(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 534 702 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.04.2025 Bulletin 2025/15

(21) Application number: **23201625.3**

(22) Date of filing: **04.10.2023**

(51) International Patent Classification (IPC):
C21C 1/06 *(2006.01)* ***B22D 41/02*** *(2006.01)*
B22D 41/12 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B22D 41/02; B22D 41/12; C21C 1/06

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) METHOD FOR REFURBISHING THE REFRACTORY LINING OF THE FILLING OPENING OF A TORPEDO CAR

(57) The invention relates to a method of refurbishing the refractory structure made of a single piece of refractory concrete surrounding the filling opening of a vessel for the conveying of molten metal, in particular molten pig iron, the method comprising the steps of: constructing a formwork on the vessel in its position of conveying; casting in-situ refractory concrete into the formwork onto the vessel to form a single piece of refractory concrete; setting of the refractory concrete; and deconstructing of the formwork; and wherein constructing the formwork comprises inflating an inflatable core element forming an air chamber extending outwards through the filling opening and inflating an inflatable support element forming an air chamber positioned within the interior of said vessel and reaching up to the vessel walls and supporting the inflated core element on its lower end.

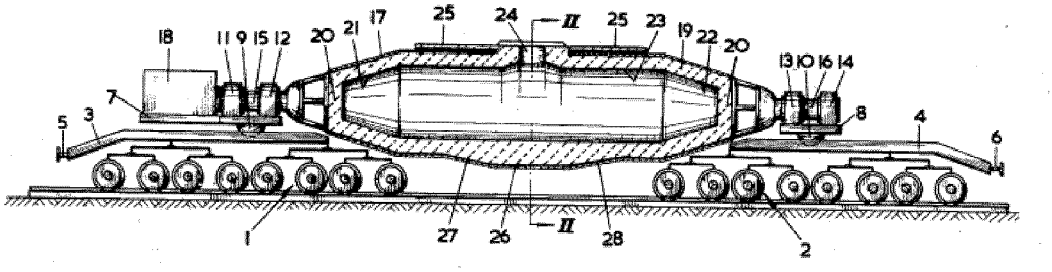

Fig.1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a vessel or torpedo car for the conveying of hot materials, particularly molten pig iron, the vessel is provided about in the centre and, in the position for conveying, in the upper part thereof, with a filling opening, the filling opening near to and on its outside is provided with a refractory structure. The invention also relates to a method of refurbishing the refractory structure near to and on the outside of said filling opening.

BACKGROUND TO THE INVENTION

[0002] It relates to a car with a vessel for the conveying of hot materials, particularly molten pig iron, comprising at least two wheel bogies one behind the other in the conveying direction, the longitudinal vessel extending with its longitudinal axis in the same direction and having an outer shell internally lined with protective refractory bricks, the vessel is tiltable about its longitudinal axis, is supported by the bogies and is provided about in the centre and, in the position for conveying, in the upper part thereof, with a filling opening, also known as the pouring mouth or spout. Such cars, often called moving mixers, hot metal cars or, in view of the shape of the vessel, torpedo cars or torpedo ladle cars, are used quite often for the conveying of pig iron from blast furnaces to steelmaking works. In practice, the vessel is filled at a blast furnace with molten pig iron of about 1500°C and is then conveyed to a steelmaking facility. The vessel is rotated about its longitudinal axis to empty the vessel, so that the pig iron is discharged through the opening into a receiver and the empty vessel is returned to a blast furnace to be refilled with pig iron. Usually this conveying takes place over rails, although the invention could also be applied to such cars for road transport. Examples of such torpedo cars are given in patent documents US-3,661,374 and US-4,524,954.

[0003] An ancillary task of such cars, from which also the name mixer or moving mixers originates, is the possibility to allow the pig iron to become somewhat more homogeneous before being processed further in the steelmaking works. By the large volume of such cars, which could take up quantities of molten iron in a range of about 175 to 450 tons, it is possible to homogenize large quantities of pig iron simultaneously therein. Moreover it is often the practice to add substances such as flux additions to the pig iron in the vessel or to take steps to sulphurise the iron in said vessel on the car.

[0004] The vessel is internally lined with protective refractory bricks which are worn by continuous use. It is often usual for such a vessel to apply additional splash shields near to and on the outside of the filling opening. The splash shields protect the shell against local superheating by spilled liquid metal during filling and emptying of the vessel. The average lifespan of such a vessel is between about 900 to 1200 cycles with each movement of the hot metal being a cycle, following which the refractory structure of the vessel is being refurbished.

[0005] The filing opening can be round or elliptical in shape and in use has a typical diameter of about 80-140 cm depending on the capacity of the vessel. The diameter is kept limited to reduce temperature loss of the hot metal. When the refractory lining around the filling opening is removed it has a typical diameter in a range of about 120-180 cm.

[0006] The refractory lining around the filling opening may be in the form of a single piece of refractory concrete instead of being build up from multiple individual bricks or from gunned concrete. Such a single piece of refractory concrete has a three-dimensional partly curved shape and, depending on the capacity of the vessel, has a total weight ranging from about 5 to 7 tons. This single piece of refractory concrete is made by constructing a mould or formwork on the vessel in its position of conveying, and pouring or casting in-situ the refractory concrete into the formwork onto the vessel, compacting of the refractory concrete using techniques known in the art, e.g. by means of vibration, and following setting of the refractory concrete the formwork can be removed and subsequently the refractory concrete is cured. Commonly a plurality of anchors are attached to the outer surface of the vessel' hull, e.g. by means of welding, and which become embedded into the refractory concrete to provide an improved connexion between the refractory concrete and the hull of the vessel.

[0007] Constructing the formwork or mould is complicated as it is build up from multiple steel components having considerable weight. The formwork is centred around a core positioned in the filling opening and corresponding to the required filling opening diameter and shape, and components are build up from the inside of the vessel to match the shape of the single piece and are in connection with the core. Some traction may be exerted in upward direction to the core and the connected components on the inside of the vessel such that there are substantially no chinks between the vessel wall and the formwork and thereby avoiding leakage of refractory concrete into the vessel when cast into the formwork. The construction and subsequent deconstruction of such a complex formwork from the inside towards the outside of the vessel requires at least one worker to be present inside the vessel in a narrow and confined space and to handle tools, equipment and heavy loads, including working with so-called hands-on-the-load, all of which may prompt safety issues. Such working conditions are undesirable and ideally to be avoided or at least limited.

[0008] It in an object to provide a method for refurbishing the refractory lining around the filling opening of a vessel for the conveying of hot materials, particularly for molten pig iron, the method offering improved working conditions of a worker in constructing the formwork for casting refractory concrete.

DESCRIPTION OF THE INVENTION

[0009] This object and further advantages are met or exceeded by the present invention according to claim 1 and with preferred embodiments set out in the dependent claims and the description.

[0010] In order to achieve this object, the present invention proposes, in a first aspect, a method of refurbishing the refractory structure made of a single piece of refractory concrete surrounding the filling opening of a vessel for the conveying of molten metal, in particular molten pig iron, the method comprising the steps of:

- constructing a formwork or mould on the vessel in its position of conveying, thus whereby the filling opening of the vessel is facing upwards;
- providing castable refractory concrete and casting in-situ the refractory concrete into the formwork onto the vessel to form a single piece of refractory concrete;
- optionally compacting of the cast refractory concrete;
- setting and subsequently curing of the refractory concrete;
- deconstructing of the formwork;
- and wherein constructing the formwork comprises inflating an inflatable core element forming an air chamber extending outwards through the filling opening and corresponding to the required filling opening diameter and shape, and inflating an inflatable support element forming another air chamber positioned within the interior of said vessel and at least near the filling opening reaching up to the vessel walls, the core element and the support element are intended to be used in combination, the inflated support element is kept in its position via a locked-down fit with the inner vessel walls and whereby the support element supports the inflated core element on its lower end. For inflating of infltable elements ambient air may be used.

[0011] The use of a flexible inflatable core element and flexible inflatable support element instead of multiple heavy metal components results in a simplified method of refurbishing the refractory structure of the filling opening of a vessel. Fixing up the formwork required less manhours and is also less labour intensive. The method significantly reduces the amount of handling of heavy equipment and loads and avoids hands-on-the-load, in particular when working within the vessel or torpedo car. The method according to the invention further offers improved worker safety and less harsh working conditions when constructing and deconstructing the formwork from the inside of the vessel.

[0012] In an embodiment constructing the formwork further comprises positioning a flexible wall element within the filling opening and extending outwardly through the filling opening. The flexible wall element covers the whole circumference of the filling opening and may be inflatable. The flexible wall element is connected to the inflatable support element, and next positioning the inflatable core element within the flexible wall element. When inflating the inflatable core element to form an air chamber filling up the filling opening said flexible wall element, optionally inflatable flexible wall element, achieves a locked-down fit within the filling opening of the formwork and increases the shape stability of the core element while in-situ casting and setting of the refractory concrete. Thus the flexible wall element further improves the positioning of the core element and maintaining its shape within the formwork.

[0013] In an embodiment the inflatable core element, the optionally inflatable flexible wall element, and the support element are brought to and kept at sufficient pressure to maintain shape stability while in-situ casting and setting of the refractory concrete. The pressure can be applied on each of these elements via one or more air vents or valves and by using a compressor and kept at a constant level in combination with a pressure regulator. For inflating these elements ambient air may be used. Preferably each of these elements are kept at overpressure, preferably at an overpressure in a range of 0.01 to 2 Pa, while in-situ casting and setting of the refractory concrete.

[0014] In an embodiment at least the inflatable core element may be placed in tension, e.g. by applying traction in upward direction, to help to maintain the shape while in-situ casting and setting of the refractory concrete. Preferably the inflatable core element together with the (inflated) flexible wall element may be placed in tension to help to maintain the shape of the these elements.

[0015] In an embodiment the inflatable core element, the flexible wall element, and the inflatable support element can be connected or coupled to each other for example via a rope hole connection, a clamp wire connection, or velcro tape.

[0016] In another embodiment at least the inflatable core element and the inflatable support element form an inflatable one-piece element forming a single air chamber.

[0017] In an embodiment each of the inflatable core element, the flexible wall element and the inflatable support element can be made from heavy duty polyester, heavy duty coated polyester, nylon, PVC (polyvinyl chloride), TPR (thermos plastic rubber) or from EVA (ethylene vinyl acetate).

[0018] During inflation and deflation of the inflatable support element there can be some chaffing against the inner refractory lining of the vessel. In an embodiment a removable protective layer is placed or positioned between the vessel wall(s) and at least part of the inflatable support element to avoid or at least limit damaging of the support element against potential sharp edges present on the refractory bricks forming the inner refractory lining of the vessel. The protective layer can be formed by a

sheet, cloth or woven fibre mats of protective and wear resistant material made from polyamide (PA) fibres such as nylon, or from aramid fibres, such as commercially produced Kevlar, Twaron, Technora, Heracron, or Alkex, or from high molecular weight polyethylene (HMWPE) fibres, such as commercially produced Spectra or Dyneema, or from polybenzobisoxazole (PBO) fibres, such as commercially produced Zylon.

[0019] In an embodiment of the method once the in-situ cast refractory concrete has sufficient strength to maintain its shape without further support, e.g., after setting, the formwork can be deconstructed by deflating the various inflated elements by opening one or more air vents or valves or using a vacuum pump, and once deflated the element(s) can be removed manually from the vessel, and are available for a next refurbishment.

[0020] In an aspect of the invention it relates to an inflatable support element forming an air chamber for use in the method according to the invention and having a diameter in a range of about 2 to 3.5 meter and a length of about 2 to 5 meter. The inflatable support element in inflated condition may have a tubular shape forming an air chamber to obtain a better locked-down fit with the inner vessel wall(s).

[0021] In an aspect of the invention it relates to an inflatable core element forming an air chamber for use in the method according to the invention and having a diameter in a range of about 0.6 to 1.4 meter and a length of about 1 to 2.5 meter.

[0022] In a further aspect of the invention it relates to a torpedo car for the conveying of molten metal, in particular of molten pig iron, having a refurbished refractory lining around its filling opening made from a single refractory concrete piece in accordance with the invention as herein described and claimed.

BRIEF DESCRIPTION OF THE FIGURES

[0023] The invention will now be explained by means of the following non-limiting figures:

Fig. 1 shows in longitudinal section a car with a vessel according to the invention (Fig.1 is of US-3,661,374 and incorporated herein by reference);
Fig. 2 shows a perspective view of the single piece refractory concrete structure surrounding the filling opening or pouring mouth of a torpedo car;
Fig. 3 shows a cut out of a construction drawing of a torpedo car;
Fig. 4 shows a perspective view of the inflated elements forming part of the formwork in accordance with the invention.

[0024] Fig. 2 shows a perspective view of an example of a single piece refractory concrete structure (105) surrounding the filling opening or pouring mouth of a torpedo car. Such a single piece of refractory concrete has a three-dimensional partly curved shape and, depending on the capacity of the vessel, has a total weight ranging from about 5 to 7 tons.

[0025] Fig. 3 shows a cut out of a construction drawing of a torpedo car near the filling opening and illustrating the single piece refractory concrete structure (105) surrounding the filling opening (24).

[0026] Fig. 4 shows a perspective view of the inflatable core element (101) and the inflatable support element (102) in inflated condition and forming part of the formwork system for casting in-situ refractory concrete into the formwork onto the vessel to form a single piece of refractory concrete. The inflated core element (101) is positioned within a flexible wall element (103) connected via a rope hole connection to the inflated support element (102). The flexible wall element (103) together with the inflated core element (101) can be placed in tension by applying traction in upward direction (direction of the arrow) to help to maintain the shape of these elements while casting and setting of the refractory concrete around the filling opening of the vessel. The inflatable support element (102) may be provide with handles (104) to facilitate a worker with the handling of this element when positioning it on the inside of the vessel and for its removal from the inside of the vessel. The inflatable core element (101), the inflated flexible wall element (103) and the inflatable support element (102) include one or more air vents (not shown) connectable to a compressor (not shown) for inflating and deflating these elements and when inflated to keep these elements at pressure to maintain shape stability while in-situ casting and setting of the refractory concrete.

[0027] The above-discussion is intended to be merely illustrative of the present method and should not be construed as limiting the appended claims to any particular embodiment or group of embodiments. Accordingly, the specification and drawings are to be regarded in an illustrative manner and are not intended to limit the scope of the appended claims. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. Any reference signs in the claims should not be construed as limiting the scope of the appended claims.

Claims

1. Method of refurbishing the refractory structure made of a single piece (105) of refractory concrete surrounding the filling opening of a vessel for the conveying of molten metal, in particular molten pig iron, the method comprising the steps of: constructing a formwork on the vessel in its position of conveying; casting in-situ refractory concrete into the formwork onto the vessel to form a single piece (105) of refractory concrete; setting of the refractory concrete;

and deconstructing of the formwork; and wherein constructing the formwork comprises inflating an inflatable core element (101) forming an air chamber extending outwards through the filling opening and inflating an inflatable support element (102) forming another air chamber positioned within the interior of said vessel and reaching up to the vessel walls and supporting the inflated core element (101) on its lower end.

2. Method according to claim 1, wherein constructing the formwork further comprises positioning a flexible wall element (103), preferably an inflatable wall element, within the filling opening and extending outwardly through the filling opening and connecting said flexible wall element to the inflatable support element (102), and positioning the inflatable core element (101) within the flexible wall element.

3. Method according to claim 1 or 2, wherein the refractory concrete is compacted after casting into the formwork.

4. Method according to any one of claims 1 to 3, wherein the inflatable core element (101) and the support element (102) are kept at overpressure while in-situ casting and setting of the refractory concrete.

5. Method according to any one of claims 1 to 4, wherein the inflatable core element (101) and the inflatable support element (102) are kept at overpressure in a range of 0.01 to 2 Pa while in-situ casting and setting of the refractory concrete.

6. Method according to any one of claims 1 to 5, wherein the inflatable core element (101) is coupled to the inflatable support element (102).

7. Method according to any one of claims 1 to 5, wherein the inflatable core element (101) and the inflatable support element (102) form a single inflatable element.

8. Method according to any one of claims 1 to 7, wherein a protective layer is placed at least between the vessel walls and the inflatable support element (102).

9. Method according to any one of claims 1 to 8, wherein at least the inflatable core element (101) is placed in tension during in-situ casting and setting of the refractory concrete.

10. Method according to any one of claims 1 to 9, wherein at least the inflatable core element (101) and the inflatable support element (102) are made from an heavy duty polyester.

11. Method according to any one of claims 1 to 10, wherein each of the inflatable core element (101), the inflatable support element (102), and the inflatable flexible wall element (103) comprise one or more air vents.

12. Method according to any one of claims 1 to 11, wherein following setting of the refractory concrete deconstructing of the formwork comprises deflating the inflated elements and removing these elements (101,102, 103) from the vessel.

13. Inflatable support element (102) for use in the method according to any one of claims 1 to 11 and having a diameter in a range of 2 to 3.5 meter.

14. Inflatable core element (101) for use in the method according to any one of claims 1 to 12 and having a diameter in a range of 0.6 to 1.4 meter.

15. A torpedo car for the conveying of molten metal, in particular of molten pig iron, having a refurbished refractory lining around its filling opening made from a single refractory concrete piece (105) in accordance with any one of claims 1 to 12.

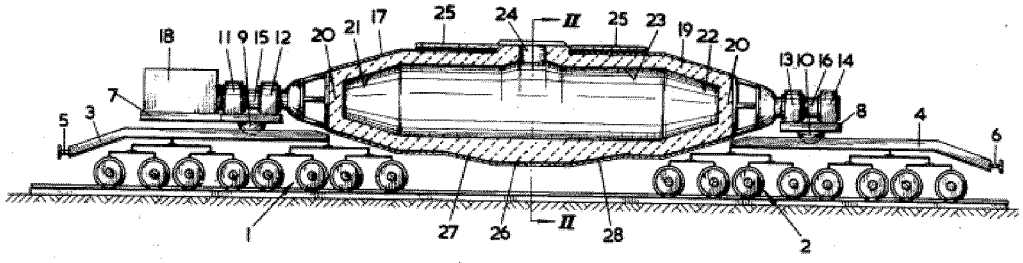
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Fig.1

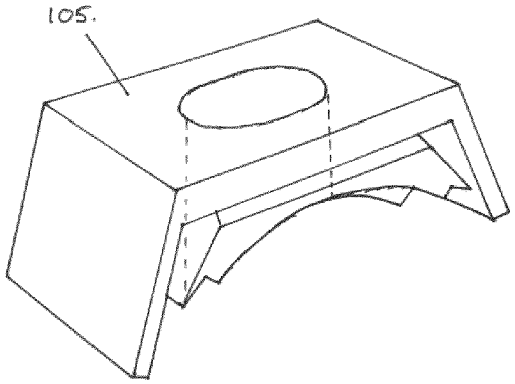
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Fig. 2

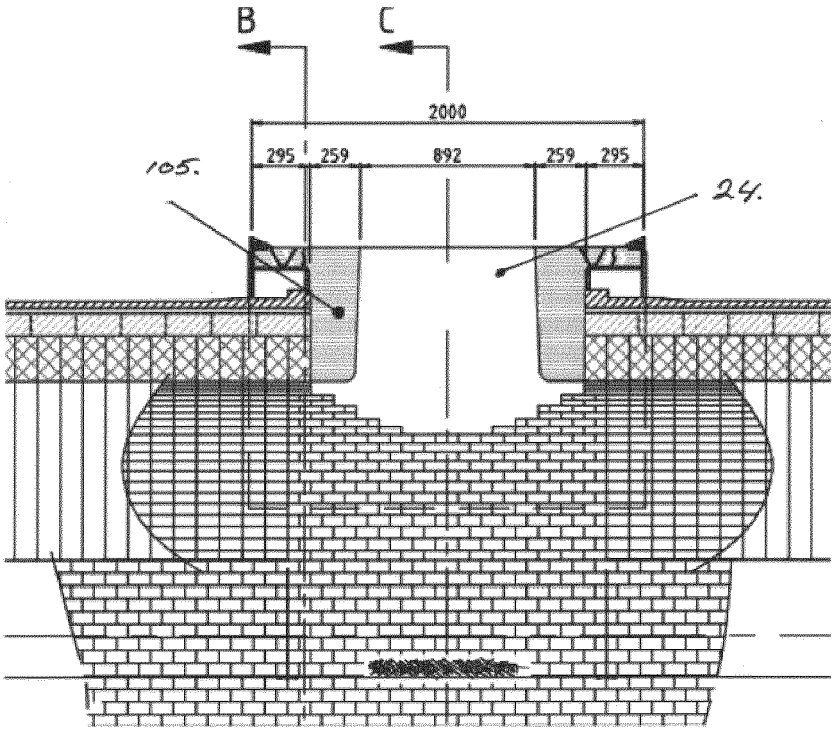

Fig. 3

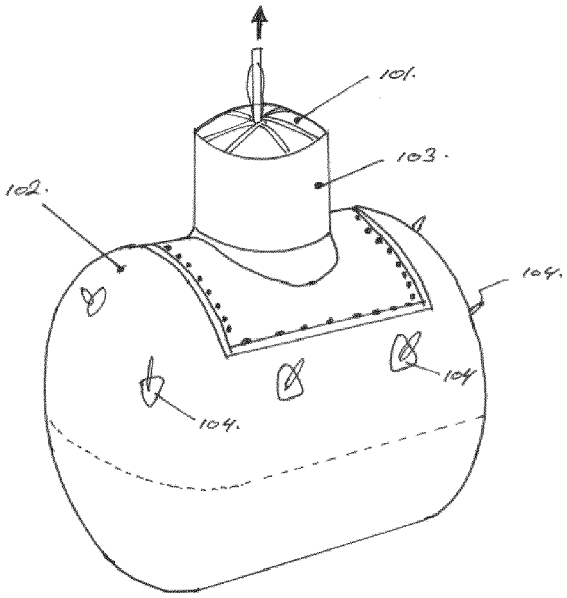

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 1625

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP H08 143926 A (KUCHIKU KOGYO; KYUSHU GOMME SEIHIN HANBAI KK; NIPPON STEEL CORP) 4 June 1996 (1996-06-04) * figures 6, 8 * * paragraphs [0013], [0014] *	1-12,15	INV. C21C1/06 B22D41/02 B22D41/12
X A	US 2021/381262 A1 (MIKSA WESLEY EARL [US]) 9 December 2021 (2021-12-09) * paragraph [0042] - paragraphs [0049], [0076] *	13,14 3,4,7,9, 10	

TECHNICAL FIELDS SEARCHED (IPC)

B22D
C21C
F27D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 January 2024	Porté, Olivier

CATEGORY OF CITED DOCUMENTS

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		WO 2020172654 A1	27-08-2020

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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