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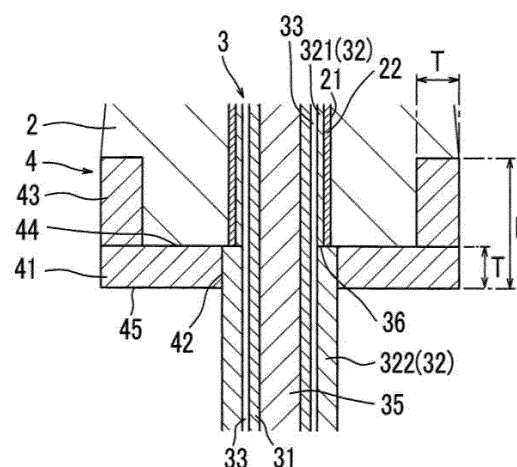
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(54) **INTEGRATED TUYERE FOR CONVERTER**

(57) Provided is a tuyere unit for a converter, comprising a single-piece metal double tube, and a tuyere refractory block integrated with the metal double tube, wherein the tuyere unit is capable of suppressing a decrease in gas flow rate due to deformation or damage of the metal double tube during installation to the converter or handling, with a simple structure. The tuyere unit comprises: a metal double tube 3 comprising a metal inner tube 31 and a metal outer tube 32, wherein the inner tube 31 is internally filled with a refractory material 35; a tuyere refractory block 2 having a through-hole 21 to which the metal double tube 3 is fixed through an adhesive 22; and a metal casing 4 which comprises a bottom plate 41 covering a lower edge surface of the tuyere refractory block 2, and a side plate 43 covering a side surface of a lower portion of the tuyere refractory block 2, wherein: the metal casing 4 has a wall thickness T of 6 mm to 20 mm, and a length L that is 3% to 50% of the entire length of the tuyere refractory block; and the outer tube 32 of the metal double tube comprises an upper outer tube 321 and a lower outer tube 322, wherein the lower outer tube 322 has a wall thickness of 3 mm or more, and wherein the lower outer tube 322 is fixedly welded to the bottom plate 41 of the metal casing.

Fig. 3



Description

TECHNICAL FIELD

[0001] The present invention relates to a tuyere to be provided in the bottom of a converter, i.e., a converter for steel making, to inject gas into the converter, and more specifically to a tuyere unit for a converter (hereinafter also referred as "converter tuyere unit"), which comprises a metal double tube having a metal inner tube internally filled with a refractory material, and a tuyere refractory block integrated with the metal double tube.

BACKGROUND ART

[0002] A tuyere is provided in the bottom of a converter, as a refractory structure for injecting gas into the converter. This tuyere can be classified into several types according to its intended purposes. For example, when it is mainly intended to agitate molten steel in the converter, there are several types of tuyeres, such as a tuyere in which a plurality of metal thin tubes are buried in a refractory block, and a tuyere using a single-piece metal double tube having a metal inner tube internally filled with a refractory material.

[0003] Here, the "metal double tube having a metal inner tube internally filled with a refractory material" means a metal double tube comprising a metal inner tube and a metal outer tube, wherein the inner tube is internally filled with a refractory material, and a gap (slit-shaped gap) is defined between the inner and outer tubes to serve as a gas passage. In this specification, the "metal double tube having a metal inner tube internally filled with a refractory material" will hereinafter be also referred to simply as "metal double tube".

[0004] As the tuyere in which a plurality of metal thin tubes are buried in a refractory block, a tuyere unit in which the plurality of metal thin tubes are integrally formed with the refractory block has been put to practical use. This tuyere unit can be easily installed to a converter, thereby providing excellent on-site installability or workability.

[0005] On the other hand, the tuyere using a metal double tube is disclosed in the below-mentioned Patent Documents 1 and 2. Since this type of tuyere requires, during on-site installation, an operation of inserting the metal double tube into a through-hole of a tuyere refractory block installed inside a converter, and then fixing the metal double tube to a shell of the converter, there is a problem that it takes a lot of time and effort for the installation operation.

[0006] Further, in the metal double tube, a central part thereof (the inside (through-bore) of the inner tube) is filled with a refractory material, and thus no gas flows through the inside of the inner tube, so that the inner and outer tubes are more likely to be raised to high temperatures and melted during use. Therefore, the wall thickness of each of the inner and outer tubes is set to be as thin as about 1 mm to lessen an influence of the melting even if it occurs. This is because, if a metal double tube is used which comprises metal inner and outer tubes each having a relatively large wall thickness, and portions of the inner and outer tubes on the side of an operating surface (gas injection edge surface) of the tuyere are melted during use, the width of the slit-shaped gap becomes larger, resulting in rapid wear of the operating face.

[0007] Assume that it is attempted to integrally form such a conventional metal double tube with a tuyere refractory block. In this situation, since the wall thickness of each of the inner and outer tubes is as thin as about 1 mm, the inner and outer tubes are likely to deform due to pressure during the integral forming. Further, it is difficult to reliably form a uniform gap (slit-shaped gap) of about 1 mm between the inner and outer tubes, and in some cases, the slit-shaped gap can be collapsed.

[0008] On the other hand, in a tuyere structure described in the below-mentioned Patent Document 3, an annular tuyere comprises: an axial central part composed of a metal inner tube and a refractory filling layer; and a tube body part fixed to the outer side of the axial central part with a ring-shaped gap therebetween, wherein a tuyere refractory block is installed around the annular tuyere, while being in close contact with the tube body part. Further, it is described that the tuyere refractory block is separated from a refractory lining, and the tuyere refractory block and the annular tuyere are integrally constructed.

[0009] In the tuyere structure described in the Patent Document 3, although the tuyere refractory block and the annular tuyere are integrally constructed, as mentioned above, the annular tuyere protrudes from the tuyere refractory block. Thus, in an operation of lifting up the tuyere structure or bringing the tuyere structure into contact with an object, while gripping a protruding portion of the annular tuyere, during installation to a converter, or handling, the annular tuyere is likely to deform, leading to collapse of the ring-shaped gap (slit-shaped gap). If the slit-shaped gap is collapsed, it becomes impossible to ensure a required flow rate of gas, which will hinder the operation of the converter.

CITATION LIST

[Patent Document]

[0010]

Patent Document 1: JP-B 4765372

Patent Document 1: JP-B 6011808

5 Patent Document 1: JP-A 2009-068099

SUMMARY OF INVENTION

[Technical Problem]

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[0011] A technical problem to be solved by the present invention is to provide a tuyere unit for a converter, comprising a single-piece metal double tube, and a tuyere refractory block integrated with the metal double tube, wherein the tuyere unit is capable of suppressing a decrease in gas flow rate due to deformation or damage of the metal double tube during installation to the converter or handling, with a simple structure.

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[Solution to Technical Problem]

[0012] The present invention provides a tuyere unit for a converter, having the following features.

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1. A tuyere unit for a converter, comprising: a single-piece metal double tube comprising a metal inner tube and a metal outer tube which are concentrically arranged with a gap therebetween, wherein the inner tube is internally filled with a refractory material; a tuyere refractory block having a through-hole to which the metal double tube is fixed through an adhesive; and a metal casing fixed to the tuyere refractory block, wherein the metal casing comprises: a bottom plate which covers a lower edge surface of the tuyere refractory block and through which the metal double tube penetrates; and a side plate which covers a side surface of a lower portion of the tuyere refractory block, wherein the metal casing has a wall thickness of 6 mm to 20 mm, and a length that is 3% to 50% of an entire length of the tuyere refractory block; and the outer tube of the metal double tube comprises an upper outer tube and a lower outer tube, wherein the lower outer tube has a wall thickness of 3 mm or more that is greater than a wall thickness of the upper outer tube, and the lower outer tube is fixedly welded to the bottom plate of the metal casing.

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2. The tuyere unit as described in the section 1, wherein the upper outer tube and the lower outer tube are integrated together.

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3. The tuyere unit as described in the section 2, wherein a boundary between the upper outer tube and the lower outer tube is located at a same height position as an upper surface of the bottom plate of the metal casing, or at a height position above the upper surface of the bottom plate of the metal casing by a distance that is up to 40% of the entire length of the tuyere refractory block.

[Effect of Invention]

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[0013] In the tuyere unit of the present invention, the wall thickness and length of the metal casing covering the lower edge surface and the side surface of the lower portion of the tuyere refractory block are limited to respective given ranges, and the outer tube of the metal double tube is composed of the upper outer tube and the lower outer tube having a wall thickness greater than that of the upper outer tube, wherein the lower outer tube is fixedly welded to the bottom plate of the metal casing, so that it is possible to suppress the occurrence of deformation or damage of the metal double tube during installation to the converter or handling. This makes it possible to suppress a decrease in gas flow rate due to the deformation or damage of the metal double tube. In addition, the tuyere unit has a simple structure, and can be easily installed to a converter, thereby providing improved working efficiency.

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BRIEF DESCRIPTION OF DRAWINGS

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[0014]

FIG. 1 is a schematic longitudinal sectional view of a converter tuyere unit according to a first embodiment of the present invention,

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FIG. 2 is an enlarged cross-sectional view taken along the line A-A in FIG. 1.

FIG. 3 is an enlarged longitudinal sectional view of a metal casing area in the converter tuyere unit in FIG. 1.

FIG. 4 is an enlarged longitudinal sectional view of a gas inlet part in the converter tuyere unit in FIG. 1.

FIG. 5 is an enlarged longitudinal sectional view of a metal casing area in a converter tuyere unit according to a second embodiment of the present invention.

FIG. 6 is an enlarged longitudinal sectional view of a metal casing area in a converter tuyere unit according to yet a third embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0015] FIG. 1 is a longitudinal sectional view schematically showing an overall configuration of a converter tuyere unit 1 according to a first embodiment of the present invention. FIG. 2 is an enlarged cross-sectional view taken along the line A-A in FIG. 1, and FIG. 3 is an enlarged longitudinal sectional view of a metal casing area (i.e., the below-mentioned metal casing 4 and the vicinity thereof) in the converter tuyere unit 1.

[0016] As shown in FIGS. 1 and 2, the converter tuyere unit 1 comprises: a tuyere refractory block 2; a metal casing 4 provided on a lower portion of the tuyere refractory block 2; and a metal double tube 3 disposed to penetrate through a through-hole 21 of the tuyere refractory block 2 and the after-mentioned through-hole 42 of the metal casing 4, and fixedly welded to the metal casing 4, wherein the tuyere refractory block 2 is formed in a rectangular shape in plan view and in a truncated quadrangular pyramid shape, except for a portion thereof covered by the metal casing 4.

[0017] The metal double tube 3 is fixed to the through-hole 21 of the tuyere refractory block 2 through an adhesive 22 having a thickness of about 1 mm. The entire length of the metal double tube 3 is 1500 mm. As shown in FIG. 3, the lower portion of the tuyere refractory block 2 is formed with a stepped recess in which the metal casing is fitted, so that it has a quadrangular prism shape having a smaller length per side, as compared to the remaining portion. The metal casing 4 comprises: a bottom plate 41 covering a lower edge surface of the tuyere refractory block 2; and a side plate 43 covering a side surface of the lower portion of the tuyere refractory block 2. In this embodiment, the side plate 43 is formed in a quadrangular tubular shape. This quadrangular tubular-shaped side plate 43 is fixedly welded to an upper surface 44 of the bottom plate 41 which is formed in a rectangular shape. Although not illustrated, the metal casing 4 and the lower portion of the tuyere refractory block 2 is bonded together through an adhesive. Further, as shown in FIG. 3, the metal casing 4 has a through-hole 42 formed in a central region of the bottom plate 41, and the metal double tube 3 is disposed to penetrate through the through-hole 42, and then fixedly welded to the bottom plate 41. In this embodiment, each of the bottom plate 41 and the side plate 43 of the metal casing 4 has a wall thickness T of 12 mm, and the metal casing 4 has a length (longitudinal length) L of 50 mm (that is 5% of the entire length of the tuyere refractory block 2).

[0018] Here, each of the metal double tube 3 and the metal casing 4 is made of metal, typically of steel, such as SS (rolled steels for general structure), SC (carbon steels for machine structural use), or STKM (carbon steel tubes for machine structural use), or stainless steel.

[0019] The tuyere refractory block 2 is formed such that: the entire length thereof is 1000 mm; an upper edge surface thereof has a rectangular shape with a short side of 100 mm and a long side of 150 mm; a horizontal cross-section thereof taken along a plane in contact with an upper edge surface of the side plate 43 of the metal casing 4 has a rectangular shape with a short side of 110 mm and a long side of 160 mm; the through-hole 21 has an inner diameter of 27 mm; and the weight thereof is 50 kg.

[0020] In this embodiment, any horizontal cross-section of the tuyere refractory block 2 is a rectangular shape, as mentioned above. Alternatively, a tuyere refractory block having a cross-sectional shape such as a trapezoidal shape, a square shape, a circular shape or sector shape may be used, depending on the arrangement of furnace bottom bricks arranged therearound. Further, the entire length of the tuyere refractory block 2 may be determined according to the length of the furnace bottom bricks therearound.

[0021] As shown in FIG. 2, the metal double tube 3 comprises a metal inner tube 31 and a metal outer tube 32 which are concentrically arranged, i.e., arranged such that central axes of the inner and outer tubes 31, 32 are aligned with each other, wherein a slit-shaped gap 33 is uniformly formed between the inner and outer tubes 31, 32. In this embodiment, the width of slit-shaped gap 33 (in a radial direction of the metal double tube 3) is 1 mm, and the wall thickness of the inner tube 31 is 1.5 mm. In this embodiment, in order to allow the central axes of the inner and outer tubes 31, 32 to be aligned with each other, a plurality of protrusions 34 each extending in a longitudinal direction of the metal double tube 3 are provided on an outer peripheral surface of the inner tube 31 at even intervals in a circumferential direction of the inner tube 31. The protrusions 34 on the outer peripheral surface of the inner tube 31 can be provided by welding a plurality of metal wires each extending in the longitudinal direction (up-down direction in FIG. 1), onto the outer peripheral surface of the inner tube 31 at even intervals in the circumferential direction, or by forming a plurality of grooves each extending in the longitudinal direction, on the outer peripheral surface of the inner tube 31 at even intervals in the circumferential direction by means of cutting or the like.

[0022] The inner tube 31 is internally filled with a refractory material 35. Further, an interspace between the outer tube 32 and the tuyere refractory block 2 (through-hole 21) is filled with the adhesive 22.

[0023] As shown in FIG. 3, the outer tube 32 of the metal double tube 3 comprises an upper outer tube 321 and a lower outer tube 322, wherein a lower end of the upper outer tube 321 and an upper end of the lower outer tube 322

are joined and integrated together by welding. In this embodiment, a boundary 36 between the upper outer tube 321 and the lower outer tube 322 is located at the same height position as an upper surface 44 of the bottom plate 41 of the metal casing 4. In this embodiment, the upper outer tube 321 has a wall thickness of 1 mm, and the lower outer tube 322 has a wall thickness of 5.5 mm. However, a gap between the inner tube 31 and the upper outer tube 321 is set to be equal to a gap between the inner tube 31 and the lower outer tube 322, i.e., the width of the slit-shaped gap 33 is kept constant over the entire length of the metal double tube 3.

[0024] FIG. 4 is an enlarged longitudinal sectional view of a gas inlet part 5 for supplying gas therethrough, in the converter tuyere unit 1 in FIG. 1. As shown in FIG. 4, in this embodiment, the metal double tube 3 is provided with a connector tube 51 as the gas inlet part 5, at a lower end thereof, wherein the connector tube 51 has an inner diameter slightly greater than an outer diameter of the metal double tube 3 (lower outer tube 322) and comprises a socket 52 with respect to a gas pipe (illustration is omitted). Here, a gap between the connector tube 51 and the lower outer tube 322 is sealed by welding. Gas supplied to the socket 52 is introduced from a gas inlet port 323 provided between the lower outer tube 322 and the connector tube 51, into the gap, i.e., slit-shaped gap 33, between the inner tube 31 and the lower outer tube 322.

[0025] Next, a production method for the converter tuyere unit 1 according to this embodiment will be described below. First of all, the tuyere refractory block 2 can be obtained by: adding a binder such as phenolic resin to a refractory raw material mix comprising magnesia and flaky graphite as primary raw materials; kneading the resulting mixture; and then subjecting the kneaded product to pressure forming and heat treatment. The through-hole 21 can be provided by: after the pressure forming, pulling out a core rod buried during the pressure forming; or after the heat treatment, subjecting the resulting product to boring. The metal double tube 3 can be attached to the through-hole 21 by applying the adhesive 22 onto an outer peripheral surface of the metal double tube 3, and inserting the metal double tube 3 into the through-hole 21. The metal casing 4 can be bonded to the lower portion of the tuyere refractory block 2 through an adhesive. Subsequently, the lower outer tube 322 of the metal double tube 3 is fixedly welded to the bottom plate 41 of the metal casing 4. In this way, the converter tuyere unit 1 can be produced.

[0026] Here, as an adhesive to be used between the metal double tube 3 and the tuyere refractory block 2 and between the metal casing 4 and the tuyere refractory block 2, it is possible to use an organic or inorganic adhesive itself, and a mixture obtained by adding a refractory powder to the organic or inorganic adhesive. Specific examples thereof include one or more selected from the group consisting of an acrylic resin-based adhesive, a urethane resin-based adhesive, an epoxy resin-based adhesive, a phenolic resin-based adhesive, a sodium silicate-based adhesive, a cement-based adhesive and a silica sol-based adhesive, and a mixture obtained by adding a metal or metal oxide powder to one or more of these adhesives. In this embodiment, a magnesia powder-containing phenolic resin is used between the metal double tube 3 and the tuyere refractory block 2, and an epoxy resin-based adhesive is used between the metal casing 4 and the tuyere refractory block 2. When a refractory powder-containing adhesive is used as the adhesive between the metal double tube 3 and the tuyere refractory block 2, wear of the operating surface can be suppressed.

[0027] As above, in the production method for the converter tuyere unit 1 according to this embodiment, the metal double tube 3 is fixedly attached to the through-hole 21 of the pressure-formed tuyere refractory block 2 through an adhesive. Thus, even when using a metal double tube 3 having a relatively small wall thickness, deformation of the metal double tube 3 or collapse of the slit-shaped gap never occurs during a production process of the converter tuyere unit 1.

[0028] Here, the metal casing 4 is provided to, when lifting up the converter tuyere unit 1 or holding the converter tuyere unit 1 horizontally, prevent the tuyere refractory block 2 from being displaced and disengaged with respect to the metal casing 4, causing deformation of the metal double tube 3 inside the tuyere refractory block 2. Thus, the wall thickness T of the metal casing 4 needs to be thick enough to hold the tuyere refractory block 2 so as to prevent the tuyere refractory block 2 from being displaced with respect to the metal casing 4 when lifting up the converter tuyere unit 1 or holding the converter tuyere unit 1 horizontally. Specifically, the wall thickness T of the metal casing 4 may be set in the range of 6 mm to 20 mm. If the wall thickness T of the metal casing 4 is less than 6 mm, the displacement of the tuyere refractory block 2 is likely to occur, leading to deformation of the metal double tube 3. On the other hand, if it is greater than 20 mm, the metal casing 4 becomes excessively heavy, leading to difficulty in handling.

[0029] The length L of the metal casing 4 may be set to an appropriate value depending on the length of the tuyere refractory block 2. Specifically, it may be set to 3% or more, preferably 5% or more, of the entire length of the tuyere refractory block 2. If the length L of the metal casing 4 is less than 3% of the entire length of the tuyere refractory block 2, the displacement of the tuyere refractory block 2 is more likely to occur, leading to deformation of the metal double tube 3 or drop-off of the tuyere refractory block 2. The upper limit of the length L of the metal casing 4 needs not be particularly limited. However, considering that if the metal casing 4 is excessively length, the converter tuyere unit 1 becomes excessively heavy, leading to deterioration in handleability, the length L of the metal casing 4 may be set to 50% or less of the entire length of the tuyere refractory block 2. Further, even if the length L of the metal casing 4 is set to 30% or less of the entire length of the tuyere refractory block 2, it is sufficient.

[0030] Further, since the wall thickness of the lower outer tube 322 of the metal double tube 3 is greater than that of

the upper outer tube 321 of the metal double tube 3 as shown in FIG. 3, it is possible to suppress deformation of the metal double tube 3 even in the operation of lifting up the converter tuyere unit 1 in a horizontal posture while gripping a protruding portion of the metal double tube 3. The wall thickness of the lower outer tube 322 may be set to a value enough to prevent deformation of the metal double tube 3 even when maintaining the converter tuyere unit 1 in a horizontal posture while gripping the protruding portion of the metal double tube 3, depending on the size of the tuyere refractory block 2 used. Specifically, it may be set to 3 mm or more. If the wall thickness of the lower outer tube 322 is less than 3 mm, the metal double tube 3 of the converter tuyere unit 1 is likely to deform when a force is applied to the metal double tube 3. The upper limit of the wall thickness of the lower outer tube needs not be particularly set. However, if the wall thickness of the lower outer tube is excessively increased, the converter tuyere unit 1 is likely to become excessively heavy, leading to handling problem. Thus, in such a case, the wall thickness of the lower outer tube may be set to 10 mm or less.

[0031] In this embodiment, the upper outer tube 321 and the lower outer tube 322 is welded and joined integrally to form an single-piece metal double pipe, as mentioned above, so that the metal double pipe 3 can be simply attached to the tuyere refractory block 2 and the metal casing 4, thereby providing improved working efficiency during the production process. Further, the wall thickness of the lower outer tube 322 is increased by increasing the outer diameter of the lower outer tube 322, without changing the width of the gap (slit-shaped gap 33) between the lower outer tube 322 and the inner tube 31, so that the outer diameter of the lower outer tube 322 can be set to a smaller value, as compared to a case where the lower outer tube 322 is separated from the upper outer tube 321 without being integrated therewith (after-mentioned structure in FIG. 6). Since the outer diameter of the lower outer tube 322 is relatively small as just described, the gas inlet part 5 provided at a lower end of the lower outer tube 322 can also be made smaller. Thus, the converter tuyere unit 1 will exhibit excellent handleability during furnace construction. In addition, it is possible to reduce the weight of the entire converter tuyere unit.

[0032] On the other hand, the upper outer tube 321 of the metal double tube 3 needs not be thick but may be sufficiently thin. Thus, it is possible to suppress the occurrence of rapid wear of the operating surface even when the inner and outer tubes (the inner tube 31 and the upper outer tube 321) are melt during use, and the width of the slit-shaped gap 33 is increased. Further, since the wall thickness of each of the inner and outer tubes (the inner tube 31 and the upper outer tube 321) can be sufficiently reduced, the width of the slit-shaped gap 33 can be maintained small, and thus it is possible to prevent molten steel from entering the slit-shaped gap 33.

[0033] Specifically, the wall thickness of each of the inner tube 31 and the upper outer tube 321 may be set in the range of 0.5 mm to 3 mm. If the wall thickness of each of the inner tube 31 and the upper outer tube 321 is less 0.5 mm, working efficiency deteriorates due to deformation of the inner and outer tubes during handling in the production process. On the other hand, if it is greater than 3 mm, the inner and outer tubes are more likely to be melted during use.

[0034] The boundary 36 between the upper outer tube 321 and the lower outer tube 322 may be set at the same height position as the upper surface 44 of the bottom plate 41 of the metal casing 4, as in this embodiment, or may be set at a height position above the upper surface 44 of the bottom plate 41 of the metal casing 4 by a distance that is preferably up to 40%, more preferably up to 10%, of the entire length of the tuyere refractory block 2.

[0035] As just described, the boundary 36 between the upper outer tube 321 and the lower outer tube 322 is set at the same height position as, or at a height position above, the upper surface 44 of the bottom plate 41 of the metal casing 4, so that it becomes possible to more reliably suppress the metal double tube 3 from bending when handling the converter tuyere unit 1 while holding the protruding portion of the metal double tube 3. Here, the highest point of the height position of the boundary 36 between the upper outer tube 321 and the lower outer tube 322 needs not be particularly limited. However, considering that, if it is located above the upper surface 44 of the bottom plate 41 of the metal casing 4 by a distance that is greater than 40% of the entire length of the tuyere refractory block 2, the lower outer tube 322 is likely to come into contact with molten steel when the tuyere refractory block 2 wears during use, the distance may be preferably up to 40%, more preferably up to 10%, of the entire length of the tuyere refractory block 2.

[0036] If the boundary 36 between the upper outer tube 321 and the lower outer tube 322 is located at a height position below a lower surface 45 of the bottom plate 41 of the metal casing 4, the metal double tube 3 is highly likely to bend when handling the converter tuyere unit 1 while holding the protruding portion of the metal double tube 3. On this point, in this embodiment, the lower outer tube 322 is fixedly welded to the bottom plate 41 of the metal casing 41, i.e. the height position of the boundary 36 between the upper outer tube 321 and the lower outer tube 322 is never located below the lower surface 45 of the bottom plate 41 of the metal casing 4.

[0037] The outer diameter and the width of the slit-shaped gap 33 of the metal double tube 3 is appropriately determined by the flow rate of gas to be injected, the number of tuyeres to be installed in a converter, etc. However, in view of easiness in production and durability of tuyere bricks, and easiness in ensuring the gas flow rate, the outer diameter of the metal double tube 3 may be set in the range of 20 mm to 60 mm, and the width of the slit-shaped gap 33 of the metal double tube 3 may be set in the range of 0.5 mm to 3 mm.

[0038] The length of the protruding portion of the metal double tube 3 protruding from the metal casing 4 is determined by the wall thickness of a shell of the converter, the position of the gas pipe, etc. However, if the protruding portion is

excessively long, it is more likely to deform. Thus, it is preferably about 1000 mm as a maximum, and may be about 200 mm as a minimum.

[0039] FIG. 5 is an enlarged longitudinal sectional view of a metal casing part in a converter tuyere unit according to a second embodiment of the present invention. In the second embodiment, the boundary 36 between the upper outer tube 321 and the lower outer tube 322 is located at a height position above the upper surface 44 of the bottom plate 41 of the metal casing 4 by a distance of 20 mm (that is 2% of the entire length of a tuyere refractory block 2). In a region below the height position of the boundary 36, a through-hole 21 of the tuyere refractory block 2 is expanded radially outwardly to form a step. In the second embodiment, the upper outer tube 321 and the lower outer tube 322 are joined and integrated together by welding, as with the first embodiment.

[0040] FIG. 6 is an enlarged longitudinal sectional view of a metal casing part in a converter tuyere unit according to a third embodiment of the present invention. In this embodiment, the upper outer tube 321 and the lower outer tube 322 of the outer tube 32 of the metal double tube 3 are separated from each other without being integrated together. Specifically, an upper edge surface of the lower outer tube 322 is fixedly welded to the lower surface 45 of the bottom plate 41 of the metal casing 4. On the other hand, the lower end of the upper outer tube 321 is inserted into the through-hole 42 of the bottom plate 41, and an upper part of the inserted lower end is fixedly welded to the bottom plate 41.

EXAMPLES

[0041] The converter tuyere unit 1 according to the first embodiment illustrated in FIGS. 1 to 4 was subjected to a converter tuyere unit handling test under the condition that each of the wall thickness T of the metal casing 4, the length L of the metal casing 4, and the wall thickness of the lower outer tube 322 of the metal double tube 3 is variously set. A result of the test is shown in Table 1. Here, the material of the metal casing 4 was SS400. In the metal double tube 3, the material of each of the inner tube 31 and the upper outer tube 321 was SUS 304, and the material of the lower outer tube 322 was STKM.

[0042] In the handling test, the protruding portion of the metal double tube 3 protruding from the bottom plate 41 of the metal casing 4 of the converter tuyere unit in the converter tuyere unit placed in a horizontal posture was held by crane at two points: a position away from the bottom plate 41 of the metal casing toward a rear end of the metal double tube 3 by a length that is $1/3$ of the entire length of the protruding portion; and the rear end. Then, an operation of lifting up the converter tuyere unit by 2 m within about 1 sec while maintaining the horizontal posture, and lowering the converter tuyere unit to the original position within about two sec was repeated 5 times. Subsequently, the converter tuyere unit was separated from the crane and placed on a horizontal table, and gas (air) was supplied to the metal double tube 3 at a pressure of 0.1 MPa to measure a gas flow rate. Then, each measured gas flow rate was expressed as an index on the basis of 100 indicative of the measured gas flow rate in Inventive Example 1. A larger value of the index means a larger gas flow rate, and any example having an index of 95 or more was evaluated as "allowable". Here, a larger value of the gas flow rate measured in the handling test means smaller deformation or damage of the metal double tube 3 in the handling test.

TABLE 1

	Compara- tive Exam- ple 1	Inventive Example 1	Inventive Example 2	Inventive Example 3	Inventive Example 4	Compara- tive Exam- ple 2	Compara- tive Exam- ple 3	Inventive Example 5	Inventive Example 6	Inventive Example 7	Inventive Example 8	Compara- tive Exam- ple 4	Inventive Example 9	Inventive Example 10
Wall thick- ness of Metal Casing	10	10	10	10	6	3	15	15	15	15	15	20	20	20
Length of Metal Casing	3	6	10	20	10	10	12	12	12	12	12	15	15	15
Wall Thick- ness of Lower Outer Tube	5	5	5	5	5	5	1	3	5	30	50	20	20	20
Gas Flow Rate (in- dex)	65	100	105	107	97	84	67	95	107	110	109	88	100	105
*1: Percent to entire length of tuyere refractory block														

[0043] In Inventive Examples 1 to 3 in which the thickness of the side plate 43 of the metal casing 4 is set to different values within the range defined in the appended claims, the gas flow rate index was in the range of 100 to 107, i.e., the metal double tube 3 was kept in a good state without any deformation or damage. On the other hand, in Comparative Example 1 in which the thickness of the side plate 43 of the metal casing 4 is 3 mm that is less than the lower limit (6 mm) defined in the appended claims, the gas flow rate index was lowered to 65. This is because the metal double tube 3 was damaged and partially collapsed by the handling test.

[0044] In Inventive Example 4 in which the thickness of the bottom plate 41 of the metal casing is 6 mm, the gas flow rate index was 97, i.e., the metal double tube 3 was kept in a good state without any deformation or damage. On the other hand, in Comparative Example 2 in which the thickness of the bottom plate 41 of the metal casing 4 is 3 mm that is less than the lower limit (6 mm) defined in the appended claims, the gas flow rate index was lowered to 85. This is because the metal double tube 3 was damaged and partially collapsed by the handling test.

[0045] In Inventive Examples 5 to 8 in which the length of the metal casing 4 is set to different values within the range defined in the appended claims, the gas flow rate index was in the range of 95 to 110, i.e., the metal double tube 3 was kept in a good state without significant lowering in the gas flow rate. On the other hand, in Comparative Example 3 in which the length of the metal casing 4 is 1% of the entire length of the tuyere refractory block, that is less than the lower limit (3%) defined in the appended claims, the gas flow rate index was lowered to 67. This is because the metal double tube 3 was damaged and partially collapsed by the handling test.

[0046] In Inventive Examples 9 and 10 in which the wall thickness of the lower outer tube 322 of the metal double tube 3 is set to different values within the range defined in the appended claims, the gas flow rate index was in the range of 95 to 110, i.e., the metal double tube 3 was kept in a good state without significant lowering in the gas flow rate. On the other hand, in Comparative Example 4 in which the wall thickness of the lower outer tube 322 of the metal double tube 3 is 1.5 mm that is less than the lower limit (3 mm) defined in the appended claims, the gas flow rate index was lowered to 88. This is because the metal double tube 3 was damaged and partially collapsed by the handling test.

LIST OF REFERENCE SIGNS

[0047]

- 1: converter tuyere unit
- 2: tuyere refractory block
- 21: through-hole
- 22: adhesive
- 3: metal double tube
- 31: metal inner tube
- 32: metal outer tube
- 321: upper outer tube
- 322: lower outer tube
- 323: gas inlet port
- 33: slit-shaped gap
- 34: protrusion
- 35: refractory material
- 36: boundary
- 4: metal casing
- 41: bottom plate
- 42: through-hole
- 43: side plate
- 44: upper surface of bottom plate
- 45: lower surface of bottom plate
- 5: gas inlet part
- 51: connector tube
- 52: socket

Claims

1. A tuyere unit for a converter, comprising:

a single-piece metal double tube comprising a metal inner tube and a metal outer tube which are concentrically

arranged with a gap therebetween, the inner tube being internally filled with a refractory material;
a tuyere refractory block having a through-hole to which the metal double tube is fixed through an adhesive; and
a metal casing fixed to the tuyere refractory block, the metal casing comprising: a bottom plate which covers a
lower edge surface of the tuyere refractory block and through which the metal double tube penetrates; and a
side plate which covers a side surface of a lower portion of the tuyere refractory block,
wherein:

the metal casing has a wall thickness of 6 mm to 20 mm, and a length that is 3% to 50% of an entire length
of the tuyere refractory block; and

the outer tube of the metal double tube comprises an upper outer tube and a lower outer tube, the lower
outer tube having a wall thickness of 3 mm or more that is greater than a wall thickness of the upper outer
tube, the lower outer tube being fixedly welded to the bottom plate of the metal casing.

2. The tuyere unit as claimed in claim 1, wherein the upper outer tube and the lower outer tube are integrated together.

3. The tuyere unit as claimed in claim 2, wherein a boundary between the upper outer tube and the lower outer tube
is located at a same height position as an upper surface of the bottom plate of the metal casing, or at a height
position above the upper surface of the bottom plate of the metal casing by a distance that is up to 40% of the entire
length of the tuyere refractory block.

Fig. 1

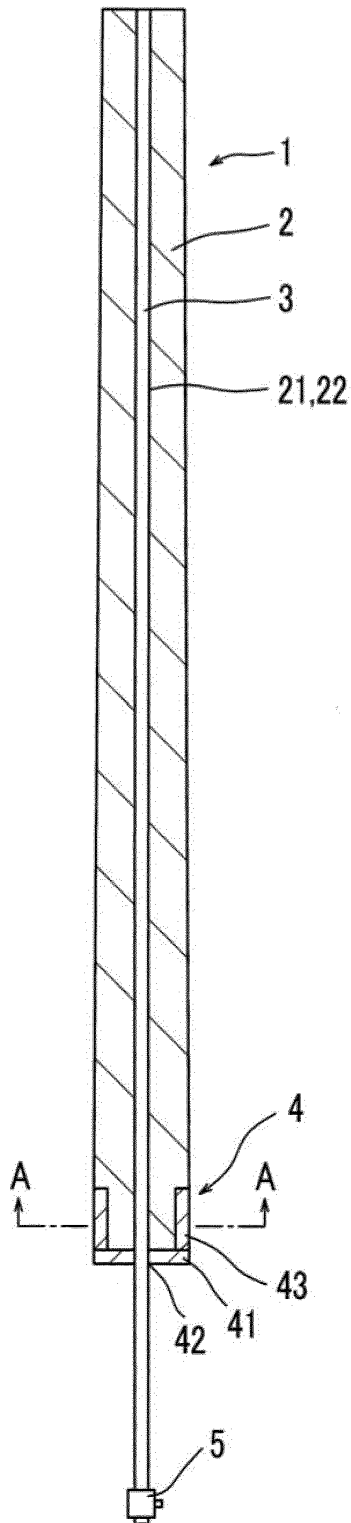


Fig. 2

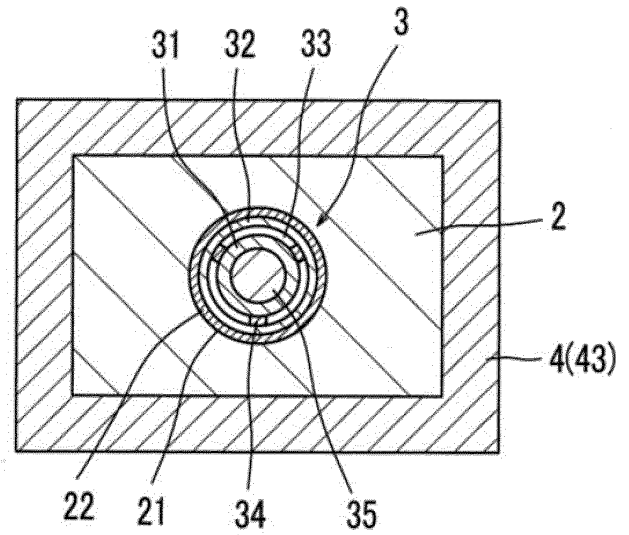


Fig. 3

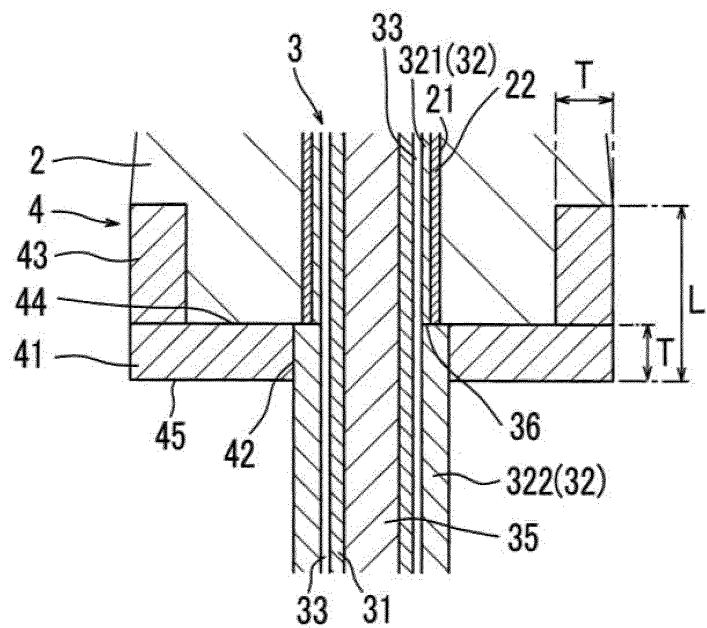


Fig. 4

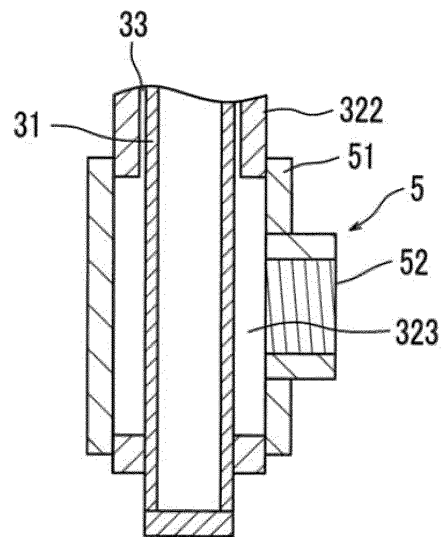


Fig. 5

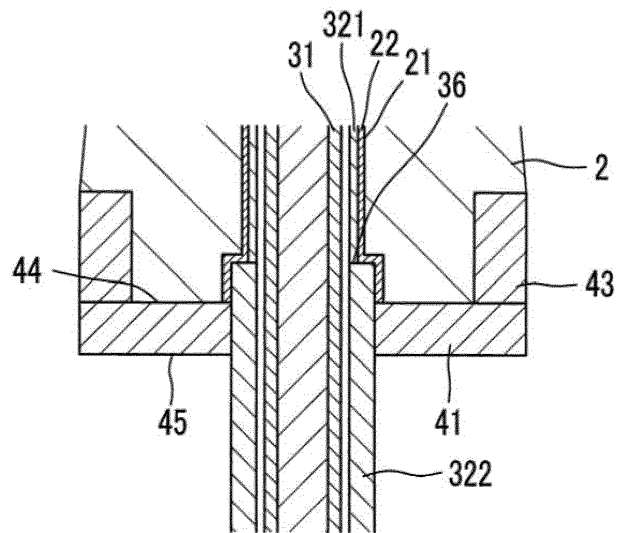
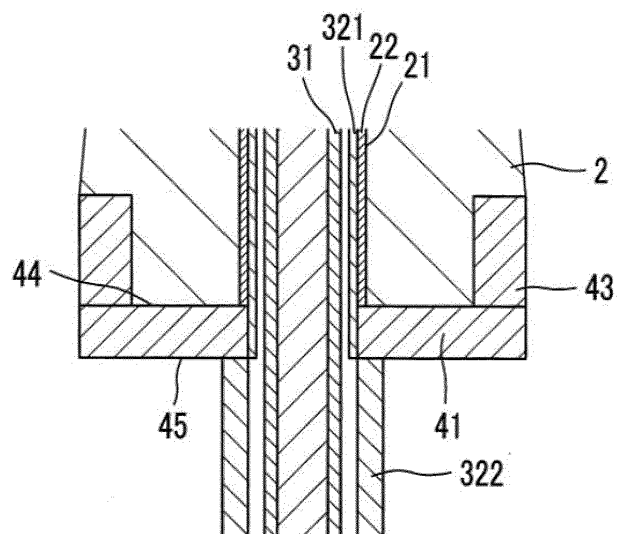


Fig. 6



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/006825

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. C21C5/48 (2006.01) i

FI: C21C5/48B

10

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)

Int.Cl. C21C5/48

15

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

20

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

25

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-283065 A (JFE STEEL CORPORATION) 19 October 2006 (2006-10-19), entire text	1-3
A	JP 57-009820 A (SUMITOMO METAL INDUSTRIES, LTD.) 19 January 1982 (1982-01-19), entire text	1-3
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 005645/1981 (Laid-open No. 121668/1982) (NIPPON STEEL CORPORATION) 28 July 1982 (1982-07-28), entire text	1-3
A	JP 57-085940 A (SUMITOMO METAL INDUSTRIES, LTD.) 28 May 1982 (1982-05-28), entire text	1-3

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

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"&" document member of the same patent family

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Date of the actual completion of the international search
18 March 2021Date of mailing of the international search report
30 March 2021

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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

5	INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. PCT/JP2021/006825
	JP 2006-283065 A 19 October 2006 (Family: none)	
10	JP 57-009820 A 19 January 1982 (Family: none)	
	JP 57-121668 U1 28 July 1982 (Family: none)	
	JP 57-085940 A 28 May 1982 (Family: none)	
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REFERENCES CITED IN THE DESCRIPTION

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- JP 4765372 B [0010]
- JP 6011808 B [0010]
- JP 2009068099 A [0010]