molten steel M and the water-cooled mold 30. With this configuration in which the surroundings of the molten steel M is first solidified, a tailing portion of the metal section 80 in the casting direction is in a state that the solidifying shell 81 surrounds still-molten metal 82.

[0029] As a completely-solidified leading end 83 of the metal section 80 is drawn out by the pinch rolls 70, the still-molten metal 83 is moved together with the solidifying shell 82 in the casting direction. The still-molten metal 82 is cooled by the sprayer 65 spraying water, allowing the thickness of the still-molten metal 82 in the metal section 80 to gradually decrease. When arriving at a specified point 85, the metal section 80 completely solidifies so that the solidifying shell 81 forms the entire thickness of the metal section. The completely solidified metal section 80 is cut in a specified size at a cut point 91, into a product P such as a slab or the like.

[0030] The shape of the molten steel M in the mold 30 and its surroundings will be described with reference to FIG. 2. FIG. 2 is a view showing the distribution of the molten steel M in the mold 30 and its surroundings.

[0031] Referring to FIG. 2, the submerged entry nozzle 25 is generally provided on the end side with a pair of opposite outlets 25a on the left and right sides of the figure. Provided that the shapes of the mold 30 and the submerged entry nozzle 25 are symmetrical with respect to the center line C, only the left sides of the mold and the nozzle are depicted in the figure.

[0032] The molten steel M is discharged out of the outlets 25a along upward and downward flow paths indicated by arrows A1 and A2, together with Ar gas.

[0033] A powder layer 51 is formed over the molten steel in the mold 30 by supplying powders using the powder feeder 50 (see FIG. 1). The powder layer 51 may include a layer of powders as supplied and a layer of powders sintered by heat of the molten steel M (the sintered layer is formed closer to the still-molten metal 82). Below the powder layer 51 is provided a slag layer or liquid-flowing layer 52 formed by powders being melted by the molten steel M. The liquid-flowing layer 52 serves to maintain temperature of the molten steel M in the mold 30 and to prevent the permeation of foreign substances. A portion of the powder layer 51 is solidified on the wall of the mold 30 to form a lubrication layer 53. The lubrication layer 53 serves to lubricate the solidifying shell 81 and the mold 30 to prevent the solidifying shell 81 from sticking to the mold 30.

[0034] The thickness of the solidifying shell 81 becomes thick in the casting direction. The solidifying shell 81 positioned in the mold 30 is thinner, and often has oscillation marks 87 generated by oscillation of the mold 30. The solidifying shell 81 is supported by the support rolls 60, and becomes thicker by the sprayer 65 spraying water. The solidifying shell 81 may have a bulging region 88 that is a protruded portion on the side toward which it becomes thicker.

[0035] A breakout means that the solidifying shell 81 in the mold breaks for any reason, so molten steel confined in the solidifying shell spills out therethrough.

[0036] Since the breakout causes damage to the casting equipment and reduces productivity, technologies to predict

and prevent this have been developed and adapted to continuous casting machines.

[0037] In the case of a method using the detection of variation and amplitude of friction, however, applicability is low due to such factors as powder-flowing characteristics, the non-homogeneity of the solidifying shell and the like.

[0038] Before the breakout takes place, a variation in pressure of a mold cylinder oscillating vertically generally occurs in the mold due to a tear by restraint or crack of the solidifying shell and to shell-expansion by thickness-reduction of the solidifying shell, and resistance force is generated in opposite direction to the oscillation of the mold as the friction force between the solidifying shell and the mold increases, so that the pressure decreases further than the development of a variation in pressure at a normal state. In addition, a specified amount of signal delay also occurs.

[0039] The variation in pressure and the amount of signal delay is proportion to resistance force of relative movement between the mold and the solidifying shell, and this resistance force is proportion to the degree of damage (restraint, crack, spilling-out of molten steel, etc.) of the solidifying shell in the mold. Thus, the present invention is intended to quantify the variation in pressure and the amount of signal delay in order to predict a breakout.

[0040] FIG. 3 is a view of a breakout prevention apparatus in a continuous casting mold according to an embodiment of the present invention. The breakout prevention apparatus includes pressure sensors 110a and 110b mounted on hydraulic cylinders of a hydraulic mold-oscillator, a signal analysis unit 120 that receives pressure signals from the pressure sensors 110a and 110b and determines the variation in pressure and signal delay, and a casting speed-control unit 130 that controls the casting speed when the signal analysis unit 120 determines pressure data deviate from set reference values.

[0041] More specifically, the hydraulic cylinders can respectively be coupled to left/right short-sides of the mold, to which left/right pressure sensors 110a and 110b are respectively attached so as to detect the pressure of respective hydraulic cylinders. Of course, if required, more hydraulic cylinders can be attached to the mold, so more pressure sensors can be mounted to the hydraulic cylinders.

[0042] The signal analysis unit 120 periodically collects pressure signals from the pressure sensors positioned on both sides of the mold in a unit time and predicts the possibility of a breakout by continuously performing the analysis of power spectra and cross correlation analysis of the pressure signals and determines whether pressure data exceed respective reference values or not. Here, the signal analysis unit 120 determines an abnormal state of the solidifying shell only when all the results of both power spectra analysis and cross correlation analysis deviate from the respective reference values.

[0043] When the signal analysis unit 120 determines and predicts the abnormal state of the solidifying shell, the casting speed-control unit 130 controls rpm of the pinch rolls 70 to decrease the casting speed, thereby preventing breakout in the solidifying shell.

[0044] FIG. 4 is a flowchart showing a breakout prevention procedure in continuous casting according to an embodiment of the present invention. The breakout prevention procedure will be described with reference to the accompanying drawings. Although the possibility of the breakout is determined by individually analyzing pressure signals from the left and right pressure sensors 110a and 110b according to the present invention, for convenient of explanation, only the pressure signal from one of the pressure sensors will be described.

[0045] When a continuous casting machine starts performing continuous casting (S10), the signal analysis unit 120 periodically collects pressure signals from pressure sensors mounted on a hydraulic mold oscillator in a unit time (S20). Here, a sampling frequency of pressure signals from the pressure sensor collected by the signal analysis unit 120 preferably has a range ranging five times the frequency of the mold. Although the frequency of the mold varies according to the casting speed, on average, it ranges from 2 to 3 Hz, so the sampling frequency preferably ranges from 15 Hz to 300 Hz. Although a higher sampling frequency produces precise results due to the higher resolution of a waveform, it may function in an adequate range, taking account of a processing speed. Further, the signal analysis unit may collect the pressure signals at 1 second intervals in a unit time of 10 seconds.

[0046] The signal analysis unit 120 divides the pressure data collected in a unit time into first and second period data (S30). That is, as shown in FIG. 5, the first period data may have at least 10 samples of pressure data collected at 1 second intervals from 1 second to 10 seconds before the present time, and the second period data may have at least 10 samples of pressure data collected at 1 second intervals from the present time to 9 seconds before the present time. The reason why the pressure data consist of 10 samples of pressure data is because the unit time is 10 seconds. Here, the reason why the unit time assumes not 1 second, but 10 seconds, is because an increased number of parameters can increase the precision of analysis. Of course, it is possible to increase or decrease the unit time if required. Here, the first period and the second period may also be called 'the present time period' and 'the previous time period', respectively, for convenience of explanation.

[0047] In order to determine amplitudes of signals with the magnitude of pressure, the first and period data are converted into data in the frequency-domain from the time-domain and the frequency-domain data of the first period, i.e. the present time period, and those of the second period, i.e. the previous time period, are analyzed with respect to their power spectra in the frequency domain (S31). Here, the power spectra mean a correlation with respect to a variation in power according to frequencies, i.e. the square of amplitude-frequency reaction, being Fourier transform of an autocorrelation

function.

[0048] As shown in FIG. 6, a normal state or an abnormal state can be determined by comparison between power spectra of the first and second period data (S32). Specifically, amplitudes of frequencies of the first and second period data in amplitudes of frequencies obtained via the comparison of power spectra are compared with each other, and when the amplitude of the frequency of the data at a relatively present time period in the first and second period data is lower than that of the other data at a relatively previous time period in the first and second period data by a reference ratio or more, an abnormal state is determined (S33). For instance, when the amplitude of the frequency of the second period data at the present time period is lower than that of the frequency of the first period data at the previous time period by a set reference ratio, i.e. 7% or more, it is determined that the solidifying shell is in an abnormal state.

[0049] Referring in detail to FIG. 6, the left-side graph shows pressure signals from the pressure sensor mounted on the mold. When the mold oscillates, the pressure of the cylinder varies with time in response to the oscillation of the mold. Here, unlike in a normal state, when an abnormal state or the occurs in the mold, such as a tear of the solidifying shell due to a restraint or crack of the solidifying shell, or shell-expansion due to reduced thickness of the solidifying shell, distortion of the pressure signals occurs, and the amplitude of the frequency is lowered as well.

[0050] Here, although the frequency varies with an oscillation frequency of the mold, as shown in the right graph of FIG. 6, the highest peak frequency is a frequency corresponding to the oscillation frequency of the mold, and the other components are harmonic-wave components of the oscillation frequency of the mold. The upper part of the right-side graph indicates the first period data converted in the frequency-domain, and the lower part of the right-side graph indicates the second period data converted in the frequency-domain. In the graph, the amplitude of the frequency corresponding to the oscillation frequency of the mold in the first period is compared with that of the frequency corresponding to the oscillation frequency in the second period, and when the amplitude of the frequency in the second period is lower than that of the frequency in the first period by a set ratio or more, an abnormal state is determined.

[0051] In the meantime, in order to determine the signal delay with the pressure signals, the signal analysis unit 120 performs cross correlation analysis between the first and second period data in the pressure data collected in a unit time (S35) so as to calculate a time delay coefficient according to the signal delay (S36). The cross correlation analysis uses a conventional cross correlation analysis algorithm, so a detailed description thereof will be omitted.

[0052] The time delay coefficient is calculated by Cross Correlation Analysis Formula using pressure data in a predefined previous time period and in a present time period in such a manner that the calculated time delay coefficient and a predefined reference value are compared with each other, and when the time delay coefficient is larger than the reference value, it is determined that the solidifying shell is in an abnormal state (S37). Here, the reference value for the time delay coefficient is 5 or more, so if the time delay coefficient is less than 5, the solidifying shell is determined to be in a normal state, but if the time delay coefficient is not less than 5, the solidifying shell is determined to be in an abnormal state. Here, the reference value for the time delay coefficient is a constant obtained by repeated tests.

[0053] The cross correlation for calculating a time delay for two signals will be described in more detail with reference to FIG. 7.

[0054] In the upper graph of FIG. 7, the one-dot chain line indicates pressure of a cylinder in the first period data (data in the previous time period), i.e. the pressure of the cylinder in a normal state, and the two-dot chain line indicates pressure of a cylinder in the second period data (data in the present time period), i.e. the pressure of the cylinder in an abnormal state.

[0055] In the first and second period data shown in the graph, a specified time of signal delay is shown along the time-axis. The contact force between the solidifying shell and the mold increases due to a tear by restraint or crack of the solidifying shell and to shell-expansion by thickness-reduction of the solidifying shell causing resistance to vertical oscillation of the mold, so that a slight time delay occurs compared to vertical oscillation of the mold in the normal state. The degree of the time delay can be quantified via a correlation calculation for calculating similarity between two signals and the degree of the time delay.

[0056] When performing the cross correlation analysis on the first and second period data shown in the upper graph of FIG. 7, the analysis result is shown in the lower graph. In the lower graph, the dotted line indicates a normal state upon the cross correlation analysis, and the solid line indicates the abnormal state upon the cross correlation analysis. That is, in the lower graph, the dotted line shows the result of the cross correlation calculation for two signals in the normal state-previous time period and the normal state-present time period, and the solid line shows the result of the cross correlation calculation for two signals in the normal state-previous time period and the abnormal state-present time period.

[0057] The result of the cross correlation calculation is expressed by the relation between the time delay (x-axis) and the magnitude of the correlation (y-axis). The similarity between two signals can be known with the time delay (x-axis) at the maximum magnitude (y-axis) of correlation. Here, the time delay is indicated by the time delay coefficient.

[0058] According to the result of the cross correlation calculation shown in the lower graph, the dotted line shows the cross correlation calculation result for normal state-data and normal state-data in which a value, i.e. a time delay coefficient, of x-axis at a maximum value of y-axis, is zero, and the solid line shows the cross correlation calculation result

for normal state-data and abnormal state-data in which a value, (i.e. a time delay coefficient), of x-axis at a maximum value of y-axis, is approximately 6.

[0059] Here, as the value (time delay coefficient) of x-axis at the maximum value of y-axis approaches zero, it is indicated that the two signals are similar and are within a normal range, and as the time delay coefficient is 5 or more, it is indicated that the two signals have low similarity and are within an abnormal range.

[0060] Finally, if the power spectrum analysis indicates that the amplitude of the frequency (corresponding to the oscillation frequency of the mold) in the second period data is reduced from that of the frequency (corresponding to the oscillation frequency of the mold) in the first period data by not less than 7%, i.e. a set ratio, and the cross correlation analysis indicates that the time delay coefficient is not less than 5, i.e. a set reference value, it is determined that the solidifying shell in the mold is in an abnormal state with the possibility of a breakout occurring on the solidifying shell (S40). In this case, the casting speed control unit 130 controls rpm of the pinch rolls 70 to decrease the casting speed, thereby preventing a breakout of the solidifying shell (S50).

[0061] According to the present invention, if the power spectrum analysis of the cylinder-pressure signals indicates that the amplitude of the frequency in the present time period is reduced from that in the previous time period by 7% or more, and the cross correlation analysis indicates that the time delay coefficient becomes 5 or more, it is determined that an abnormal state such as restraint, a tear, a crack or the like has taken place on the solidifying shell in the mold, thereby predicting that a breakout on the solidifying shell will occur. Further, from the prediction of the breakout, the casting speed is controlled, so that the breakout can be prevented.

[0062] The breakout prevention method in continuous casting is not limited to the configuration and operation of the above-mentioned embodiments. The illustrated embodiments may be modified into various forms via selective combination of the whole or a part of the embodiments.

<Description of the Reference Numerals>

[0063]

10:	Ladle	15:	Shroud nozzle
20:	Tundish	25:	Submerged entry nozzle
30:	Mold	31:	Left short-side
35:	Right long-side	40:	Mold oscillator
50:	Powder feeder	51:	Powder layer
60:	Support roll	65:	Sprayer
70:	Pinch roll	70:	Metal section
81:	Solidifying shell	82:	Molten metal
110a, 110b:	Pressure sensor	120:	Signal analysis unit
130:	Casting speed control unit		

Claims

1. A method for preventing a breakout of molten steel in a solidifying shell in a mold in continuous casting, the method comprising:

periodically collecting time-domain pressure data about a change in pressure of a cylinder of a mold oscillator from a pressure sensor mounted onto the cylinder;
dividing the pressure data into first and second period data, converting respective period data to frequency-domain data, and analyzing power spectra of the converted data;
calculating a time delay coefficient associated with a delay in signal by analyzing pressure data collected in a unit time with respect to a cross correlation between the first and second period data; and
comparing amplitudes of respective frequencies of the first and second period data obtained via the analysis of the power spectra, and controlling a casting speed when the amplitude of the frequency of present time period data of the first and second period data is reduced from that of previous time period data of the first and second period data by a reference ratio or more and the calculated time delay coefficient is not less than a reference value.

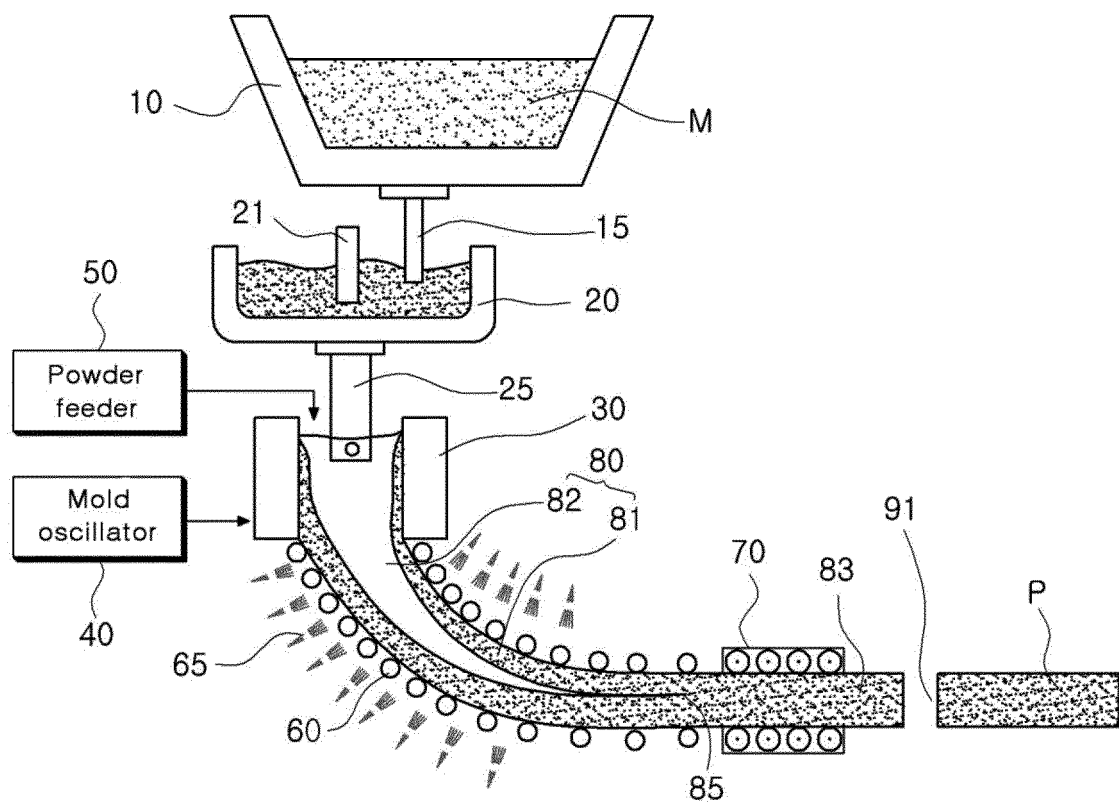
2. The method of claim 1, wherein the reference ratio for the amplitudes of the frequencies is 7% or more.

3. The method of claim 1, wherein the reference value for the time delay coefficient is 5 or more.

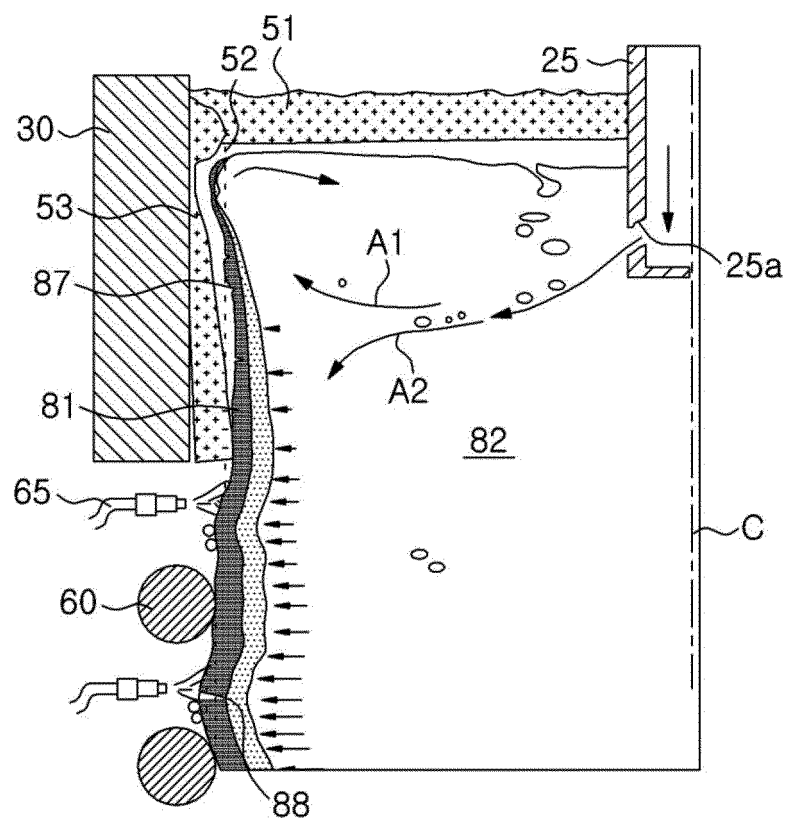
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4. The method of claim 1, wherein the first period data has at least 10 samples of pressure data collected at 1 second intervals from 1 second to 10 seconds before the present time, and the second period data has at least 10 samples of pressure data collected at 1 second intervals from the present time to 9 seconds before the present time.
5. The method of claim 1, wherein the pressure data is collected at 1 second intervals.
6. The method of claim 1, wherein a sampling frequency in which the pressure data is periodically collected ranges from 15 Hz to 300 Hz.
7. The method of claim 1, wherein the amplitude of the frequency is that of the frequency corresponding to an oscillation frequency of the mold.
8. The method of claim 1, wherein, when all of the amplitude of the frequency and the time delay coefficient deviate from set ranges, the casting speed is reduced to prevent the breakout.

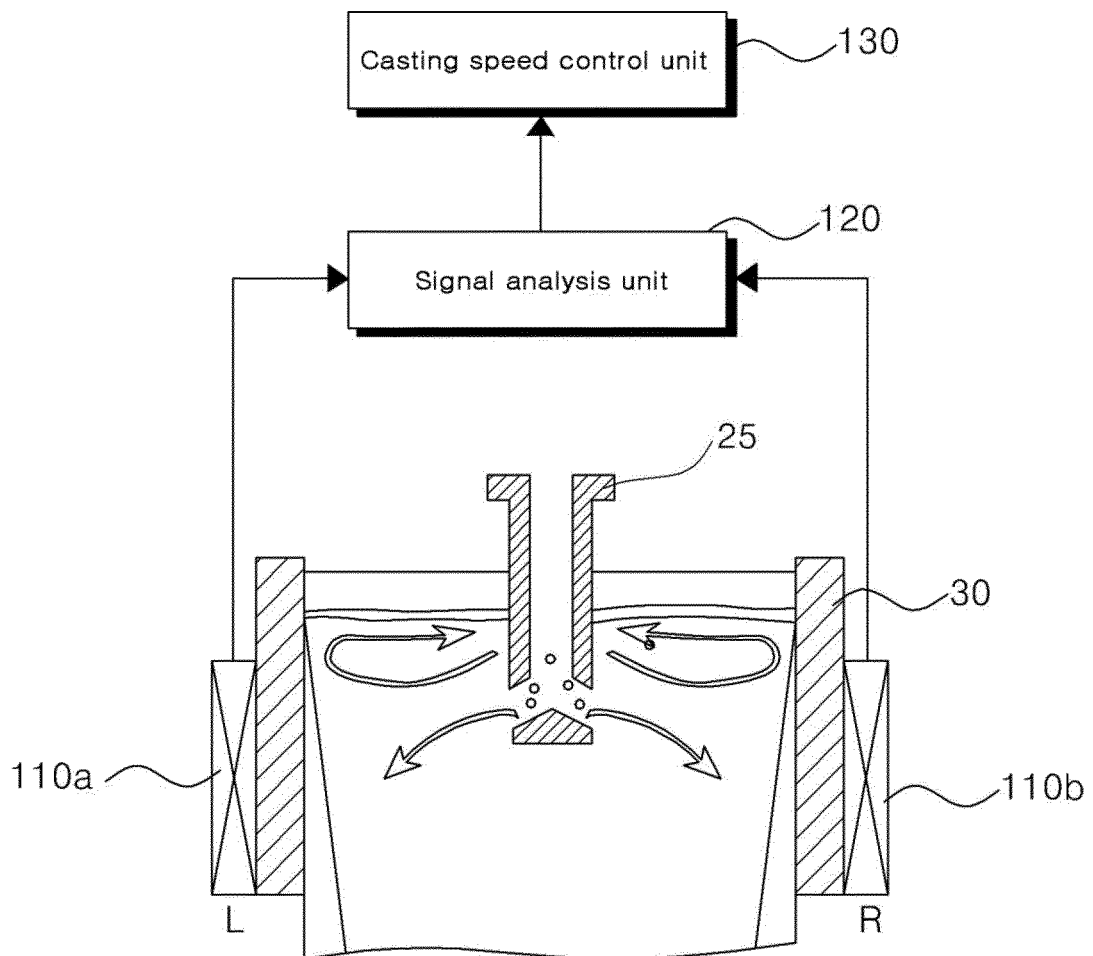
[Drawings 1]



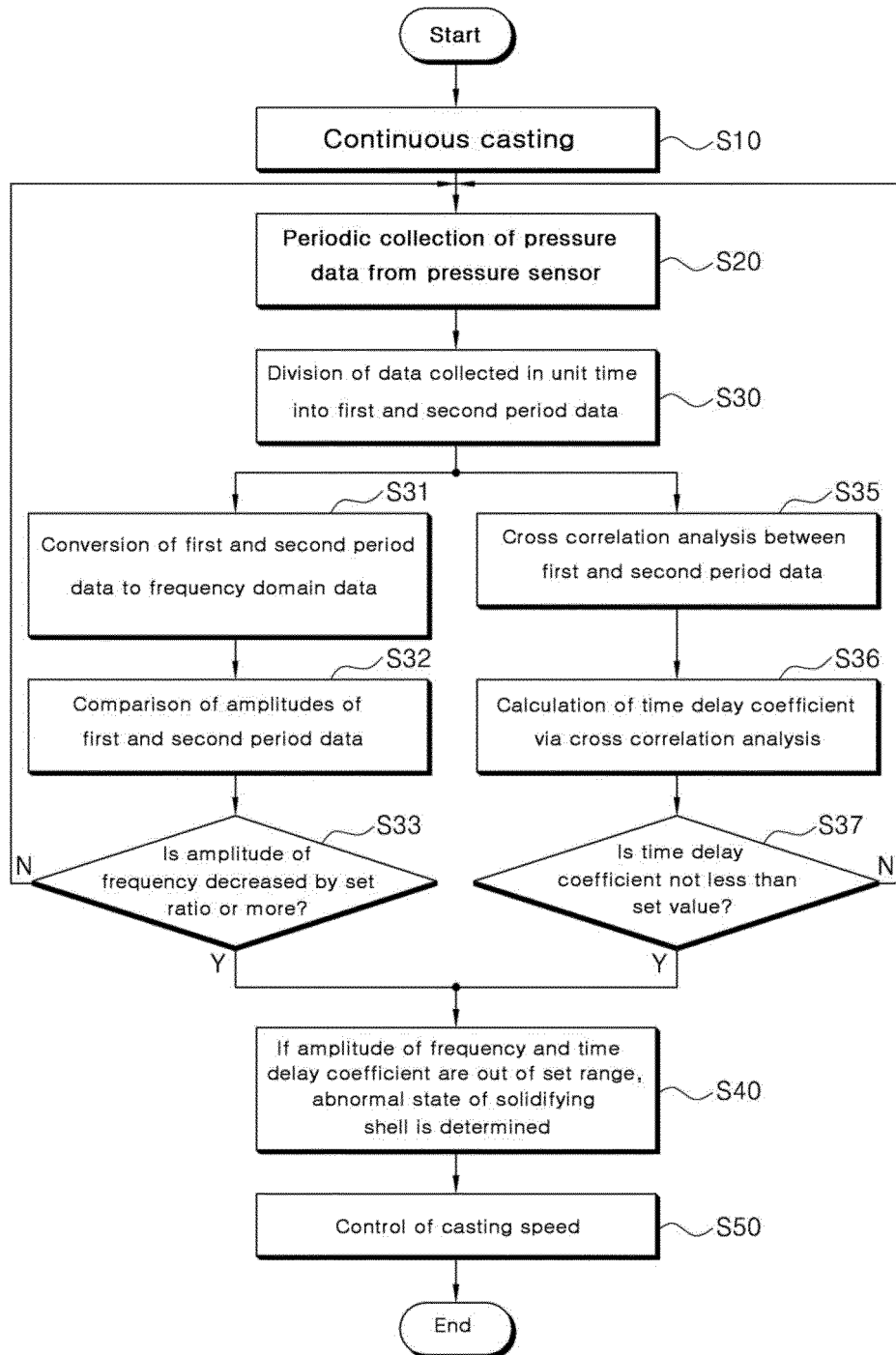
[Drawings 2]



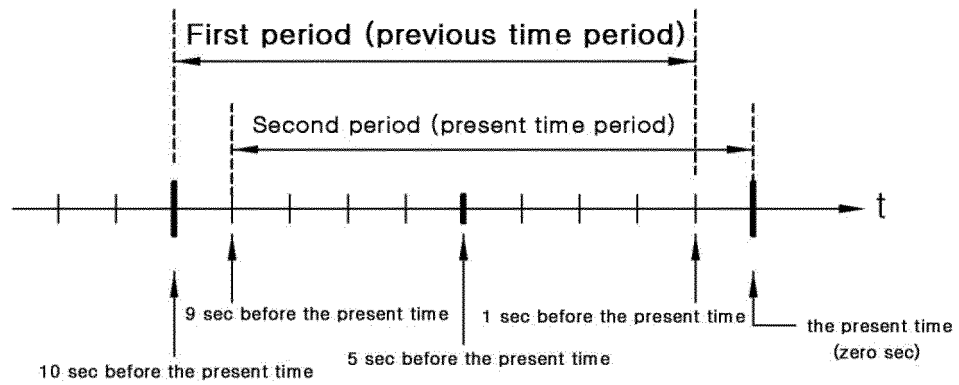
[Drawings 3]



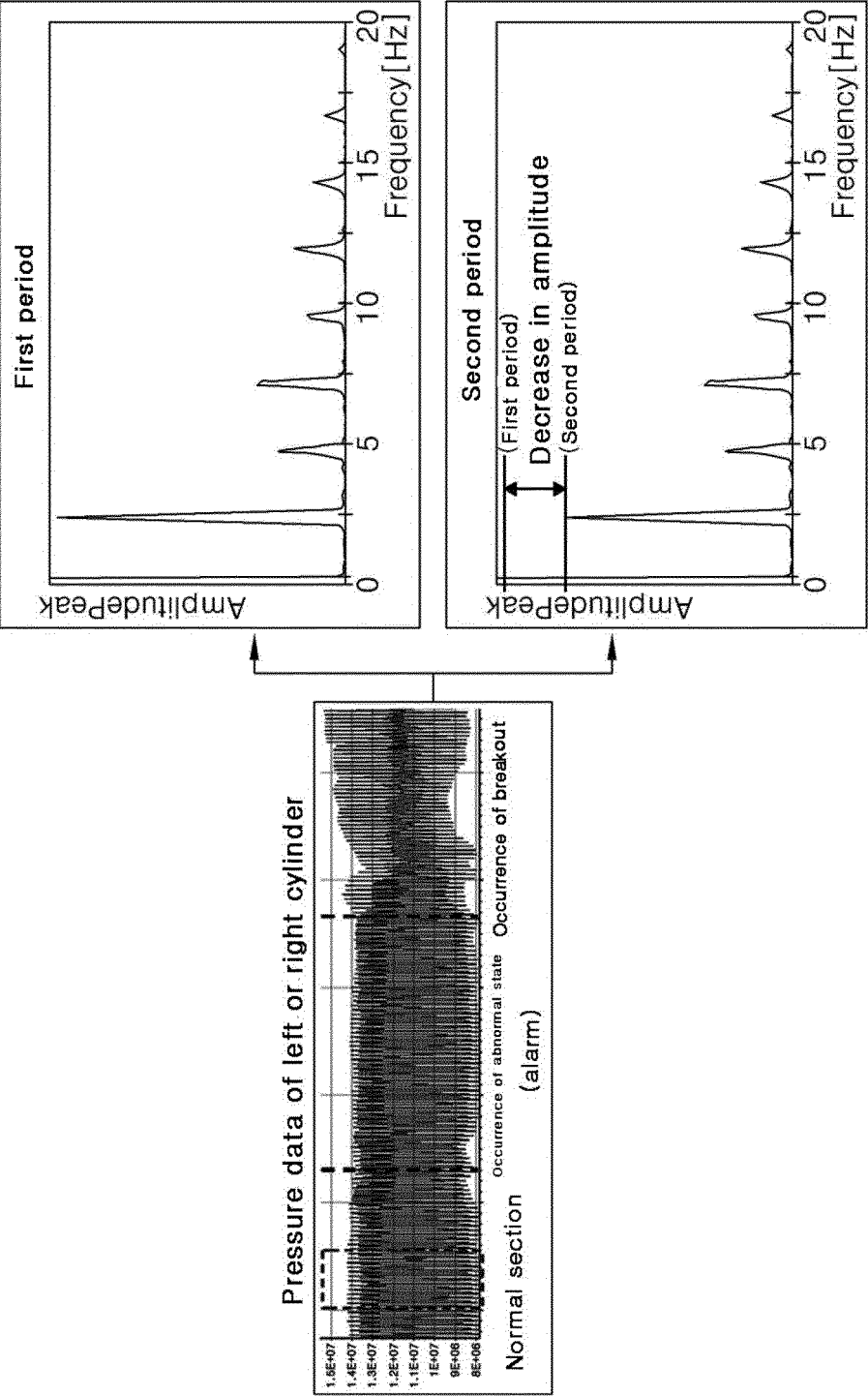
[Drawings 4]



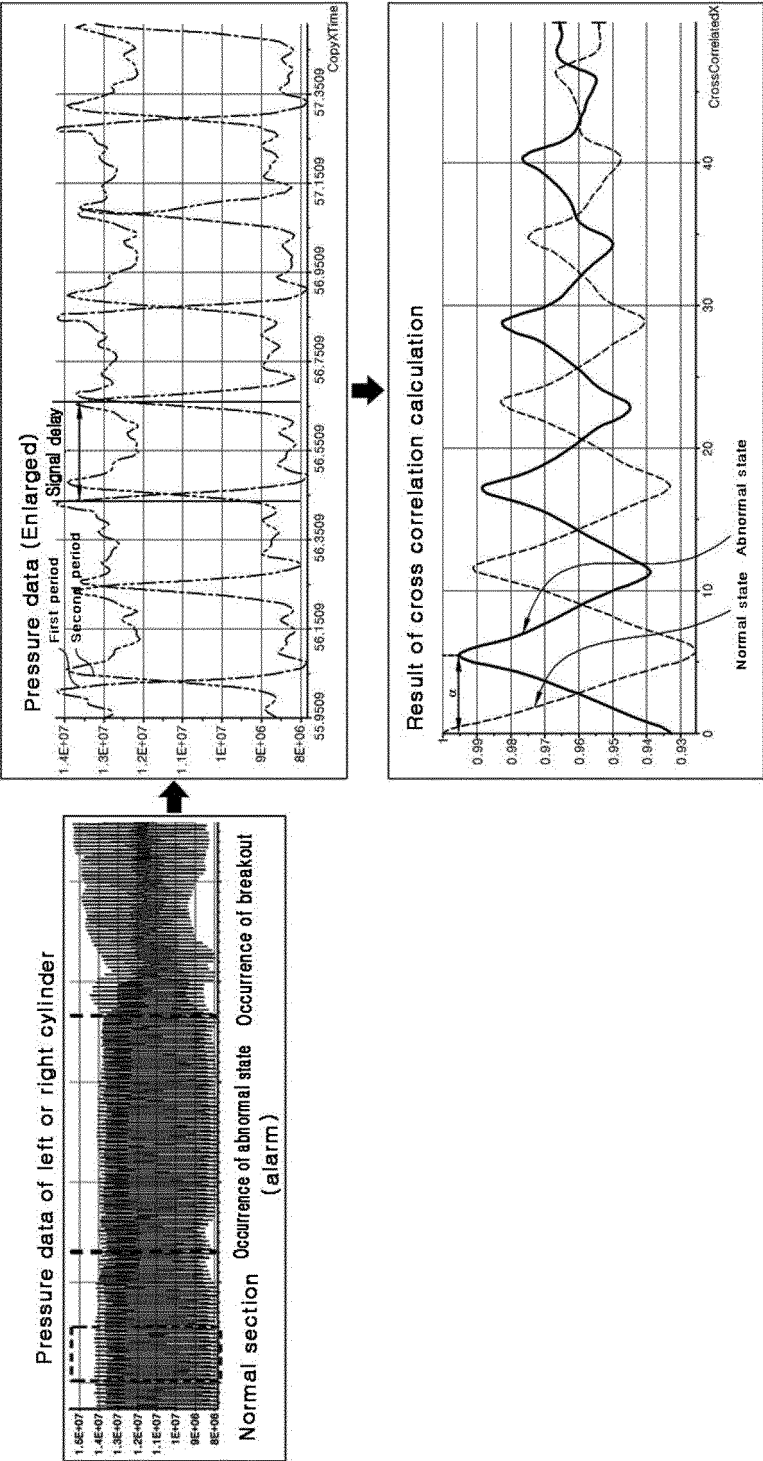
[Drawings 5]



[Drawings 6]



[Drawings 7]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2012/011552

A. CLASSIFICATION OF SUBJECT MATTER

B22D 11/16(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)

B22D 11/16; B22D 11/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & Keywords: brake out, slab break, spectrum, frequency, break-out, rupture, spectrum

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 08-047762 A (NIPPON STEEL CORP.) 20 February 1996 See claims 1, 2 and figure 1.	1-8
A	JP 57-149054 A (SUMITOMO METAL IND., LTD.) 14 September 1982 See claim 1 and figure 1.	1-8
A	KR 10-2001-0045770 A (RESEARCH INSTITUTE OF INDUSTRIAL SCIENCE & TECHNOLOGY et al.) 05 June 2001 See page 4, line 9 - page 5, line 21 and figure 1.	1-8
A	JP 06-063716 A (AICHI STEEL WORKS LTD.) 08 March 1994 See abstract and figure 1.	1-8
A	WO 89/011364 A1 (USX ENGINEERS AND CONSULTANTS INC.) 30 November 1989 See abstract and figures 1-3.	1-8

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

* Special categories of cited documents:	"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

24 APRIL 2013 (24.04.2013)

Date of mailing of the international search report

25 APRIL 2013 (25.04.2013)

Name and mailing address of the ISA/KR



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Authorized officer

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2012/011552

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 08-047762 A	20.02.1996	NONE	
JP 57-149054 A	14.09.1982	NONE	
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		KR 10-1990-0701439 A	03.12.1990
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		WO 89-11364 A1	30.11.1989

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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