



(51) International Patent Classification:

C21C 5/52 (2006.01) C21B 5/00 (2006.01)
C21B 3/00 (2006.01) C21B 11/00 (2006.01)

(21) International Application Number:

PCT/IB2016/057828

(22) International Filing Date:

20 December 2016 (20.12.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/272,547 29 December 2015 (29.12.2015) US
62/414,166 28 October 2016 (28.10.2016) US

(71) Applicant: **SABIC GLOBAL TECHNOLOGIES B.V.**
[NL/NL]; Plasticslaan 1, 4612 PX Bergen op Zoom (NL).

(72) Inventor: **AL-GAHTANI, Masoud Said**; SABIC T&I,
P.O. Box 11669, Jubail, 31961 (SA).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,

HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))

Published:

— with international search report (Art. 21(3))

(54) Title: SYSTEMS AND METHODS FOR FEEDING MANUFACTURING BY-PRODUCTS TO A FURNACE

10

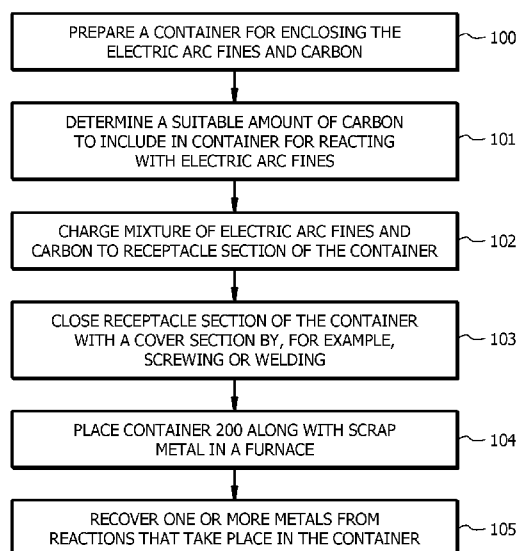


FIG. 1

(57) Abstract: Systems and methods are disclosed that involve, in the operation of an electric arc furnace (EAF), disposing a composition into a container for smelting in the electric arc furnace. The composition may include EAF fines and carbonaceous fines. The systems and methods involve placing the container and a steel precursor into the EAF to react the EAF fines with the carbonaceous fines and melting the container and the steel precursor. Methods for feeding manufacturing by-products to a furnace for melting in the furnace, including filling a container with manufacturing by-products including at least one of iron and baghouse dust (BHD), the container having a melting point greater than or equal to a melting point of the iron and a melting point of the iron and baghouse dust (BHD). The method further includes securing the container closed with a lid, charging the container into the furnace, and melting, via the furnace, the container, the iron and baghouse dust (BHD) in the furnace.

SYSTEMS AND METHODS FOR FEEDING MANUFACTURING BY-PRODUCTS TO A FURNACE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to United States Provisional
5 Application No. 62/272,547 entitled "METHOD AND APPARATUS FOR FEEDING
MANUFACTURING BYPRODUCTS TO A FURNACE," filed December 29, 2015, and
United States Provisional Application No. 62/414,166 entitled "METHOD FOR UTILIZING
AND FEEDING BAG HOUSE DUST TO ELECTRIC ARC FURNACE," filed October 28,
2016, all of which are hereby incorporated herein by reference in their entireties.

FIELD OF INVENTION

[0002] The present invention relates to manufacturing steel in a furnace. More
specifically, the present invention relates to systems and methods for utilizing manufacturing
by-products such as iron by-products and electric arc furnace fines as raw material to charge
the furnace, such as an electric arc furnace.

BACKGROUND OF THE INVENTION

[0003] Steel is an alloy of iron. The element to which iron is typically alloyed is
carbon. Industrially, steel is made by smelting iron ore or iron scrap, or both, in a furnace.
There are mainly two types of furnaces for making steel: blast furnaces and electric arc
furnaces. Electric arc furnaces are typically used to smelt iron scrap.

[0004] In the manufacture of steel in an electric arc furnace, a scrap basket charges
(feeds) iron scraps into the electric arc furnace. Electrodes are then placed into the electric
arc furnace. Once the electrodes are in place, they are electrified so that they transmit a
powerful electric current to the iron scrap charge, which creates an arc and generates heat.
The heat melts the iron scrap, forming a pool of molten metal.

[0005] Fluxes such as lime are added, which helps to remove impurities via slag,
which forms on top of the molten iron. Once sufficient molten iron has been formed, the
electric arc furnace is tapped to pour the molten iron into a ladle. Depending on the grade of
steel being produced, the molten iron undergoes further treatment to produce the grade of
steel desired, in a process often referred to as secondary steelmaking.

[0006] Overall, the steelmaking process produces by-products such as slag (mentioned above), iron by-products, and dust. The iron by-product can be melted and recast. The dust also includes iron that can be melted and recast, but may also include contaminant materials including zinc, other metals, and other minerals. The dust is usually carried off in furnace off-gas. One or more baghouse dust collectors collect the dust (a type of electric arc furnace fines) before they have an opportunity to escape into the atmosphere. Hence, this dust from the electric arc furnace is called baghouse dust (BHD). BHD builds-up in the baghouse dust collector and, thus, the baghouse dust collector has to be de-dusted periodically. When the baghouse dust collector is de-dusted, heaps of BHD may be collected. This collected BHD is considered hazardous waste, which makes it expensive to handle and dispose of.

[0007] Depending on the charge to, and operation of, the electric arc furnace, the BHD may comprise iron, zinc, and other metals and minerals produced as a by-product of the steelmaking process. In addition to the inconvenience and expense of handling and disposing of the BHD as hazardous waste, valuable metals such as iron included in the BHD are lost from the steel making process when the BHD is discarded. In other words, a certain percentage of the iron in the charge to the electric arc furnace is not recovered as a metal product because of electric arc furnace fines exiting the steel making process via BHD.

[0008] Because the BHD is made up of small particles, it is difficult to recycle the BHD into the furnace for further processing to recover metal from the BHD. Such recycling is difficult to achieve because the small particles, if re-introduced in the electric arc furnace, as is, would not be able to stay there for sufficient time to allow them to be exposed to appropriate processing conditions to recover iron from the BHD. The flow of off-gas from the electric arc furnace would be expected to blow such BHD out of the electric arc furnace to the baghouse dust collector.

BRIEF SUMMARY OF THE INVENTION

[0009] Systems and methods have been discovered that address the foregoing problems. The systems and methods involve using electric arc furnace fines (*e.g.*, BHD) as raw material for steel production rather than simply discarding these fines to a baghouse dust collector. In one particular aspect, the invention concerns introducing electric arc furnace fines (alone or in combination with another reactant material such as carbonaceous fines) into

an electric arc furnace in a manner that sufficiently shields the fines and, if present, the other reactant material, from the convective flow of gases in the electric arc furnace for a predetermined period. This predetermined period is sufficient to allow conditions to be achieved that transform the electric arc furnace fines and optionally other reactant material to a form not susceptible to removal from the electric arc furnace by the convective flow of gases. Therefore, iron from the fines can be used to produce steel rather than be discarded.

[0010] In embodiments of the invention, the electric arc furnace fines and the other reactant material are sufficiently shielded in the electric arc furnace so that the electric arc furnace fines are able to melt and/or the electric art fines and the other reactant material are able to react with each other to form a liquid. The formed liquid includes molten iron and, unlike the electric arc furnace fines, is not susceptible to being removed from the electric arc furnace by hot upwardly flowing gases. The molten metal then becomes a portion of the larger pool of molten metal, formed from other steel precursors, in the furnace. In this way, iron from the electric arc furnace fines is recovered to form steel, instead of being discarded as waste in BHD.

[0011] In embodiments of the invention the electric arc furnace fines and other material to be reacted with the electric arc furnace fines are placed in a container that envelopes these other reactant materials. The container may be adapted such that the electric arc furnace fines melt within the container and/or the electric arc furnace fines and the other material reacts to form a liquid before the container itself melts. In this way, the electric arc furnace fines and other reactant material are not exposed to electric arc furnace gases.

[0012] Embodiments of the invention include a method that includes disposing a composition into a container, the composition comprising electric arc furnace fines and carbonaceous fines. The method may further include placing the container and a steel precursor into an electric arc furnace and melting the container and the steel precursor, thereby introducing the composition to the steel precursor.

[0013] Embodiments of the invention include a method that includes disposing a composition into a container via an opening of the container, the composition comprising electric arc furnace fines and carbonaceous fines. The method may further include coupling a lid to the container to at least partially close the opening and placing the container and scrap

steel into an electric arc furnace. The method may further include melting the container and the scrap steel, thereby introducing the composition to the scrap steel.

[0014] Embodiments of the invention include a method for feeding manufacturing by-products to a furnace for melting in the furnace. The method may include filling a container with manufacturing by-products including at least one of iron and dust, the container having a melting point greater than or equal to a melting point of the iron and a melting point of the dust. The method may further include, securing the container closed with a lid, charging the container into the furnace, and melting, via the furnace, the container, the iron and the dust in the furnace.

[0015] Embodiments of the invention include a method for feeding manufacturing by-products to a furnace for melting in the furnace. The method may include filling a container with manufacturing by-products including at least one of iron and dust, the container being composed of scrap steel and having a melting point greater than or equal to a melting point of the iron and a melting point of the dust. The method may further include, securing the container closed with a lid via at least one of a screw closure and welding. The method may also include charging the container into a molten metal portion of the furnace, and melting, via the furnace, the container, the iron and the dust in the furnace.

[0016] The following includes definitions of various terms and phrases used throughout this specification.

[0017] The term “bag house dust” is defined as dust collected by a bag house dust collector that collects dust from off-gas of an electric arc furnace.

[0018] The terms “about” or “approximately” are defined as being close to as understood by one of ordinary skill in the art. In one non-limiting embodiment the terms are defined to be within 10%, preferably, within 5%, more preferably, within 1%, and most preferably, within 0.5%.

[0019] The terms “wt.%”, “vol.%” or “mol.%” refer to a weight, volume, or molar percentage of a component, respectively, based on the total weight, the total volume, or the total moles of material that includes the component. In a non-limiting example, 10 moles of component in 100 moles of the material is 10 mol.% of component.

[0020] The term “substantially” and its variations are defined to include ranges within 10%, within 5%, within 1%, or within 0.5%.

[0021] The terms “inhibiting” or “reducing” or “preventing” or “avoiding” or any variation of these terms, when used in the claims and/or the specification, includes any measurable decrease or complete inhibition to achieve a desired result.

[0022] The term “effective,” as that term is used in the specification and/or claims, means adequate to accomplish a desired, expected, or intended result.

[0023] The use of the words “a” or “an” when used in conjunction with the term “comprising,” “including,” “containing,” or “having” in the claims or the specification may mean “one,” but it is also consistent with the meaning of “one or more,” “at least one,” and “one or more than one.”

[0024] The words “comprising” (and any form of comprising, such as “comprise” and “comprises”), “having” (and any form of having, such as “have” and “has”), “including” (and any form of including, such as “includes” and “include”) or “containing” (and any form of containing, such as “contains” and “contain”) are inclusive or open-ended and do not exclude additional, unrecited elements or method steps.

[0025] The process of the present invention can “comprise,” “consist essentially of,” or “consist of” particular ingredients, components, compositions, etc. disclosed throughout the specification.

[0026] Other objects, features and advantages of the present invention will become apparent from the following figures, detailed description, and examples. It should be understood, however, that the figures, detailed description, and examples, while indicating specific embodiments of the invention, are given by way of illustration only and are not meant to be limiting. Additionally, it is contemplated that changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description. In further embodiments, features from specific embodiments may be combined with features from other embodiments. For example, features from one embodiment may be combined with features from any of the other embodiments. In further embodiments, additional features may be added to the specific embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] For a more complete understanding, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0028] FIG. 1 shows a method for introducing electric arc furnace fines, as raw material, into an electric arc furnace, according to embodiments of the invention;

[0029] FIG. 2 shows a system for introducing electric arc furnace fines, as raw material, into an electric arc furnace, according to embodiments of the invention;

[0030] FIG. 3 shows a system for introducing electric arc furnace fines, as raw material, into an electric arc furnace, according to embodiments of the invention;

[0031] FIG. 4 shows a system for introducing iron by-products and electric arc furnace fines, as raw material, into an electric arc furnace, according to embodiments of the invention; and

[0032] FIG. 5 shows a manufacturing by-products feeding and melting process, according to embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0033] Systems and methods have been discovered that introduce electric arc furnace fines into an electric arc furnace in a manner that sufficiently shields the electric arc furnace fines and carbonaceous material that may be provided for reaction with the electric arc furnace fines. The systems and methods sufficiently shield the electric arc furnace fines and carbonaceous material from the flow of gases in the electric arc furnace for a predetermined period. This predetermined period is sufficient to allow conditions to be achieved that transform the electric arc furnace fines and the carbonaceous material into a form not susceptible to removal from the electric arc furnace by the flow of gases in the electric arc furnace.

[0034] In embodiments of the invention, the electric arc furnace fines and carbonaceous material are sufficiently shielded in the electric arc furnace so that the electric arc furnace fines are able to melt and/or the electric arc furnace fines and carbonaceous material are able to react with each other to form a liquid, *e.g.*, molten iron, molten steel,

and/or molten slag. Liquids such as molten iron, steel, and slag, unlike the electric arc furnace fines, are not susceptible to being removed from the electric arc furnace by hot upwardly flowing gases. Thus, the molten metal becomes a part of the larger pool of molten metal (*e.g.*, steel and/or iron) in the electric arc furnace. The molten metal may then be used to form steel in secondary steelmaking. In this way, iron and/or steel from the electric arc furnace fines, which previously would typically be discarded as waste, may be recovered to form steel.

[0035] In embodiments of the invention the electric arc furnace fines and the carbonaceous material are placed in a container that envelopes the electric arc furnace fines and the carbonaceous material. The container may be adapted such that the electric arc furnace fines in the container melt and/or the electric arc furnace fines and the carbonaceous material react to form a liquid before the container itself melts to expose the electric arc furnace fines and the carbonaceous material to significant flow of electric arc furnace gases.

[0036] FIG. 1 shows method 10 for introducing electric arc furnace fines (*e.g.* BHD) into an electric arc furnace, as raw material, according to embodiments of the invention. FIG. 2 shows system 20 for introducing BHD into an electric arc furnace, as raw material, according to embodiments of the invention. System 20 may be used in carrying out method 10.

[0037] Referring to FIG. 1, method 10 may begin at block 100, which includes preparing a container, such as container 200 (FIG.2), for enclosing and shielding the electric arc furnace fines and carbon (*e.g.*, carbonaceous fines), if the carbon is to be present. The electric arc furnace fines may include metallic particles formed as a by-product of the steelmaking process and include material such as BHD. The carbonaceous material may include amorphous carbon such as coal and/or other materials having carbon such as coke. In embodiments of the invention, the carbonaceous material may be prepared to have particle sizes similar to the particle sizes of the electric arc furnace fines with which the carbonaceous material will react. In this way, the surface area exposure between the electric arc furnace fines and the carbonaceous material may be enhanced so that the reaction between these materials occur as quickly as possible.

[0038] Referring to FIG. 2, container 200 may be made of metal such as iron and/or steel. In embodiments of the invention, container 200 may be made from scrap metal, such

as industrial scrap metal. The industrial scrap metal can be ferrous industrial scrap metal. In embodiments of the invention, the ferrous industrial scrap metal can include ferrous metals and alloys composed at least in part by iron such as mild steel, carbon steel, stainless steel, cast iron, wrought iron and the like. The industrial scrap metal can be non-ferrous industrial scrap metal. In embodiments of the invention, the non-ferrous industrial scrap metal can include metals and alloys such as aluminum, brass, copper, nickel, tin, lead, zinc, gold, silver and the like. Further, in embodiments of the invention, container 200 is composed of any combination of industrial scrap metals. For example, container 200 can be composed of aluminum, copper, brass, iron, lead, bronze and the like, or any combinations thereof.

[0039] The metal that makes up the walls of container 200 may be adapted so that container 200: (1) transmits heat to its contents, *e.g.*, transmits heat to at least BHD 201 and carbon 202; (2) withstand the temperature of the electric arc furnace for a sufficient time to allow BHD 201 to melt and/or BHD 201 and carbon 202 to react; and (3) eventually melts to release molten metal, including molten iron and/or steel. Container 200 may be adapted to achieve the foregoing by using particular metallic compositions for its metallic walls, minimum thicknesses of its walls, and particular combinations thereof. Container 200 may be adapted to withstand expanding pressures of gases within container 200, once container 200 is subjected to the heat of the electric arc furnace.

[0040] The melting point of steel decreases as its carbon content increases. Thus, limiting the amount of carbon may help to ensure that container 200 can withstand the temperatures in electric arc furnace 300 for a predetermined period. In embodiments of the invention, container 200 may have walls that include steel with a maximum of 0.3 wt.% carbon. In embodiments of the invention, container 200 may be made of low carbon (*e.g.*, 0.3 wt.% carbon) steel with a minimum wall thickness.

[0041] Container 200 may have receptacle section 200A, which has walls partially enclosing space 200C for receiving BHD 201 and carbon 202 (*e.g.*, carbonaceous material, amorphous carbon, coal, coke and/or other materials having carbon). In embodiments of the invention, carbon 202 includes fines and have particle sizes similar to BHD 201. Container 200 may further have lid section 200B for attachment to receptacle section 200A to enclose BHD 201 and carbon 202 in space 200C. Lid section 200B may be adapted to be attached to receptacle section 200A by methods such as welding, screwing (*e.g.*, lid section 200B having a screw portion and receptacle section 200A having a corresponding threaded portion), *etc.*

In embodiments of the invention, when lid section 200B is attached to receptacle section 200A, container 200 may become a gas-tight container. In some embodiments of the invention, container 200 may not be a gas-tight container but may sufficiently enclose BHD 201 and carbon 202 such that electric arc furnace gases do not flow into container 200 and
5 blow out BHD 201 and carbon 202 before they are able to melt and/or react to form molten metal.

[0042] Container 200 may be of any shape (*e.g.*, cuboidal, cylindrical, spherical, *etc.*). Container 200 may be of different sizes. The size of container 200 may be predetermined based on how much BHD 201 and carbon 202 will be added to container 200 and whether a
10 particular amount of air (which may be the gas that fills space in container 200 not occupied by BHD 201 and carbon 202) is needed for a particular reaction desired to take place in container 200. In embodiments of the invention, container 200 can have an absolute dimension size of 25 cm³, 250 cm³, 25000 cm³, 2500000 cm³, and the like. The absolute dimension size of the container 200 can correspond to the size of a furnace. The size of the
15 container 200 can correspond to the furnace so one container 200 can fit inside the furnace, or a plurality of containers 200 can fit inside the furnace. Preferably, container 200 has a size such that the total volume of the container defined by its outside dimensions is less than 1% of the total interior volume of the furnace, preferably less than 0.5%, less than 0.01%, less than 0.005% or less than 0.001%.

[0043] In embodiments of the invention, the internal volume of container 200 may be configured so that heat transfer to BHD 201 and carbon 202 at the inner most location of container 200 is sufficient to allow BHD 201 at that innermost location to melt and/or BHD 201 and carbon 202 at that innermost location to react prior to the walls of container 200 melting to allow furnace gases to flow in space 200C at an extent that could remove BHD
25 201 and carbon 202, as fines, from container 200. Alternatively or additionally, container 200 may be configured so that the distance between any two portions of the walls of container 200 that are directly opposite each other (*e.g.*, a height or width of a cuboidal container or a height or diameter of a cylindrical container) may be such that it does not exceed a particular value. Alternatively or additionally, container 200 may be configured so
30 that no location within space 200C is at a distance greater than a particular value from any wall of container 200.

[0044] In embodiments of the invention, container 200 is completely filled or substantially filled with reactant materials such as BHD 201 and carbon 202. In embodiments of the invention, container 200 is able to withstand a particular temperature range for a fixed period of time before any of its walls disintegrate sufficiently to allow furnace gases to flow into container 200 in a manner that could remove BHD 201 and carbon 202, as fines, from space 200C. To be able to withstand a particular temperature range for a fixed period of time, container 200 may have a melting point that is greater than or equal to a melting point of BHD 201 that is disposed in container 200. For example, container 200 can have a melting point that is greater than or equal to a melting point of BHD 201. Thus, container 200 can be configured to resist melting until the BHD 201 inside container 200 is melted and/or reacted with carbon 202. In embodiments of the invention, container 200 may have a melting point that is lower than the melting point of BHD 201. Container 200 can further include a cross-section to divide the contents of BHD 201 into a first section and a second section.

[0045] Referring again to FIG. 1, method 10 may include, at block 101, determining a suitable amount of carbon 202 to include in container 200 for reacting with BHD 201. Determining a proper amount of carbon 202 may involve taking into account the composition and amount of BHD 201. For example, a chemical analysis may be carried out on BHD 201 to determine its composition. It should be noted that, in embodiments of the invention, other materials apart from carbon 202 may be provided in container 200 for reaction with BHD 201, such as when chemical analysis of BHD 201 suggests such reactions may be warranted, for example, to prevent certain impurities from being introduced into the molten metal.

[0046] Method 10 may involve, at block 102, charging (adding) reactants such as BHD 201 and carbon 202, in desired quantities, to receptacle section 200A. In embodiments of the invention, BHD 201 and carbon 202 may be mixed prior to charging them to receptacle section 200A. Alternatively or additionally, BHD 201 and carbon 202 may be mixed after being charged to receptacle section 200A. In embodiments of the invention, in addition to reactants such as BHD 201 and carbon 202, trace metals including manganese, lead, chromium and the like may be added to receptacle section 200A. It should be noted further that, in embodiments of the invention, iron by-product (*e.g.*, iron dust 203, FIG. 4, discussed below), may be charged to receptacle section 200A in addition to or as an alternative to BHD 201 and/or carbon 202.

[0047] After charging reactants at block 102, method 10 may then involve, at block 103, closing receptacle section 200A with lid section 200B by, for example, screwing or welding, and the like, or combinations thereof. After enclosing reactants such as BHD 201 and carbon 202 in container 200, at block 104, method 10 may involve placing container 200 along with a steel precursor (*e.g.*, iron ore or scrap metal) in a furnace. In embodiments of the invention, container 200 may be charged along with scrap metal to an electric arc furnace.

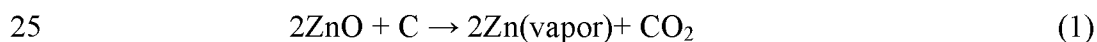
[0048] FIG. 3 shows system 30, in which container 200 and scrap metal 302 are being charged to electric arc furnace 300 by scrap basket 301. In embodiments of the invention, container 200 is charged with scrap metal 302 into the bottom of electric arc furnace 300 and into molten metal 303. In embodiments of the invention, electric arc furnace 300 can be an electric arc furnace that heats charged material by means of an electric arc. Electric arc furnace 300 can range in size from small units of approximately one ton capacity (used in foundries for producing cast iron products) up to about 400 ton units used for secondary steelmaking. Industrial electric arc furnace temperatures can be up to 1,800°C, while certain laboratory electric arc furnaces can exceed 3,000°C. Electric arc furnace 300 can be composed of a refractory-lined body, usually water-cooled in larger sizes, covered with a retractable roof, and through which one or more electrodes enter electric arc furnace 300. The refractory material used to make electric arc furnace 300 is chemically and physically stable at high temperatures. The refractory material used in electric arc furnace 300 of embodiments of the invention can be, but is not limited to, oxides of aluminum, silicon, magnesium, zirconium, calcium, as well as fire clays, binary or ternary compounds such as tungsten carbide, boron nitride, hafnium carbide, or tantalum hafnium carbide, or mixtures thereof. These heat resistant materials may be present throughout entire electric arc furnace 300, throughout some of electric arc furnace 300, or present in certain components of electric arc furnace 300. For instance, refractory materials may be used to line the entire interior surface of electric arc furnace 300, or only the portions of electric arc furnace 300 that come into contact with liquid molten metal materials. Further, the heat resistant refractory materials may be used as a protective layer for special components that come in continuous contact with the liquid molten metals.

[0049] An exemplary electrode used in the electric arc furnace can be a graphite electrode, although the electrodes used are non-limiting, and may include other types of electrodes. In embodiments of the invention, electric arc furnace 300 may be in the shape of

a shoe, where the bottom of the electric arc furnace has a curved shape. In embodiments of the invention, the bottom of the electric arc furnace may be flat or squared. The shape and size of electric arc furnace 300 is non-limiting, and thus various shapes and sizes of electric arc furnace 300 may be used in embodiments of the invention.

5 **[0050]** Container 200 may be configured so that it encloses and shields BHD 201 and carbon 202 from the flow of gases in electric arc furnace 300 for a period of time sufficient to allow BHD 201 and carbon 202 to achieve desired conditions to allow BHD 201 to melt and/or to allow BHD 201 and carbon 202 to react with each other. To ensure that these desired conditions are achieved, container 200 may be adapted to transfer sufficient heat to
10 BHD 201 and carbon 202 from electric arc furnace 300 to allow the melting and reacting mentioned above, while shielding these materials. Put differently, container 200 may be adapted to transfer heat from, and withstand the temperatures of, electric arc furnace 300 for a sufficient time to enable BHD 201 to melt and/or BHD 201 and carbon 202 to react so that BHD 201 and carbon 202 are no longer fines. When BHD 201 and carbon 202 are
15 transformed into materials that are no longer fines, it is no longer possible for such fines to get caught into the flow of gases in electric arc furnace 300 and thereby sucked into electric arc 300's de-dusting system. According to embodiments of the invention, after the sufficient time has passed, the heat in electric arc furnace 300 also melts container 200. Thus, container 200 becomes part of molten metal 303 in electric arc furnace 300.

20 **[0051]** When container 200 is in solid form, in electric arc furnace 300, BHD 201 and carbon 202 may be subjected to a temperature in a specified temperature range sufficient to facilitate reactions (1) and (2) below. At this temperature inside container 200, Fe and Zn oxides in BHD 201 react with elemental carbon in carbon 202 to yield iron and zinc according to the following chemical reactions:



[0052] In reaction (1), carbon deoxidizes zinc oxide to produce zinc vapor. In reaction (2), carbon deoxidizes iron oxide to produce molten iron.

[0053] Referring again to FIG. 1, method 10 may include, at block 105, recovering
30 metal previously included in BHD 201. In embodiments of the invention, recovering metal

previously included in BHD 201 may include allowing container 200 to melt and the iron formed in reaction (2) to flow into molten metal 303 (FIG. 3). In this way, recovering metal previously included in BHD involves disposing iron from BHD 201 in a steel product that includes scrap metal smelted in electric arc furnace 300.

5 [0054] Alternatively or additionally, in embodiments of the invention, recovering metal previously comprised in BHD 201 may include cooling off-gas from electric arc furnace 300 to recover vaporized metal such as vaporized zinc, produced by reaction (1).

[0055] By implementing systems and methods described herein, the yield of iron from a smelting process in an electric arc furnace may be improved, as well as the yield for
10 by-products such as Zn may be improved. At the same time, the difficulty and expense of dealing with a hazardous material in the form of BHD can be reduced or avoided.

[0056] FIG. 4 shows a system for housing manufacturing by-products, according to embodiments of the invention. As FIG. 4 shows, manufacturing by-products such as iron dust and by-product dust (*e.g.*, BHD) may be placed in a container without carbonaceous
15 material for melting in a furnace. System 40 may include container 200 having receptacle section 200A, lid section 200B, and enclosing space 200C, as described above with respect to FIG. 2. Container 200 is adapted to hold iron dust 203 and/or BHD 201. System 40 can include one or more containers 200. For example, a first container can be utilized to store a second container filled with iron dust 203 and/or BHD 201 and a third container filled with
20 iron dust 203 and/or BHD 201.

[0057] In embodiments of the invention, container 200 can be filled with manufacturing by-products to be fed into a furnace for melting. The manufacturing by-products can include materials such as iron dust 203 and BHD 201 (FIG. 4). Container 200 can include additives of steel manufacturing in addition to the manufacturing by-products. In
25 embodiments of the invention, container 200 can be filled with manufacturing by-products as well as trace metals including manganese, lead, chromium, and the like.

[0058] It may be preferable that the container 200 is fully filled with manufacturing by-products; however, container 200 can be partially filled with manufacturing by-products. Container 200 is fully filled with manufacturing by-products when there is no headspace
30 between the iron dust 203 and/or the dust by-product 106 inside container 200 and the bottom of lid section 200B. Container 200 can be filled with a predetermined quantity of iron dust

203 and a predetermined quantity of BHD 201. For example, container 200 can include a mass ratio of iron dust 203 to BHD 201 such as 1:20, 1:10, 1:4, 1:2, 1:1, 0:1, 2:1, 4:1, 10:1, 12:1, and the like. In embodiments of the invention, container 200 can include a range of volume of a particular manufacturing by-product. Thus, container 200 can be configured to be filled with less than or equal to 40% BHD 201, less than or equal to 50% iron dust 203, greater than or equal to 60% BHD 201, greater than or equal to 75% iron dust 203, and the like.

[0059] Container 200 can be filled with manufacturing by-products according to a particular packing density. The packing density may influence the mechanical and physical properties of the yield of the furnace. In embodiments of the invention, container 200 can have a particular packing density for iron dust 203 and/or a particular packing density for BHD 201.

[0060] Container 200 may include a melting point that is greater than or equal to a melting point of the manufacturing by-products that container 200 has in it. For example, container 200 can have a melting point that is greater than or equal to a melting point of iron dust 203 and a melting point of BHD 201. Thus, container 200 can be configured to resist melting until iron dust 203 inside container 200 is melted, until the BHD 201 inside container 200 is melted, after iron dust 203 inside container 200 has melted, and/or after the BHD 201 inside container 200 has melted. In embodiments of the invention, container 200 may have a melting point that is lower than the melting point of one or more of iron dust 203 and BHD 201. Container 200 can further include a cross-section to divide the contents of the manufacturing by-products into a first section and a second section. For example, container 200 can include a first section to be filled with iron dust 203 and a second section to be filled with BHD 201. The cross-section can be included in container 200 to prevent iron dust 203 and BHD 201 from mixing before container 200 is melted in the furnace.

[0061] Iron dust 203 can include direct reduced iron, sponge iron, fine direct reduced iron, and/or ultra fine direct reduced iron. The direct reduced iron can be produced from direction reduction of iron ore. The iron ore can initially be in the form of lumps, pellets or fines. The iron ore may be reduced by reducing gas that is produced from natural gas or coal. The reducing gas can be a mixture composed of reducing agents such as hydrogen and carbon monoxide. The particle size of iron dust 203 can range from 3 mm to 20 mm for 90% to 100% of the particle size distribution with a maximum particle size distribution of 5%

including particle sizes greater than 20 mm and a maximum particle size distribution of 5% including particle sizes less than 3 mm. Iron dust 203 can be collected, for charging into container 200, by the manufacturing plant. Iron dust 203 can have a melting point that is less than or equal to the melting point of container 200.

5 **[0062]** BHD 201 may include bag house dust, fine bag house dust, and/or ultra fine bag house dust. In embodiments of the invention, BHD 201 comprises zinc, other metals and other minerals produced from the processes involved in steel production including mercury, lead, chromium, and/or manganese and the like. The particle size of BHD 201 can range from 5 μm to 50 μm for 75% to 100% of the particle size distribution, with a maximum
10 particle size distribution of 25% for particle sizes of less than 5 μm . BHD 201 can be collected, for charging into container 200, by the manufacturing plant. BHD 201 can have a melting point that is less than or equal to the melting point of container 200.

[0063] Lid section 200B can be configured to be secured to receptacle section 200A. Container 200 may have one or more lid sections 200B. For example, container 200 can
15 include a cross-section to divide the manufacturing by-products into a first section and a second section. In embodiments of the invention, there may be a first lid located at a first end of container 200 for the first section and a second lid located at a second end of container 200, opposite the first end, for the second section. A plurality of lid sections 200B can be utilized to compartmentalize iron dust 203 and BHD 201. Lid section 200B can secure
20 container 200 closed via a screwing closure, welding, fastening, or any other method of securing a container closed that is known. Lid section 200B can be composed of industrial scrap metal. In embodiments of the invention, lid section 200B may be composed of scrap steel. In embodiments of the invention, lid section 200B may be composed of any industrial scrap metals or combinations thereof that are known such as combinations of aluminum,
25 copper, brass, iron, lead, bronze, and the like. Lid section 200B can be composed of the same combination of industrial scrap metals as receptacle section 200A. Lid section 200B can also be composed of a different combination of industrial scrap metals in comparison to receptacle section 200A. For example, receptacle section 200A can be composed of scrap steel and lid section 200B can be composed of a different grade of scrap steel such that lid section 200B
30 has a lower melting point than receptacle section 200A. Thus, lid section 200B can be configured to melt simultaneously with iron dust 203 and BHD 201. Lid section 200B, iron dust 203 and BHD 201 can be configured to melt simultaneously in a furnace while container

200 can be configured to withstand melting. In embodiments of the invention, container 200 can be a reusable container. In embodiments of the invention, container 200 can be composed of ceramic, the same material that the furnace is composed of, or any material that has a melting point that is greater than or equal to the melting point of the furnace.

5 **[0064]** System 30 may be used for feeding and melting of steel manufacturing by-products, according to embodiments of the invention. As noted above, system 30 may include container 200, lid section 200B of container 200, electric arc furnace 300, molten metal 303 and scrap basket 301. In embodiments of the invention, container 200 may include manufacturing by-products, such as iron dust 203 and BHD 201 disposed in receptacle
10 section 200A and secured closed with lid section 200B. Container 200 may be charged into electric arc furnace 300 to be melted, along with the by-products housed in container 200 300. Preferably, in embodiments of the invention, container 200 is added to electric arc furnace 300 when electric arc furnace 300 is at least partially filled with molten metallic material. Further, in embodiments of the invention, it may also be preferable that container
15 200 is added to electric arc furnace 300 prior to any final adjustment of the composition of the material inside electric arc furnace 300, *e.g.*, container 200 may be charged to electric arc furnace 300, and then any final adjustments may be made by adding other additives.

[0065] In embodiments of the invention, container 200, having manufacturing by-products disposed therein, can be charged into electric arc furnace 300 along with scrap metal
20 302 from scrap basket 301. In embodiments of the invention, container 200 includes manufacturing by-products, such as iron dust 203 and/or BHD 201 being charged into electric arc furnace 300 in a dried form, a heated form, and the like. Scrap basket 301 can charge scrap such as steel, or any other industrial scrap metals that are known into electric arc furnace 300. Scrap metal 302 from scrap basket 301 can be charged into electric arc furnace
25 300 in a dried form, a heated form, and the like. Container 200 and scrap metal 302 can be simultaneously charged into electric arc furnace 300 when electric arc furnace 300 is empty. Container 200 can be charged into empty electric arc furnace 300 first, and scrap metal 302 can be charged into electric arc furnace 300 second. Scrap metal 302 can be charged into the empty electric arc furnace 300 first, and container 200 can be charged into electric arc
30 furnace 300 second. Scrap metal 302 can be charged into empty electric arc furnace 300 first, container 200 can be charged into electric arc furnace 300 second, and then more scrap metal 302 can be added to electric arc furnace 300. In embodiments of the invention, electric arc

furnace 300 contains a predetermined quantity of molten metal prior to the charging of container 200 and scrap metal 302 into electric arc furnace 300.

[0066] Container 200 including manufacturing by-products, such as iron dust 203 and BHD 201, and scrap metal 302 can be charged into electric arc furnace 300 in predetermined quantities by weight. For example, the quantities being charged into electric arc furnace 300 can include a small quantity of manufacturing by-products, such as iron dust 203 and BHD 201, by weight and a large quantity of scrap by weight. Thus, the summation of the charged materials can include 15%, 20%, 25% and the like of manufacturing by-products by weight. In embodiments of the invention, the quantities being charged into electric arc furnace 300 can include a large quantity of manufacturing by-products by weight and a small quantity of scrap by weight. Thus, the summation of the charged materials can include 75%, 80%, 85% and the like of manufacturing by-products by weight.

[0067] Container 200 and scrap metal 302 can be melted in molten metal 303 in electric arc furnace 300. System 30 can include one or more containers 200 to increase the yield of electric arc furnace 300. Container 200 can be composed of a shape that corresponds to the shape of electric arc furnace 300. For example, container 200 can include lid section 200B and/or receptacle section 200A being round to fit into the bottom of a round bottom of electric arc furnace 300. Thus, container 200 can be charged into a predetermined position in electric arc furnace 300. Additionally or alternatively, container 200 can be composed of ceramic, the same material that electric arc furnace 300 is composed of, or any material that has a melting point that is greater than or equal to the melting point of electric arc furnace 300.

[0068] The by-products, such as iron dust 203 and BHD 201, housed container 200 can be configured to resist dedusting of the dedusting system of electric arc furnace 300. The dedusting system of electric arc furnace 300 removes predetermined materials and/ minerals from the headspace (*e.g.*, that area above the molten metal and the upper opening of electric arc furnace 300. By charging iron dust 203 and BHD 201 into electric arc furnace 300 in closed container 200, iron dust 203 and BHD 201 resist dedusting; meaning the added dust is not blown out of electric arc furnace 300 or otherwise lost inadvertently. Thus, the by-products, such as iron dust 203 and BHD 201, in container 200 can be utilized by electric arc furnace 300 to increase the yield of electric arc furnace 300.

[0069] FIG. 5 shows a flowchart of manufacturing by-products feeding and melting process 50, according to embodiments of the invention. Manufacturing by-products feeding and melting process 50 shows the process of charging container 200 filled with manufacturing by-products, such as iron dust 203 and BHD 201, into electric arc furnace 300 and melting container 200 filled with manufacturing by-products, such as iron dust 203 and BHD 201, in electric arc furnace 300. At block 500, container 200 may be filled with manufacturing by-products. The manufacturing by-products can include iron dust 203 and BHD 201. Iron dust 203 can include fine direct reduced iron. Container 200 can be filled with a predetermined quantity of iron dust 203 and a predetermined quantity of BHD 201. In embodiments of the invention, container 200 may be composed of any combination of industrial scrap metals that is known. For example, container 200 can be composed of aluminum, copper, brass, iron, lead, bronze and the like, or any combinations thereof.

[0070] At block 501, container 200 may be secured closed with lid section 200B. Lid section 200B can secure container 200 closed via a screwing closure, welding, fastening, or any other method of closing that is known onto receptacle section 200A. At block 502, closed container 200 may be charged into electric arc furnace 300. Container 200 can be charged into electric arc furnace 300 alongside scrap from scrap basket 301. Scrap basket 301 can deliver scrap metal 302, which may include steel, or any other industrial scrap metals that are known, into electric arc furnace 300.

[0071] At block 503, container 200 and the by-products, such as iron dust 203 and BHD 201, disposed in container 200 are melted in electric arc furnace 300. Container 200 and the by-products, such as iron dust 203 and BHD 201, disposed in container 200 can be melted in the molten metal 303 of electric arc furnace 300. In embodiments of the invention, container 200 and the by-product, such as iron dust 203 and BHD 201, of container 200 are melted alongside scrap metal 302 from scrap basket 301 in molten metal 303 of electric arc furnace 300. System 30 can include one or more containers 200 to increase the yield of the melting in electric arc furnace 300. Container 200 can be composed of ceramic, the same material that electric arc furnace 300 is composed of, or any material that has a melting point that is greater than or equal to the melting point of electric arc furnace 300. Thus, the by-products, such as iron dust 203 and BHD 201, disposed in container 200 can be melted by electric arc furnace 300 but container 200 can be configured to withstand the heat provided by electric arc furnace 300. In embodiments of the invention, container 200 could be reused

to be filled more than one time with the manufacturing by-products, such as iron dust 203 and BHD 201.

[0072] Manufacturing by-products feeding and melting process 50 may increase the overall yield for melting in electric arc furnace 300. Container 200, manufacturing by-products, and lid section 200B are charged into electric arc furnace 300 to be melted in electric arc furnace 300. The manufacturing by-products of container 200 resist a de-dusting system of the electric arc furnace 300 so that the overall yield of electric arc furnace 300 can increase. In embodiments described herein, an electric arc furnace is discussed. It should be noted, however, that alternatively or additionally, other types of furnaces such as blast furnaces may be used in embodiments of the invention.

[0073] Embodiments of the invention may encompass one or any combination of the aspects listed below.

[0074] Aspect 1: A method comprising: (1) disposing a composition into a container, the composition comprising electric arc furnace (EAF) fines and carbonaceous fines; (2) placing the container and a steel precursor into an EAF; and (3) melting the container and the steel precursor, thereby introducing the composition to the steel precursor.

[0075] Aspect 2: The method of aspect 1 further comprising: preparing the container so that the container is adapted to enclose and shield the composition from flow of gases in an EAF for a period of time sufficient to allow the EAF fines to melt.

[0076] Aspect 3: The method of aspect 2, wherein the period of time is sufficient to allow the EAF fines and the carbonaceous fines to react with each other.

[0077] Aspect 4: The method of any of aspects 1 to 3, wherein walls of the container comprise steel with a maximum of 0.3% carbon.

[0078] Aspect 5: The method of any of aspects 1 to 4, wherein the container comprises a receptacle section for receiving the composition and a lid section for attachment to the receptacle section to enclose the composition within the container.

[0079] Aspect 6: The method of aspect 5 wherein the receptacle section is attached to the lid section by screwing or welding.

[0080] Aspect 7: The method of any of aspects 1 to 6, wherein the steel precursor is scrap metal.

[0081] Aspect 8: The method of any of aspects 1 to 7 further comprising: determining a suitable amount of carbonaceous fines to include in the container with a particular amount of EAF fines.

[0082] Aspect 9: The method of aspect 8 wherein the determining a suitable amount comprises analysis to determine constituents of EAF fines.

[0083] Aspect 10: The method of any of aspects 1 to 9, further comprising recovering metal previously comprised in EAF fines.

[0084] Aspect 11: The method of aspect 10, wherein the recovering comprises disposing iron from the EAF fines in a metal product produced by an electric arc furnace.

[0085] Aspect 12: The method of aspect 11, wherein recovering comprises cooling off-gas from said electric arc furnace to recover vaporized metal from the EAF fines.

[0086] Aspect 13: The method of aspect 12, wherein the vaporized metal is zinc.

[0087] Aspect 14: The method of any of aspects 1 to 13, wherein the carbonaceous fines comprise coke.

[0088] Aspect 15: A method for feeding manufacturing by-products to a furnace for melting in the furnace, including: filling a container with manufacturing by-products including at least one of iron dust and by-product dust (e.g., BHD), the container having a melting point greater than or equal to a melting point of the iron dust and a melting point of the by-product dust; securing the container closed with a lid; charging the container into the furnace; and melting, via the furnace, the container, the iron dust and the by-product dust in the furnace.

[0089] Aspect 16: The method aspect 15, wherein the container is composed of scrap steel.

[0090] Aspect 17: The method of aspects 15 or 16, wherein the lid is secured via at least one of a screw closure and welding.

[0091] Aspect 18: The method of any one of aspects 15 to 17, further including: charging the container into a molten metal portion of the furnace.

[0092] Aspect 19: The method of any one of aspects 15 to 18, wherein the by-product dust present in the container is melted and resists dedusting to remain in the furnace.

5 **[0093]** Aspect 20: A method of preparing a container with manufacturing by-products for feeding to a furnace and melting in the furnace, including: filling the container with manufacturing by-products including at least one of iron dust and by-product dust, the container having a melting point greater than or equal to a melting point of the iron dust and a melting point of the by-product dust; and securing the container closed with a lid.

10 **[0094]** Aspect 21: The method of aspect 20, wherein the container is composed of scrap steel.

[0095] Aspect 22: The method of either aspect 20 or aspect 21, wherein the lid is secured via at least one of a screw closure and welding.

15 **[0096]** Aspect 23: A container for housing manufacturing by-products for feeding to a furnace and melting in the furnace, including: the container filled with by-products including at least one of iron dust and by-product dust; the container having a melting point greater than or equal to a melting point of the iron dust and a melting point of the by-product dust; and a lid to secure the container closed.

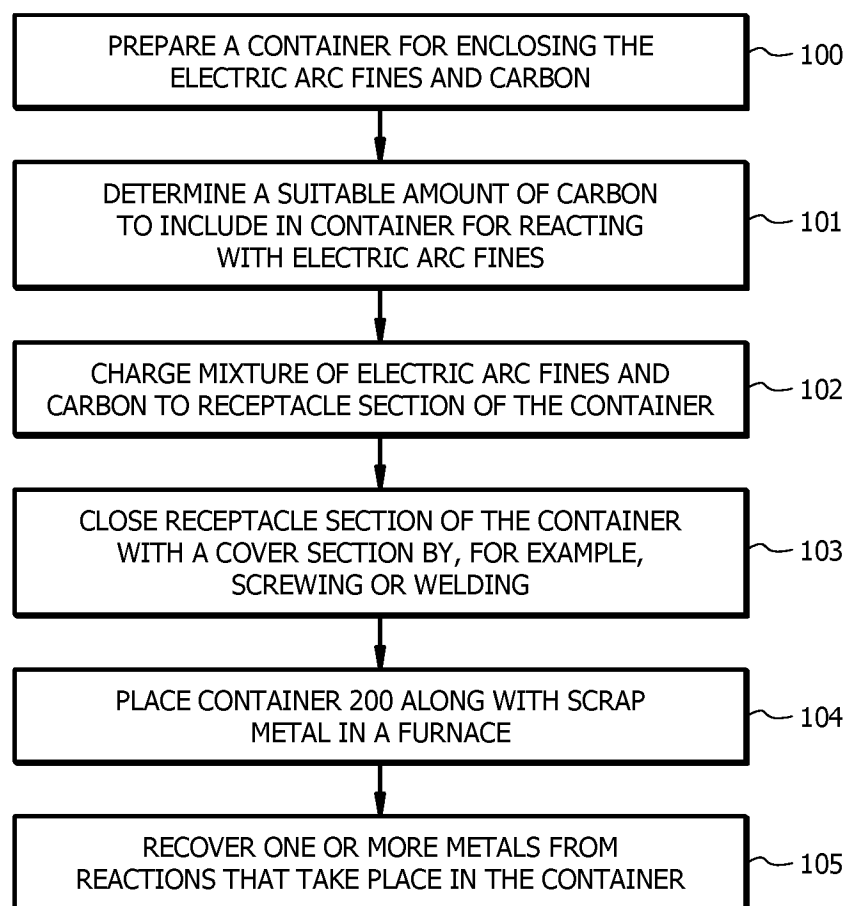
20 **[0097]** Aspect 24: The container for housing manufacturing by-products for feeding to a furnace and melting in the furnace of aspect 23, wherein the container is composed of scrap steel.

[0098] Aspect 25: The container for housing manufacturing by-products for feeding to a furnace and melting in the furnace of either aspects 9 or 10, wherein the lid is secured via at least one of a screw closure and welding.

CLAIMS

1. A method comprising:
 - (1) disposing a composition into a container, the composition comprising electric arc furnace (EAF) fines and carbonaceous fines;
 - (2) placing the container and a steel precursor into an EAF; and
 - (3) melting the container and the steel precursor, thereby introducing the composition to the steel precursor.
2. The method of claim 1 further comprising:
preparing the container so that the container is adapted to enclose and shield the composition from flow of gases in an EAF for a period of time sufficient to allow the EAF fines to melt.
3. The method of claim 2, wherein the period of time is sufficient to allow the EAF fines and the carbonaceous fines to react with each other.
4. The method of any of claims 1 to 3, wherein walls of the container comprise steel with a maximum of 0.3% carbon.
5. The method of any of claims 1 to 4, wherein the container comprises a receptacle section for receiving the composition and a lid section for attachment to the receptacle section to enclose the composition within the container.
6. The method of claim 5 wherein the receptacle section is attached to the lid section by screwing or welding.
7. The method of any of claims 1 to 6, wherein the steel precursor is scrap metal.
8. The method of any of claims 1 to 7 further comprising: determining a suitable amount of carbonaceous fines to include in the container with a particular amount of EAF fines.
9. The method of claim 8 wherein the determining a suitable amount comprises analysis to determine constituents of EAF fines.
10. The method of any of claims 1 to 9, further comprising recovering metal previously comprised in EAF fines.

11. The method of claim 10, wherein the recovering comprises disposing iron from the EAF fines in a metal product produced by an electric arc furnace.
12. The method of claim 11, wherein recovering comprises cooling off-gas from said electric arc furnace to recover vaporized metal from the EAF fines.
13. The method of claim 12, wherein the vaporized metal is zinc.
14. The method of any of claims 1 to 13, wherein the carbonaceous fines comprise coke.
15. A method for feeding manufacturing by-products to a furnace for melting in the furnace, comprising:
 - filling a container with manufacturing by-products including at least one of iron dust and by-product dust, the container having a melting point greater than or equal to a melting point of the iron dust and a melting point of the by-product dust;
 - securing the container closed with a lid;
 - charging the container into the furnace; and
 - melting, via the furnace, the container, the iron dust and the by-product dust in the furnace.
16. The method claim 15, wherein the container is composed of scrap steel.
17. The method of claim 15, wherein the lid is secured via at least one of a screw closure and welding.
18. A container for housing manufacturing by-products for feeding to a furnace and melting in the furnace, comprising:
 - the container filled with by-products including at least one of iron dust and by-product dust;
 - the container having a melting point greater than or equal to a melting point of the iron dust and a melting point of the by-product dust; and
 - a lid to secure the container closed.
19. The container of claim 18, wherein the container is composed of scrap steel.
20. The container of claim 18, wherein the lid is secured via at least one of a screw closure and welding.

10*FIG. 1*

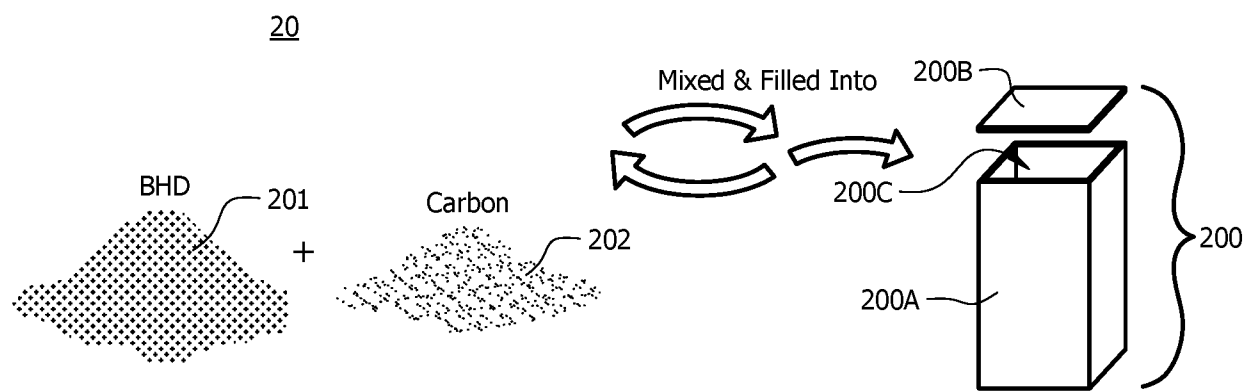
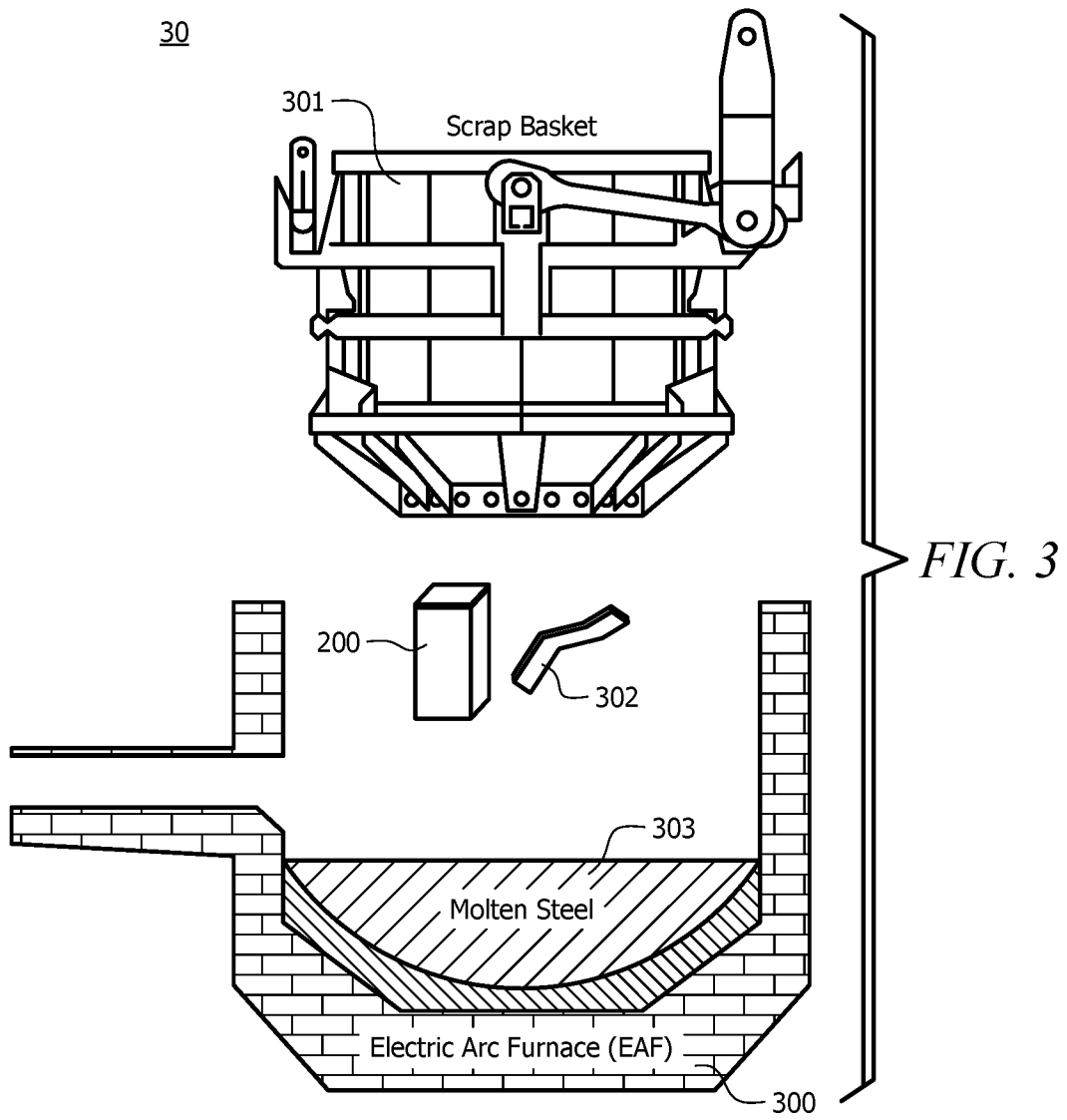
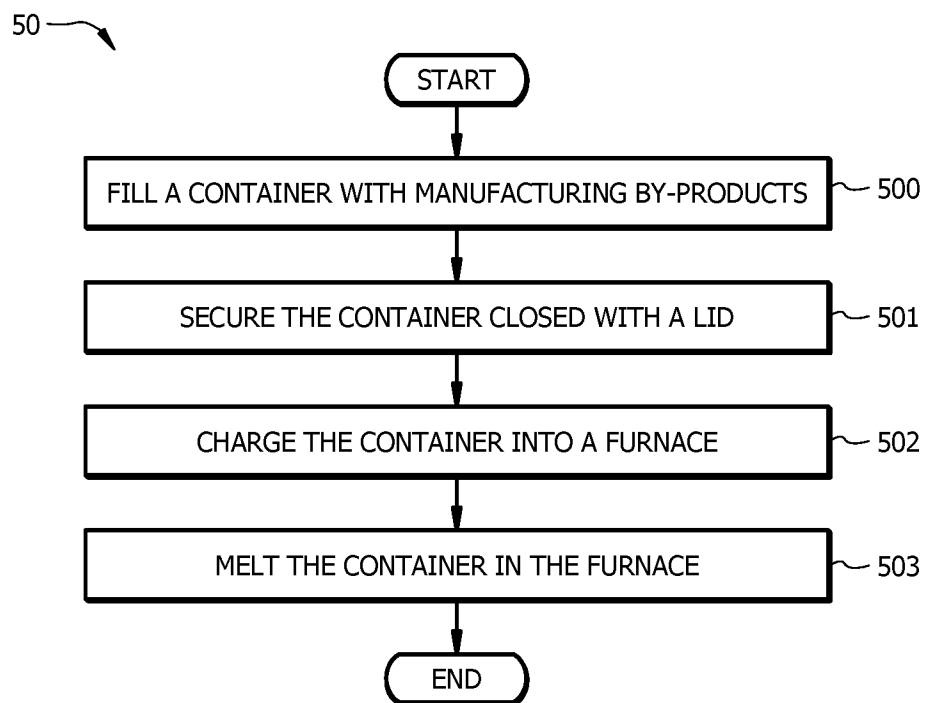
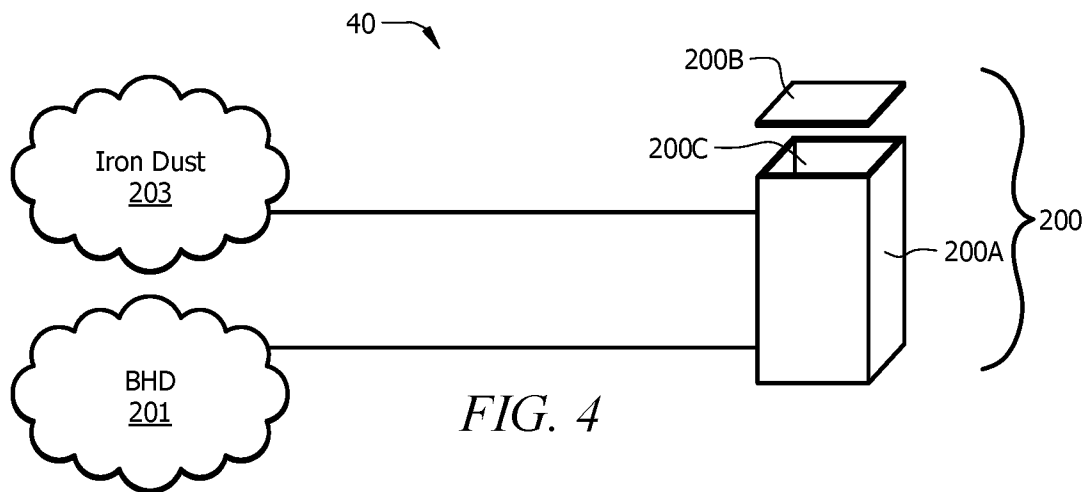


FIG. 2



*FIG. 5*

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/057828

A. CLASSIFICATION OF SUBJECT MATTER

INV. C21C5/52 C21B3/00 C21B5/00 C21B11/00
ADD.

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)

C21C C21B

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

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/146430 A2 (IRON MOUNT CORP [US]; REIFFEL LEONARD [US]) 21 December 2007 (2007-12-21) claims 1-12 paragraph [0008] - paragraph [0012] paragraph [0004]	1-20
X	WO 2013/151711 A1 (HOFFMAN HENRY H [US]; HOFFMAN JEFFREY J [US]; MARINO ANTHONY L [US]) 10 October 2013 (2013-10-10) figure 1 claims 1-3 paragraph [0008] - paragraph [0013] paragraph [0004]	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"T" 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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

14 March 2017

Date of mailing of the international search report

22/03/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gimeno-Fabra, Lluís

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/057828

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/260438 A1 (BASICH JOHN [CA]) 23 November 2006 (2006-11-23) paragraph [0035] paragraph [0046] - paragraph [0057] paragraph [0041] - paragraph [0046] -----	1-20
A	WO 2007/145972 A2 (REIFFEL LEONARD [US]) 21 December 2007 (2007-12-21) figures 8a-d paragraph [0016] - paragraph [0026] paragraph [0050] - paragraph [0054] -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/057828

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2007146430	A2	21-12-2007	NONE	

WO 2013151711	A1	10-10-2013	CA 2869553 A1	10-10-2013
			EP 2834380 A1	11-02-2015
			US 2015013497 A1	15-01-2015
			WO 2013151711 A1	10-10-2013

US 2006260438	A1	23-11-2006	CA 2542203 A1	06-10-2006
			US 2006260438 A1	23-11-2006

WO 2007145972	A2	21-12-2007	US 2009193933 A1	06-08-2009
			WO 2007145972 A2	21-12-2007
