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UNDERSIZED OXIDIC IRON CARRIERS****Publication Classification**(76) Inventors: **Christian Boehm**, Thalheim (AT); **Hado
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(57)

ABSTRACT

A method for producing compacts containing iron oxide from undersized oxidic iron carriers may include producing a mixture which comprises undersized oxidic iron carriers, bentonite as a binder and water, pressing the mixture and hardening the green compacts obtained by the pressing, as well as to the compacts produced by the method and to the use of the compacts as lump iron carriers. The mixture may be subjected to a kneading process lasting at least 3 minutes and up to 30 minutes, prior to the pressing. The compacts may thus be produced without a maturing process.

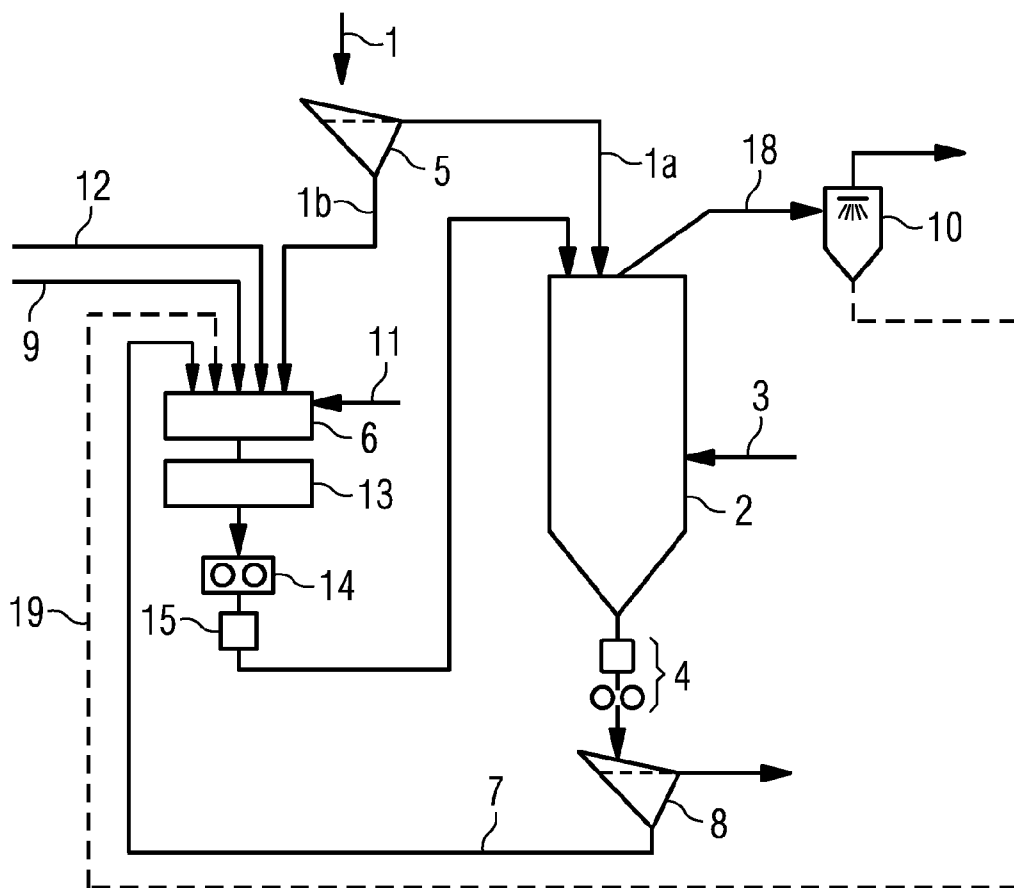


FIG 1

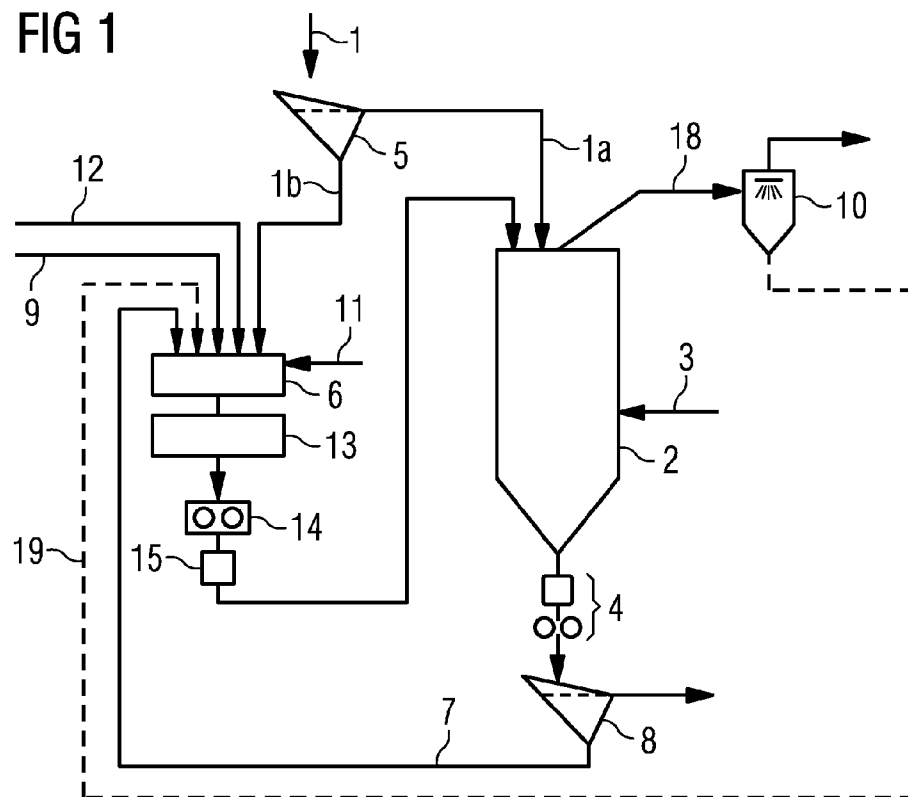
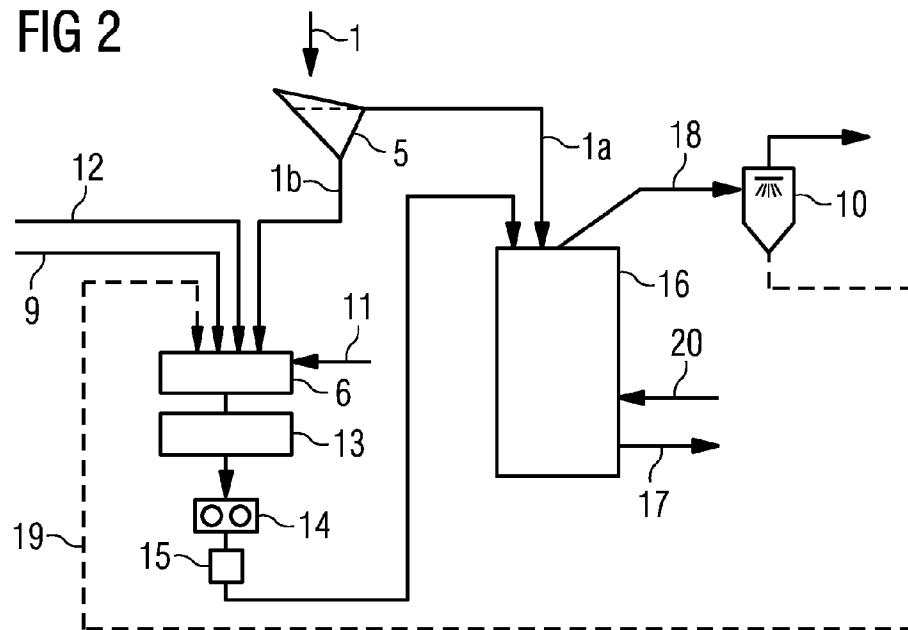


FIG 2



BENTONITE-BOUND COMPACTS OF UNDERSIZED OXIDIC IRON CARRIERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a U.S. National Stage Application of International Application No. PCT/EP2011/054214 filed Mar. 21, 2011, which designates the United States of America, and claims priority to AT Patent Application No. A 636/2010 filed Apr. 19, 2010. The contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to a method for producing compacts containing iron oxide from undersized oxidic iron carriers by producing a mixture which comprises undersized oxidic iron carriers, bentonite as a binder and water, pressing the mixture and hardening the green compacts obtained by the pressing, as well as to the compacts produced by the method and to the use of the compacts as lump iron carriers.

BACKGROUND

[0003] In many processes for producing sponge iron which use a direct reduction shaft with a fixed bed, for example according to the MIDREX® or HYL® processes, or in melt reduction methods for producing liquid pig iron in which reduction takes place in a shaft, for example in the COREX® process, lump oxidic iron carriers such as lump ore or pellets can be used as starting material. Owing to transport and handling, the lump oxidic iron carriers suffer abrasion or may fragment. The products of such degradation are too fine for use in a direct reduction shaft with a fixed bed, since they reduce the gas permeability of a fixed bed overall and increase the risk of poor distribution of the reduction gases, or channeling with associated incomplete reduction in certain regions. Before charging into a direct reduction shaft with a fixed bed, it is therefore necessary to separate an undersize of oxidic iron carriers due to such degradation from the lump oxidic iron carriers by screening and/or sifting, for example screening for a particle size of 6.3 mm and sifting for a particle size of <200 µm.

[0004] The term undersize is intended to mean particles whose particle size is less than 10 mm, preferably less than 6.3 mm, particularly preferably less than 5 mm. These values indicate the mesh width of the screen used for the screening, through which the undersize falls. The particle size of an undersize is referred to as undersized.

[0005] In order to be able to use the undersize, it must be converted into a lump form, that is to say agglomerated. If sintering or pelleting systems are present in the vicinity, this equipment may be used for agglomeration of an undersize. Often, cold briquetting systems for briquetting the undersize are also available in the plant assembly. In some cases, the undersize of the lump oxides is also returned to the ore supplier by return freight.

[0006] Agglomeration methods for converting finely particulate material into lump form, such as pelleting or sintering, can only be operated economically on a large scale. For this reason, agglomeration is often not carried out and the undersize from degradation of the lump oxidic iron carriers is stockpiled without being used.

SUMMARY

[0007] In one embodiment, a method for producing compacts containing iron oxide from undersized oxidic iron carriers includes producing a mixture which comprises the undersized oxidic iron carriers, bentonite as a binder and water, pressing the mixture and hardening the green compacts obtained by the pressing, wherein the mixture is subjected after combining its components to a kneading process lasting at least 3 minutes, preferably at least 5 minutes, up to 30 minutes, preferably up to 20 minutes, particularly preferably up to 15 minutes, which is followed by the pressing.

[0008] In a further embodiment, the mixture comprises from 3 to 12 weight % of bentonite, expressed in terms of the amount of undersized oxidic iron carriers. In a further embodiment, the mixture also comprises metallurgical residual materials containing iron,

[0009] preferably at least one member of the group

[0010] metalized Fe fines,

[0011] scale,

[0012] metallurgical dust,

[0013] metallurgical sludge,

[0014] material which comes from a steel production process, in which recovered sponge iron and/or recovered pig iron is employed by using compacts produced as disclosed herein.

[0015] In a further embodiment, the mixture also comprises finely particulate hematitic and/or limonitic material. In a further embodiment, the mixture also comprises finely particulate material formed during the removal of dust from top gas, reduction gas or generator gas of a plant for reducing oxidic iron carriers by means of a reduction gas. In a further embodiment, the mixture is heated during the kneading process.

[0016] In another embodiment, a compact is obtained by any of the methods disclosed above. In another embodiment, such a compact is used as a lump oxidic iron carrier for producing sponge iron or liquid pig iron.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Example embodiments will be explained in more detail below with reference to figures, in which:

[0018] FIG. 1 schematically shows an example embodiment of a direct reduction plant.

[0019] FIG. 2 schematically shows an example embodiment of a melt reduction plant.

DETAILED DESCRIPTION

[0020] Some embodiments provide a method for converting the undersize into lump form, which makes the undersize suitable for economic use in order to produce sponge iron or liquid pig iron.

[0021] For example, some embodiments provide a method for producing compacts containing iron oxide from undersized oxidic iron carriers by producing a mixture which comprises the undersized oxidic iron carriers, bentonite as a binder and water, pressing the mixture and hardening the green compacts obtained by the pressing, wherein the mixture is subjected after combining its components to a kneading process lasting at least 3 minutes, preferably at least 5 minutes, up to 30 minutes, preferably up to 20 minutes, particularly preferably up to 15 minutes, which is followed by the pressing.

[0022] The compacts are agglomerates, produced by pressing, of finely particulate materials. Examples of forms of compacts are briquettes, tablets and plates or extrudates, or lump fragments produced by careful disagglomeration from plates or extrudates.

[0023] An advantage of producing compacts from the undersized oxidic iron carriers, compared with pelleting, is that compact production, for example briquetting, can react more flexibly to variations in the quality and quantity of the materials used, and it is possible to obviate preparation of the materials used by fine grinding as well as the firing of green pellets. Compact production, for example briquetting, is therefore in principle more suitable for processing an under-size which occurs in amounts of up to 100 000 t/a.

[0024] Bentonite is used as a binder. Bentonite is intended to mean a material which is a mixture of various clay minerals and contains smectitic phyllosilicates, e.g., montmorillonite, as the main component. The smectitic phyllosilicates, e.g., montmorillonite, are present in amounts of at least 60%, preferably at least 70% as a weight percentage. The bentonite may be a naturally occurring rock, or derivatives of a naturally occurring rock obtained by providing additives or carrying out method steps.

[0025] The term undersized oxidic iron carriers is also, for example, meant to include dusts which result from the batching of lump oxidic iron carriers.

[0026] The mixture may comprise from 3 to 12 weight % of bentonite, expressed in terms of the amount of undersized oxidic iron carriers, preferably from 6 to 10 weight %. With less bentonite, it is not possible to ensure a sufficient binder effect. With more bentonite, the additional bentonite consumption does not provide any significant benefit in its effect as a binder in the compact. Also, further processing of the compacts in a steelworks is made more difficult owing to the increased slag formation due to the higher bentonite content. In addition, a higher bentonite component represents unnecessary ballast during transport of the compacts.

[0027] The components of the mixture may be combined in one or more steps. For example, the solid components of the mixture may be combined and premixed first, before water is added in order to create a doughy consistency. The doughy mixture of all the components is then subjected to the kneading process.

[0028] The solid and liquid components of the mixture may, however, also all be combined in one step.

[0029] The kneading process lasts at least 3 minutes, preferably at least 5 minutes, up to 30 minutes, preferably up to 20 minutes, particularly preferably up to 15 minutes, the limit values respectively being included. With a duration of less than 3 minutes, the properties of the green compacts and compacts obtained are insufficient. With a duration of more than 30 minutes, no significant change in the properties of the green compacts and compacts is achieved, but the time saving compared with maturing decreases with an increasing duration of the kneading process.

[0030] When using bentonite as a binder, it is conventional to leave the mixture comprising bentonite and water, and especially the bentonite, to swell for several hours while storing it at rest

[0031] a process which is also referred to as maturing—in order to allow the binding ability of the bentonite binder to be exerted. The duration of the maturing is referred to as the maturing time.

[0032] The kneading process disclosed herein, to which the mixture is subjected after combining its components, allows the time-consuming maturing to be eliminated, without significant impairment or even with improvement of the properties of the compacts. For the same throughput, this reduces the storage space necessary for this treatment step (bunker or pile volume), or with the same storage size it is possible to achieve a higher throughput. Furthermore, the mixture—and therefore the structure of the final product, the compact—is homogenized so that the amount of binder necessary for a particular compact quality can be reduced.

[0033] Table 1 shows the evaluation of tests of the production of compacts in relation to the drop shatter resistance (SF) and the point pressure strength (PDF) of the compacts in the scope of a test campaign. For this, the compacts are produced by the disclosed method with a kneading process, or according to conventional maturing processes. The compacts are briquettes.

[0034] The drop shatter resistances of green compacts and compacts produced according to the disclosed method, and of green compacts and compacts produced with maturing—respectively with the same starting materials and under otherwise identical conditions—are of the same order of magnitude, both for green compacts and for air-dried and thermally dried compacts.

[0035] In comparison to compacts and green compacts produced with maturing—respectively with the same starting materials and under otherwise identical conditions—compacts and green compacts produced by the method according to the disclosed method exhibit an increase in point pressure strength, particularly in the case of compacts produced by thermal drying.

[0036] The behavior of the compacts in relation to point pressure strength after thermal drying is regarded as an indication of the behavior of the compacts after charging into a reduction zone. Particularly owing to their point pressure strength properties, the compacts produced according to the disclosed method are much more suitable for use in an industrial reduction process than compacts produced with maturing.

[0037] Sinter feed from the Fabrica mine in Minas Gerais State/Brazil (FERTECO) was used as undersized oxidic iron carrier for all the tests shown in Table 1. The particle size used for producing the compacts was 0-8 mm with a d50 of 0.75 mm and a d95 of 3.15 mm. In order to set up constant test conditions, the sinter feed was thermally dried to a moisture content of <1% before the tests.

[0038] The following commercially available bentonites were used:

[0039] IK=IKO Bond D® (activated calcium bentonite from IKO Erbslöh containing about 90% montmorillonite)

[0040] VO=VOLCLAY® (natural sodium bentonite from Süd-Chemie containing about 70-80% montmorillonite)

[0041] TI=TIXOTON® (activated calcium bentonite from Süd-Chemie containing about 70% montmorillonite)

[0042] CA=CALCIGEL® (natural calcium bentonite from Süd-Chemie)

[0043] The mixtures were produced in a batch mixer of the type FM130D from Lödige.

[0044] The kneading mechanism from Köppern which was used for the kneading processes consisted of a vertically standing cylindrical container, through which a centrally rotating shaft with kneading arms is passed.

[0045] Heating of the kneading mechanism, which could be carried out in order to supply heat to the mixture during the kneading process, took place through the housing, to which end saturated steam at 6 to 8 bar was available.

[0046] The green compacts were produced by means of a test roll press of the type 52/10 from Köppern. The cushion-shaped format selected for the green compacts had a nominal volume of 20 cm³. The material to be pressed was delivered by means of gravity feeders. Composites consisting of a plurality of green compacts were produced by the test roll press. These composites contain green compacts both in the edge region of the composites and in the central region of the composites.

[0047] In order to obtain individual green compacts or individual compacts for determination of the drop shatter resistance and the point pressure strength, the composites are broken up along the dividing seams between the individual green compacts. Generally, the composites break up into individual green compacts during extraction from the test roll press.

[0048] For the compacts produced according to Table 1, the bentonite (Bent) and subsequently water (W) were initially added to the undersized oxidic iron carrier—the mixing time was 2 minutes in each case. The percentages indicated for bentonite and water are percentages by weight; the percentage by weight refers to the amount of undersized oxidic iron carriers used in the respective test.

[0049] Following the mixing process, the mixture was kneaded in the kneading mechanism in order to produce compacts according to the disclosed method. The kneading mechanism was heated in some cases, specifically with indirect heating through the housing. Results obtained in this way are indicated in Table 1 by the entries Knd+H in the Treatment column, H standing for heating. Entries Knd–H in the Treatment column mean that the kneading mechanism was not heated.

[0050] In order to produce compacts with maturing, the mixture was left to rest in a maturing container after the mixing process.

[0051] After the kneading process in the kneading mechanism, or the maturing in the maturing container, the mixtures as material to be pressed were subjected to pressing in the test roll press, in order to produce green compacts.

[0052] The green compacts thereby obtained are still soft—which is indicated in technical terminology by the prefix “green”—and are subjected to hardening, in order to obtain the finished compact. This hardening may be carried out for example by at least partial drying by storage in air and/or a heat treatment.

[0053] After the pressing, individual green compacts were respectively studied immediately, in technical terminology while green, in terms of drop shatter resistance (SF) and point pressure strength (PDF). The results of these studies are shown in the columns SF green and PDF green. The measurements of drop shatter resistance and point pressure strength were respectively repeated after 1 h of hardening in air and after 24 h or 72 h of hardening in air. The results of these studies are shown in the columns “SF 24 h (72 h)*” and “PDF 24 h (72 h)*”.

[0054] A subset of the green compacts obtained in the respective tests were dried over 30 min at 290° C., and likewise studied for drop shatter resistance and point pressure strength after cooling in air. The results of these studies are shown in the columns “SF dry” and “PDF dry”.

[0055] For the drop shatter test (based on ASTM D440) in order to establish the drop shatter resistance, a sample weighing 4 kg of green compacts, or compacts hardened by drying in air or by thermal drying, is dropped four times through a drop tube from a height of 2 m into a collection container, the bottom of which is made in the form of a solid steel plate. The drop tube has a diameter of 200 mm and the collection container has a diameter of 260 mm. The thickness of the steel plate is 12 mm. Evaluation of the drop shatter test by screening analysis is carried out after the second and fourth drops. The numerical values in Table 1 respectively indicate the proportion of the particle size fraction >20 mm after four drops.

[0056] In order to determine the point pressure strength, a test machine of the type 469 from ERICHSEN was used. In this test method, individual green compacts, or compacts hardened by drying in air or by thermal drying, are clamped between two holders, the lower of which is coupled to a force transducer and the upper is continuously adjusted by means of a spindle drive in order to apply a gradually increasing pressure load. The lower holder is formed by a round plate with a diameter of 80 mm and the upper by a horizontal metal rod with a diameter of 10 mm. The forward increment rate for the upper holder is 8 mm/min. The point pressure strength is registered as the maximum load recording of a green or hardened compact before fracture—the entries in Table 1 indicate the average point pressure strength at fracture as a result of point pressure loading in newtons. Six green compacts or compacts from the central region and six green compacts or compacts from the edge region of the composites obtained in the test roll press were respectively studied. Average values were calculated from the data obtained in these studies, the minimum and maximum values respectively being ignored. The average values are indicated in Table 1.

TABLE 1

Test No.	Bent [wt %]	W [wt %]	Treatment	SF green	SF 24 h (72 h)*	SF dry	PDF green	PDF 24 h (72 h)*	PDF dry
1	10% IK	5%	Knd + H 30 min	94	90	95	494	821	2188
2	10% IK	5%	Matu. 120 min	92	96	89	159	331	941
3	10% IK	5%	Matu. 240 min	89	96	91	139	287	797
4	10% IK	5%	Knd – H 30 min	93	94	91	209	441	1056
5	10% VO	5%	Knd + H 15 min	94	92	94	640	783	2129
6	10% VO	5%	Matu. 60 min	93	97	92	112	191	784
7	10% TI	5%	Knd + H 15 min	95	93	93	555	859	1987
8	10% TI	5%	Matu. 60 min	91	97	80	147	295	722
9	10% CA	5%	Knd + H 15 min	95	93*	93	261	835*	1551
10	10% CA	5%	Matu. 60 min	85	95*	76	97	447*	1385

[0057] Some embodiments provide a compact obtained by the disclosed method and the use of a compact obtained by the disclosed method as a lump oxidic iron carrier for producing sponge iron or liquid pig iron. Sponge iron may for example be produced in a reduction shaft, a rotary furnace or a rotary

tube, in which case the sponge iron may constitute an intermediate product for the production of liquid pig iron in a melt reduction process by means of a melt-down gasifier. This may also involve combined melt reduction/direct reduction plants or combined direct reduction/coal gasification plants. For this use, the compacts are employed in the same way as other types of lump oxidic iron carriers are employed.

[0058] According to one embodiment of the method, the mixture also comprises metallurgical residual materials containing iron, for example metalized Fe fines, scale, for example roll scale, metallurgical dust, for example blast furnace dust or converter dust or BOF ejections or fine metallic slag dust or EAF ejections or EAF dust, metallurgical sludge, for example blast furnace sludge or BOF sludge or hot rolling mill sludge, fine iron, iron swarf.

[0059] Such material coming from dedusting devices or scrubbers is optionally subjected to a preparation step for iron enrichment, before it is used for the production of compacts.

[0060] The mixture may comprise at least one member of the group

[0061] metalized Fe fines,

[0062] scale,

[0063] metallurgical dust,

[0064] metallurgical sludge,

[0065] material which comes from a steel production process, in which recovered sponge iron and/or pig iron is employed by using compacts produced as disclosed herein.

[0066] This, for example, also includes the use of undersized material screened from the sponge iron.

[0067] For example, it also includes the use of material obtained after screening during a shutdown, carried out for example for maintenance reasons, of a unit for obtaining sponge iron and/or pig iron—for example a direct reduction shaft or a melt-down gasifier. The term metalized Fe fines is intended to mean fine-grained metalized iron (Fe) carriers, fine-grained meaning a particle diameter of up to 6 mm. The metallurgical residual materials containing iron preferably have a combined content of iron and carbon which is more than 50 weight %. The combined content of iron and carbon above that is economically viable, however, depends on the relevant amount of metallurgical residual materials containing iron and the dumping costs for such metallurgical residual materials containing iron. It may be preferable to use material which comes from a steel production process in which sponge iron and/or pig iron obtained by using compacts produced according to the disclosed method is employed. In this way, these metallurgical residual materials can be recycled into the process leading to their production. Such recycling is beneficial since metallurgical residual materials—for example metalized Fe fines, scale, metallurgical dust, metallurgical sludge—contain large proportions of iron and/or carbon, and the recycled materials do not need to be dumped expensively. During the reduction process, the iron contained in the metallurgical residual materials leads to a saving on iron ore and the carbon leads to a saving on reducing agent.

[0068] Certain metallurgical residual materials, in particular scale, fine iron, iron swarf, owing to their granular shape or their mechanical properties, act as structurally reinforcing components in the compact by increasing—mechanically by internal friction—the force which needs to be exerted in order to destroy the compacts. The greater this force is, the greater is the strength of the compact. The structurally reinforcing effect is manifested by an increased strength of the compacts.

The strength is conventionally considered differently according to cold strength, which indicates the strength at room temperature, and hot strength, which indicates the strength at a temperature—defined by the test conditions respectively set up—higher than room temperature. Besides improving the cold strength of compacts by metallurgical residual materials containing iron, the hot strength of compacts—particularly under the conditions existing during the reduction—can also be improved by metallurgical residual materials containing iron. The carbon contained in many metallurgical residual materials may, for example, initiate reduction reactions inside the compacts when heating the compact, which in turn leads to reinforcement of the hot strength of the compact.

[0069] When using undersized oxidic iron carriers and metallurgical residual materials together in order to produce compacts, additional strength is therefore imparted to the compacts. It is thus possible to save on binder—which is in fact present in the compact in order to provide strength—and therefore limit the introduction of inert substances or slag-forming agents into the compact.

[0070] In quantitative terms, the mixture may comprise up to 100 weight % of the metallurgical residual materials containing iron, expressed in terms of the amount of undersized oxidic iron carriers.

[0071] According to another embodiment, the mixture also comprises finely particulate hematitic and/or limonitic material, finely particulate being intended to mean a particle diameter of less than 6 mm. If oxidic material which is difficult to reduce by a reduction method is present—particularly in the form of magnetite—then problems of reduction kinetics associated with such material can be overcome by mixing the material which is difficult to reduce—present for example in the form of magnetite—with finely particulate material which is easy to reduce by the same reduction method—in particular present in the form of hematite or limonite. In accordance with the Austrian patent AT399887, an improvement of the reduction kinetics is to be expected from this mixture.

[0072] Finely particulate reducible material is formed in plants for the reduction of oxidic iron carriers by means of a reduction gas, for example plants for carrying out sponge iron production processes, in which a direct reduction shaft with a fixed bed is used, for example according to the MIDREX® or HYL® processes, or in melt reduction methods for producing liquid pig iron, inter alia in the form of dust or sludge from dedusting devices or scrubbers for removing dust from top gas, reduction gas or generator gas.

[0073] Using this material increases the economic viability of a process for producing sponge iron or liquid pig iron owing to the recycling of material into the process circuit. For reasons of process economy, it may be preferable that the mixture for producing compacts containing iron oxide also comprises finely particulate material formed during the removal of dust from top gas, reduction gas or generator gas of a plant for the reduction of oxidic iron carriers by means of a reduction gas.

[0074] Here, top gas is intended to mean a gas which, after having performed its reduction task in relation to the oxidic iron carriers, is extracted from the unit filled with oxidic iron carriers in which it has performed its reduction task. In the case of direct reduction in a direct reduction shaft, for example, top gas is the gas which is fed out of the direct reduction shaft.

[0075] Generator gas is intended to mean a gas which is formed in a melt-down gasifier—or in a coal gasifier for

producing a gas to be used for direct reduction of iron ore—by gasifying carbon carriers in the presence of oxygen. For melt reduction processes, such a generator gas is cooled to an optimal reduction temperature and scrubbed before it is used as a reduction gas for reducing oxidic iron carriers.

[0076] Reduction gas is the gas with the aid of which the oxidic iron carriers are reduced, while itself being oxidized.

[0077] Sludge obtained by means of scrubbers from the gases is formed by treating the waste water of the scrubbers, with dust washed out settling as sludge. This sludge is extracted and prepared by at least partial dewatering for the use as disclosed herein. Optionally, the dewatering may also comprise thermal drying.

[0078] If sludge is present in the mixture of the disclosed method comprising undersized oxidic iron carriers, bentonite as a binder and water, at least some of the water of the mixture may be introduced into the mixture by means of the sludge. The degree of dewatering of the sludge will then be selected accordingly.

[0079] According to one embodiment, the mixture is heated during the kneading process. This may for example be done as indirect heating through the housing of the kneading mechanism, or as direct steam heating.

[0080] A comparison of tests No. 1 and No. 4 in Table 1 shows that heating the mixture during the kneading process has positive effects in respect of a significantly increased point pressure strength.

[0081] In principle, the disclosed method can make the undersize, and finely particulate material formed in process steps during production of steel from pig iron material—for instance DRI, suitable for the production of pig iron and steel. By recycling material, a larger proportion of the raw materials is converted into an end product and therefore they effectively become cheaper. Dumping, or return freight costs, which have previously had to be counted in for undersize and other materials from DRI, pig iron or steel producers, which are used in the disclosed production of compacts, may be obviated.

[0082] Furthermore, the disclosed method may be used to obtain the compacts more rapidly than by maturing.

[0083] FIG. 1 schematically shows an example embodiment of a direct reduction plant. Lump components of oxidic iron carriers 1 are reduced in a direct reduction shaft 2 with a fixed bed by a reduction gas 3 to form direct reduced iron (DRI). After passing through a compaction device 4, the DRI is delivered as hot briquetted iron (HBI) to a consumer. Top gas extracted from the direct reduction shaft 2 has its dust load removed in a dedusting device 10, here a gas scrubber. Before charging their lump components 1a into the direct reduction shaft 2, the oxidic iron carriers 1 have an undersized fraction 1b, which is unsuitable for use in the direct reduction shaft 2, removed from them by screening on a screen 5. In FIG. 1, the screen is arranged immediately before the direct reduction shaft 2; in principle, of course, it may be located at any desired position of the input path for oxidic iron carriers. Optionally after a breaking process in a breaking device (not represented in FIG. 1 for the sake of clarity), this undersized fraction 1b is delivered to a mixing device 6. In the mixing device 6, the undersized fraction 1b is mixed with bentonite as a binder 12, with undersized material 7 which is formed in the HBI screening device 8 downstream of the compaction device 4, with residual materials from a steelworks 9—in the present case metalized Fe fines and scale—and with sludge 19 from the dedusting device 10, as well as with water 11. The listed

components of the mixture produced in the mixing device 6 are combined in two steps. Specifically, the solid components of the mixture—bentonite as a binder 12, undersized material 7, residual materials from a steelworks 9, sludge 19 from the dedusting device 10—are initially combined and premixed in a first step, before water 11 is added in a second step in order to create a doughy consistency. The sludge 19 from the dedusting device 10 is dewatered and thermally dried before being combined, this not being graphically represented separately for the sake of clarity. After combination of the solid components of the mixture in a first mixer of the mixing device 6, water 11 is added in a second mixer downstream of the first mixer. The mixture with a doughy consistency is kneaded intensively in a kneading device 13 for a period of 15 minutes.

[0084] The kneaded mixture is then delivered to a pressing device 14. The product of the pressing carried out in the pressing device 14 is green compacts which are still soft. These green compacts are hardened by storing in air on a storage site 15, while being at least partially dried and therefore hardened to form compacts. After their hardening carried out in this way, the compacts obtained by the hardening are delivered to the direct reduction shaft 2. In the direct reduction shaft 2, the compacts produced according to the disclosed method are converted in the same way as the lump components 1a of the oxidic iron carriers.

[0085] FIG. 2 schematically shows an example embodiment of a melt reduction plant. Elements of FIG. 2 which are comparable to FIG. 1 are provided with the same references as in FIG. 1. Lump components of oxidic iron carriers 1 are charged into a melt reduction unit 16. The melt reduction unit 16 comprises a melt-down gasifier, in which carbon carriers are gasified in the presence of oxygen 20 in order to obtain a reduction gas. The reduction gas is fed into a shaft which contains the lump components of the oxidic iron carriers 1. During flow through this shaft, at least partial reduction of the lump components of the oxidic iron carriers takes place. The material prerduced in this way is subsequently introduced into the melt-down gasifier, where it is fully reduced and melted. The resulting liquid pig iron 17 is removed from the melt-down gasifier. Top gas 18 extracted from the melt reduction unit 16 has its dust load removed in a dedusting device 10, here a gas scrubber. Sludge formed during wet dedusting of generator gas from the melt-down gasifier, which is carried out in order to produce cool gas, is used in a similar way to the sludge 19, although this is not represented for the sake of clarity. Before charging their lump components 1a into the melt reduction unit 16, the oxidic iron carriers 1 have an undersized fraction 1b, which is unsuitable for use in the melt reduction unit 16, removed from them by screening on a screen 5. Optionally after a breaking process in a breaking device (not represented in FIG. 2 for the sake of clarity), this undersized fraction 1b is delivered to a mixing device 6. In the mixing device 6, the undersized fraction 1b is mixed with bentonite as a binder 12, with residual materials from a steelworks 9—in the present case metalized Fe fines and scale—and with sludge from the dedusting device 10, as well as with water 11. The listed components of the mixture produced in the mixing device 6 are combined in two steps. Specifically, the solid components of the mixture—bentonite as a binder 12, undersized material 23, residual materials from a steelworks 9, sludge 19 from the dedusting device 10—are initially combined and premixed in a first step, before water 11 is added in a second step in order to create a doughy consistency.

tency. The sludge **19** from the dedusting device **10** is dewatered and thermally dried before being combined, this not being graphically represented separately for the sake of clarity. After combination of the solid components of the mixture in a first mixer of the mixing device **6**, water **11** is added in a second mixer downstream of the first mixer. The mixture with a doughy consistency is kneaded intensively in a kneading device **13** for a period of 15 minutes.

[0086] The kneaded mixture is then delivered to a pressing device **14**. The product of the pressing carried out in the pressing device **14** is green compacts which are still soft. These green compacts are hardened by storing in air on a storage site **15**, where they are at least partially dried and therefore hardened to form compacts. After their hardening carried out in this way, the compacts obtained by the hardening are delivered to the melt reduction unit **16**. In the melt reduction unit **16**, the compacts produced according to the disclosed method are converted in the same way as the lump components 1a of the oxidic iron carriers.

LIST OF REFERENCES

- [0087] **1** oxidic iron carriers
- [0088] **2** direct reduction shaft
- [0089] **3** reduction gas
- [0090] **4** compaction device
- [0091] **5** screen
- [0092] **6** mixing device
- [0093] **7** undersized material **7** (which is formed in the HBI screening device **8** downstream of the compaction device **4**)
- [0094] **8** HBI screening device
- [0095] **9** residual materials from a steelworks
- [0096] **10** dedusting device
- [0097] **11** water
- [0098] **12** binder (bentonite)
- [0099] **13** kneading device
- [0100] **14** pressing device
- [0101] **15** storage site
- [0102] **16** melt reduction unit
- [0103] **17** liquid pig iron
- [0104] **18** top gas
- [0105] **19** sludge
- [0106] **20** oxygen

What is claimed is:

1. A method for producing compacts containing iron oxide from undersized oxidic iron carriers, comprising:
 - producing a mixture that comprises (a) undersized oxidic iron carriers produced by degradation of lump oxidic iron carriers, lump ore, or pellets and having a particle size of less than 10 mm, (b) bentonite as a binder, and (c) water,
 - kneading the mixture using a kneading process having a duration of at least 3 minutes, and
 - after the kneading process, pressing the mixture and hardening the green compacts obtained by the pressing.

2. The method of claim **1**, wherein the mixture comprises from 3% weight to 12% weight of bentonite, relative to the weight of undersized oxidic iron carriers in the mixture.

3. The method as of claim **1**, wherein the mixture also comprises metallurgical residual materials containing iron selected from the group consisting of:

- metalized Fe fines,
- scale,
- metallurgical dust,
- metallurgical sludge, and
- material from a steel production process.

4. The method of claim **1**, wherein the mixture also comprises at least one of finely particulate hematitic material and finely particulate limonitic material.

5. The method of claim **1**, wherein the mixture also comprises finely particulate material formed during the removal of dust from top gas, reduction gas, or generator gas of a plant for reducing oxidic iron carriers using a reduction gas.

6. The method of claim **1**, comprising heating the mixture during the kneading process.

7. A compact obtained by:

- producing a mixture that, comprises (a) undersized oxidic iron carriers produced by degradation of lump oxidic iron carriers, lump ore, or pellets and having a particle size of less than 10 mm, (b) bentonite as a binder, and (c) water,

- kneading the mixture using a kneading process having a duration of at least 3 minutes, and
- after the kneading process, pressing the mixture and hardening the green compacts obtained by the pressing.

8. A method for producing sponge iron or liquid pig iron, comprising:

- producing a compact by:

- producing a mixture that comprises (a) undersized oxidic iron carriers produced by degradation of lump oxidic iron carriers, lump ore, or pellets and having a particle size of less than 10 mm, (b) bentonite as a binder, and (c) water,

- kneading the mixture using a kneading process having a duration of at least 3 minutes, and
- after the kneading process, pressing the mixture and hardening the green compacts obtained, by the pressing, and

- producing sponge iron or liquid pig iron by a process that uses the produced compact as a lump oxide.

9. The method of claim **1**, wherein the duration of the kneading process is between 5 minutes and 30 minutes.

10. The method of claim **1**, wherein the duration of the kneading process is between 5 minutes and 20 minutes.

11. The method of claim **1**, wherein the duration of the kneading process is between 5 minutes and 15 minutes.

12. The method of claim **1**, wherein the undersized oxidic iron carriers have a particle size of less than 6.3 mm.

13. The method of claim **1**, wherein the undersized oxidic iron carriers have a particle size of less than 5 mm.

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