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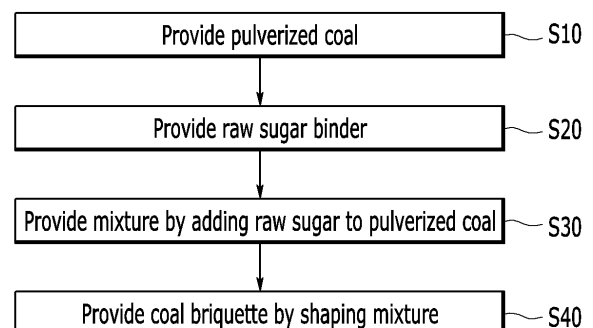
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(54) **BRIQUETTES AND METHOD FOR PRODUCING SAME**

(57) A method for manufacturing coal briquettes being charged into a dome portion of a melter-gasifier and then quickly heated therein in a molten iron manufacturing apparatus that includes the melter-gasifier into which reduced iron is charged and a reducing furnace connected with the melter-gasifier and providing the reduced iron is provided. The method for manufacturing the coal briquettes includes: i) providing pulverized coal; ii) providing a raw sugar binder of 0 to 10 parts by weight with respect to 100 parts by weight of the pulverized coal; iii) providing a mixture by adding the raw sugar binder to the pulverized coal; and iv) providing coal briquettes by shaping the mixture.

FIG. 1



Description**CROSS-REFERENCE TO RELATED APPLICATION**

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2013-0164462 and 10-2014-0187759 filed in the Korean Intellectual Property Office on December 26, 2013 and December 24, 2014, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION**(a) Field of the Invention**

[0002] The present invention relates to coal briquettes and a method for manufacturing the same. More particularly, the present invention relates to coal briquettes of which cold strength is improved while saving manufacturing cost, and a method for manufacturing the same.

(b) Description of the Related Art

[0003] In a reduced iron smelting process, iron ore is used in a reduction furnace and a melter-gasifier furnace that smelts reduced iron ore. When smelting iron ore in the melter-gasifier furnace, coal briquettes as a heat source to smelt the iron ore are charged to the melter-gasifier furnace. After reduced iron is smelted in the melter-gasifier furnace, the reduced iron is converted to molten iron and slag and is discharged to the outside. The coal briquettes that are charged to the melter-gasifier furnace form a coal packed bed. Oxygen is injected through a tuyere that is installed in the melter-gasifier furnace such that the coal packed bed is burned to generate a combustion gas. The combustion gas is converted to a reduction gas of a high temperature while moving upward through the coal packed bed. The reduction gas of a high temperature is discharged to the outside of the melter-gasifier furnace to be supplied to a reduction furnace as a reduction gas.

[0004] In general, coal briquettes are manufactured by mixing coal and a binder. In this case, molasses is used as a binder. The components of the molasses vary depending on where it is sourced, and it is difficult to consistently control the ingredients according to a sugar manufacturing process. Therefore, in the case where a coal briquette is prepared by using molasses as a binder, it is difficult to control the quality of the coal briquette. Particularly, in the case of using high moisture molasses, there are problems in that the quality of the coal briquette is reduced.

[0005] The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

SUMMARY OF THE INVENTION

[0006] The present invention has been made in an effort to provide a method for manufacturing coal briquettes having excellent cold strength with low manufacturing cost. In addition, coal briquettes manufactured using the above-stated method are provided.

[0007] According to an exemplary embodiment of the present invention, a method for manufacturing coal briquettes being charged into a dome portion of a melter-gasifier and then quickly heated therein in a molten iron manufacturing apparatus that includes the melter-gasifier into which reduced iron is charged and a reducing furnace connected with the melter-gasifier and providing the reduced iron is provided. The method for manufacturing the coal briquettes according to the exemplary embodiment of the present invention includes: i) providing pulverized coal; ii) providing a raw sugar binder of 0 to 10 parts by weight with respect to 100 parts by weight of the pulverized coal; iii) providing a mixture by adding the raw sugar binder to the pulverized coal; and iv) providing coal briquettes by shaping the mixture.

[0008] In the providing the raw sugar binder, the raw sugar binder may be provided as a raw sugar solution, and the raw sugar solution may include raw sugar at about 35 wt% to about 85 wt%. The raw sugar solution may include raw sugar at about 65 wt% to about 85 wt%.

[0009] The providing the raw sugar binder may include: i) crushing sugarcane while injecting water; ii) providing sugarcane juice by juicing the crushed sugarcane; and iii) providing sugarcane syrup by removing impurities from the sugarcane juice and concentrating the sugarcane juice. In the providing the sugarcane juice, the amount of solid content included in the sugarcane juice may be about 10 wt% to about 30 wt%. Preferably, in the providing the sugarcane syrup as the raw sugar binder, the amount of solid content included in the sugarcane juice may be about 50 wt% to 90 wt%. More preferably, the amount of solid content included in the sugarcane syrup may be about 65 wt% to about 85 wt%. Further more preferably, the amount of solid content included in the sugarcane syrup may be about 70 wt% to about 78

wt%.

[0010] The providing the raw sugar binder may further include adding paraffin to the sugarcane syrup, and the amount of paraffin may be greater than 0 and less than 1 wt% with respect to the amount of sugarcane syrup. In the providing the mixture, the mixture may be mixed for about 5 minutes to about 7 minutes at a temperature of about 50°C to about 100°C. In the providing the sugarcane syrup as the raw sugar binder, the amount of total reducing sugar included in the sugarcane syrup may be about 65wt% to about 90wt%. In the providing the pulverized coal, the pulverized coal may be at least one selected from a group consisting of thermal coal, weak coking coal, brown coal, and anthracite coal.

[0011] The providing the raw sugar binder may include: i) providing a melted solution by melting the raw sugar with steam of about 70°C to about 120°C; and ii) providing the raw sugar binder as a raw sugar solution by adding water to the melted solution and agitating the water-added melted solution at a temperature about 60°C to about 70°C.

[0012] The method for manufacturing the coal briquettes according to the exemplary embodiment of the present invention further includes providing at least one hardener selected from a group consisting of quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, and sulfuric acid. In the providing the mixture, the hardener may be added more to the pulverized coal and the amount of hardener with respect to 100 parts by weight of the pulverized coal may be 1 part by weight to 6 parts by weight.

[0013] In the providing the raw sugar binder, a ratio of solid content with respect to the amount of total reducing sugar included in the raw sugar binder may be greater than 1 and less than 1.2. In the providing the raw sugar binder, the raw sugar binder may include at least one selected from a group consisting of sucrose, glucose, and fructose. The raw sugar binder may include sucrose and the amount of sucrose with respect to 100 parts by weight of the pulverized coal may be greater than 0 and less than 4 parts by weight. The amount of sucrose may be 2 parts by weight to 4 parts by weight. The raw sugar binder may include glucose and the amount of glucose with respect to 100 parts by weight of the pulverized coal may be greater than 0 and less than 4 parts by weight. More preferably, the amount of glucose may be 2 parts by weight to 4 parts by weight.

[0014] The raw sugar binder may include fructose and the amount of fructose with respect to 100 parts by the pulverized coal is greater than 0 and less than 4 parts by weight. The amount of fructose may be 2 parts by weight to 4 parts by weight.

[0015] The reducing furnace may be a fluidized bed reduction furnace or a packed bed reduction furnace. In the providing the raw sugar binder, the raw sugar binder may be provided as a raw sugar solution and the amount of raw sugar solution with respect to 100 parts by weight of the pulverized coal may be 3 parts by weight to 10 parts by weight. More preferably, the amount of raw sugar solution may be 6 parts by weight to 10 parts by weight. The amount of raw sugar solution may be 8 parts by weight to 10 parts by weight. The amount of sucrose included in the raw sugar solution may be 45 wt% to 75 wt%. In the providing the raw sugar binder, viscosity of the raw sugar binder may be 100cp to 10,000cp. In the providing the pulverized coal, the amount of moisture in the pulverized may be 3 wt% to 12 wt%..

[0016] Coal briquette according to another exemplary embodiment of the present invention is charged into a dome portion of a melter-gasifier and then quickly heated therein in a molten iron manufacturing apparatus that includes the melter-gasifier into which reduced iron is charged and a reducing furnace connected with the melter-gasifier and providing the reduced iron. The coal briquette includes pulverized coal and a raw sugar binder, and the amount of raw sugar binder with respect to 100 parts by weight of pulverized coal is greater than 0 and less than 10 parts by weight, and the raw sugar binder includes at least one selected from a group consisting of sucrose, glucose, and fructose.

[0017] When the raw sugar binder includes sucrose, the amount of sucrose may be greater than 0 and less than 4 parts by weight with respect to 100 parts by weight of the pulverized coal. The amount of sucrose may be 2 parts by weight to 4 parts by weight. When the raw sugar binder includes fructose, the amount of fructose may be greater than 0 and less than 4 parts by weight with respect to 100 parts by weight of the pulverized coal. More preferably, the amount of fructose may be 2 parts by weight to 4 parts by weight.

[0018] The coal briquette may further include at least one hardener selected from a group consisting of quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, and sulfuric acid, wherein the amount of hardener is 0.1 part by weight to 6 parts by weight with respect to 100 parts by weight of the pulverized coal. The amount of solid content included in the raw sugar may be 16 wt% to 96 wt%. More preferably, the amount of solid content may be 78 wt% to 96 wt%.

[0019] According to the present invention, cold strength of the coal briquettes can be improved by using a raw sugar binder including sucrose. In addition, coal briquette that is inexpensive and has excellent cold strength can be manufactured by using sugarcane juice. When sugarcane juice is used, an oversaturated concentration recrystallization process may not need to be repeated for producing raw sugar. In addition, equipment investment cost consumed for producing concentrated syrup can be reduced, and according to coal briquettes can be manufactured with low cost. Further, the sugarcane syrup can be stored for a long period of time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a schematic flowchart of a method for manufacturing coal briquettes according to an exemplary embodiment of the present invention.

FIG. 2 shows a chemical formula of components of a binder used in the method for manufacturing the coal briquettes of FIG. 1.

FIG. 3 is a schematic graph illustrating variation of compression strength of coal briquettes according to use of raw sugar and molasses.

FIG. 4 schematically illustrates a raw sugar manufacturing apparatus for providing the raw sugar binder of FIG. 1.

FIG. 5 schematically illustrates a molten iron manufacturing apparatus using the coal briquettes of FIG. 1.

FIG. 6 schematically illustrates another molten iron manufacturing apparatus using the coal briquettes of FIG. 1.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0021] Terms such as first, second, and third are used to illustrate various portions, components, regions, layers, and/or sections, but not to limit them. These terms are used to discriminate the portions, components, regions, layers, or sections from other portions, components, regions, layers, or sections. Therefore, a first portion, component, region, layer, or section as described below may be a second portion, component, region, layer, or section within the scope of the present invention.

[0022] It is to be understood that the terminology used therein is only for the purpose of describing particular embodiments and is not intended to be limiting. It must be noted that, as used in the specification and the appended claims, the singular forms include plural references unless the context clearly dictates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated properties, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other properties, regions, integers, steps, operations, elements, and/or components thereof.

[0023] Unless it is mentioned otherwise, all terms including technical terms and scientific terms used herein have the same meaning as the meaning generally understood by a person with ordinary skill in the art to which the present invention belongs. The terminologies that are defined previously are further understood to have the meanings that coincide with related technical documents and the contents that are currently disclosed, but are not to be interpreted as having ideal or very official meanings unless defined otherwise.

[0024] It is understood that the term "raw sugar binder" used hereinafter includes all materials including sucrose. In addition, it is understood that the raw sugar binder includes solid and liquid state materials.

[0025] The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

[0026] FIG. 1 schematically illustrates a flowchart of a method for manufacturing coal briquettes according to an exemplary embodiment of the present invention. The flowchart of the method for manufacturing coal briquettes of FIG. 1 is an exemplary flowchart, and the present invention is not limited thereto. Thus, the manufacturing method of coal briquettes can be variously modified.

[0027] As shown in FIG. 1, the method for manufacturing coal briquettes includes: i) providing pulverized coal; ii) providing a raw sugar binder; iii) providing a mixture by adding the raw sugar binder to the pulverized coal; and iv) providing coal briquettes by shaping the mixture. The method may further include other steps.

[0028] First, pulverized coal is provided in S10. The pulverized coal is raw coal. An amount of water mixed in the pulverized coal is maintained with 3 wt% to 12 wt% by mixing the water in advance. When the amount of water mixed in the pulverized coal is controlled to be in the above-stated range, pores of pulverized coal particles are blocked. As a result, the hardener and the binder mixed in the next process cannot penetrate into the pulverized coal particles but exist at the outside thereof, and thus the binder couples pulverized coal particles well, thereby efficiently improving cold strength of coal briquettes. Further, the coal particles may be crushed to make the size of 90 wt% of more of the coal particles be less than 3 mm. When sugarcane syrup is used as a binder, the pulverized coal may be thermal coal, weak coking coal, brown coal, or anthracite coal, and this will be described later. That is, coal briquettes of which hot strength is improved by mixing sugarcane syrup and the above-stated type of pulverized coal can be manufactured. Thus, deterioration of hot strength and cold strength of the coal briquettes due to a change of coal type of pulverized coal can be prevented.

[0029] Next, a raw sugar binder is provided in S20. As the raw sugar binder, raw sugar or a raw sugar solution may be used. Sugarcane juice may be used as the raw sugar solution, or raw sugar may be dissolved in water. The raw sugar solution may include raw sugar at 35 wt% to 85 wt%. If the amount of raw sugar is too low, cold strength and hot strength of the coal briquettes may be deteriorated. On the contrary, when the amount of raw sugar is too high, moldability of coal briquettes may be deteriorated and manufacturing cost is increased. Therefore, the amount of raw sugar is adjusted within the above-stated range. More preferably, the raw sugar solution may include raw sugar at 65 wt% to 85

wt%. A temperature of the raw sugar solution may be 10 °C to 80 °C. When the temperature of the raw sugar solution is too high, peripheral equipment may be deteriorated. On the contrary, when the temperature of the raw sugar solution is too low, flowability of the solution may be deteriorated. Accordingly, the temperature of the raw sugar solution is adjusted within the above-stated range.

[0030] The amount of raw sugar binder may be greater than 0 and less than 10 parts by weight with respect to 100 parts by weight of pulverized coal. When the amount of raw sugar binder is too high, manufacturing cost of the coal briquettes may be increased. When the amount of raw sugar binder is too low, cold strength of the coal briquettes may be deteriorated. Thus, the amount of raw sugar binder is preferably adjusted within the above-stated range.

[0031] Viscosity of the raw sugar solution may be adjusted to be within a range of 100 cp to 10,000 cp. When the viscosity of the raw sugar solution is too low, the raw sugar solution is not suitable for being used. When the viscosity of the raw sugar solution is too high, the flowability of the solution is deteriorated, thereby deteriorating manufacturing process efficiency. Therefore, the viscosity of the raw sugar solution is preferably adjusted within the above-stated range.

[0032] When coal briquette is manufactured by adding the raw sugar solution to the pulverized coal as a binder, properties of the coal briquette can be improved. In addition, since cold strength of the coal briquette can be improved when the raw sugar solution is used as a binder, the raw sugar solution can replace molasses that is used as a binder.

[0033] The raw sugar solution used in the coal briquettes as a raw sugar binder should have viscosity of less than 25,000 cp at 25°C for transfer, storage, a sufficient amount of discharge. For such an above-stated viscosity condition, a solid content of the raw sugar solution may be greater than zero and less than 85%. In addition, the amount of moisture of the pulverized coal may be 5 wt% to 12 wt%. The amount of total reducing sugar in the solid content that is related with strength of the coal briquette may be 25 wt% or more and 100 wt% or less. When the amount of solid content of the raw sugar solution is 73 wt% to 90 wt%, 5 parts by weight to 14 parts by weight of raw sugar solution may be used as a binder with respect to 100 parts by weight of pulverized coal. In this case, the amount of moisture of pulverized coal may be 5 wt% to 12 wt%. Further, a hardener of 2 parts by weight to 6 parts by weight may be used with respect to 100 parts by weight of pulverized coal. When the amount of solid content included in the coal briquette is low and the amount of moisture included in the coal briquette is high, compression strength of the coal briquette is deteriorated due to moisture.

[0034] Preferably, the amount of solid content included in the raw sugar binder may be 16 wt% to 96 wt%. More preferably, the amount of solid content may be 35 wt% to 85 wt%. When the amount of solid content is low, cold strength of the coal briquettes cannot be improved. In addition, when the amount of solid content is high, the flowability of the binder is deteriorated, thereby deteriorating manufacturing process efficiency. Accordingly, coal briquettes having excellent cold strength can be manufactured by using the solid content within the above-stated range.

[0035] Unlike the raw sugar binder, when a molasses binder is condensed, a solid content becomes higher than 80% such that viscosity becomes 25,000cp, and accordingly the raw sugar binder cannot be applied to the manufacturing of coal briquettes. Viscosity of the raw sugar binder is 100cp to 10,000cp, which is 40 times lower than the viscosity of molasses. Accordingly, the raw sugar binder is appropriate in transfer, storage, or quantitative discharge. In addition, when the raw sugar binder is mixed with pulverized coal, mixing efficiency is increased, thereby enhancing strength deviation in coal briquettes.

[0036] In S30, the raw sugar binder is added to the pulverized coal such that a mixture thereof is provided. As a binder, the raw sugar binder is used instead of molasses. The raw sugar binder includes sucrose, glucose, and fructose. When sugarcane syrup is used as the raw sugar binder, the mixture may be mixed for about 5 minutes to about 7 minutes. When mixing time is insufficient, the sugarcane syrup cannot be evenly dispersed into the pulverized coal. In addition, when the mixing time is too long, flowability of the mixture is deteriorated, thereby causing increase of manufacturing cost. Thus, it is preferred to control the mixing time within the above-stated range. Further, a mixing temperature of the mixture is preferably about 50°C to about 100°C for the same reason as described above. Hereinafter, sucrose, glucose, or fructose will be described in further detail with reference to FIG. 2.

[0037] FIG. 2 shows a chemical formula of components of a binder used in the method for manufacturing coal briquettes of FIG. 1. That is, FIG. 2 shows a chemical formula of sucrose, glucose, and fructose. A product name of sucrose is sugar. Sucrose, which is a main component of sugar in sugarcane juice, sugar beet juice, and acer psedu-sieboldianum, is a disaccharide made from α -glucose and β -fructose joined in a 1,2 linkage, and has a molecular formula of $C_{12}H_{22}O_{11}$. Since sucrose has excellent sweetness and strength, sucrose is used as a reference material in evaluation of sweeteners. Glucose is a representative aldohexose, which is a monosaccharide having 6 carbon atoms and an aldehyde group. Glucose is a monosaccharide with a formula $C_6H_{12}O_6$, and is a main compound of carbohydrate metabolism and can synthesize 38 ATPs per glucose molecule. There are D-type and L-type optical isomers, and only the D-type isomer (D-glucose) occurs in nature and the D-glucose is called grape sugar. Meanwhile, sucrose is a type of 2-ketohexose, also referred to as levulose, and is distributed as a glass type and a disaccharide type or homopolysaccharide type such as levan (β 2, fructan) or inulin (β 1, fructan) in fruits, vegetables, and honey.

[0038] Table 1 shows characteristics of a coal briquette binder manufactured using sucrose, glucose, fructose, and molasses as a coal briquette binder. As shown in Table 1, when the coal briquette is manufactured, properties of coal

briquette is excellent in the order of sucrose, fructose, and glucose. Here, sucrose can replace molasses because it has excellent compression strength and drop strength compared to molasses.

(Table 1)

Section		Sucrose	Glucose	Fructose	Molasses
Compression strength (after 1hr)		56.6	28.0	40.0	50.8
Drop strength		99.8%	85.0%	42.9%	95.3%
Technical analysis	VM	30.02	29.74	30.52	29.52
	Ash	12.84	12.95	13.34	13.48
	FC	56.61	56.88	55.69	56.56

[0039] In manufacturing of coal briquettes, hot strength and cold strength of the coal briquettes are improved through caramelization reaction between a monosaccharide and a hardener. Thus, properties of the coal briquette can be improved by adding sucrose, glues, or fructose to pulverized coal as a binder or adding a raw sugar solution to pulverized coal. Meanwhile, the monosaccharide should be deformed to a polymer in order to prevent the monosaccharide from being easily attached to a shaping roll, and cold strength is not deteriorated.

[0040] When sucrose is mixed to pulverized, the amount of sucrose with respect to 100 parts by weight of pulverized coal may be 0 to 5 parts by weight. More preferably, the amount of sucrose may be about 2 parts by weight to about 5 parts by weight. When the amount of sucrose is too low, cold strength of the coal briquette may be deteriorated. When the amount of sucrose is too high, the mixture cannot be easily shaped into coal briquette and the mixture is attached to a roll. Therefore, the amount of sucrose is adjusted within the above-stated range.

[0041] Glucose may be mixed to pulverized coal as a binder. When the glucose is mixed, the amount of glucose with respect to 100 parts by weight of pulverized coal may be about 4 parts by weight or less. More preferably, the amount of glucose may be about 2 parts by weight to 4 parts by weight. When the amount of glucose is too low, cold strength of the coal briquette may be deteriorated. When the amount of glucose is too high, the mixture cannot be easily shaped into coal briquette and the mixture is attached to a roll. Therefore, the amount of glucose is adjusted within the above-stated range.

[0042] Fructose may be mixed to pulverized coal as a binder. When the fructose is mixed, the amount of fructose with respect to 100 parts by weight of pulverized coal may be about 4 parts by weight or less. More preferably, the amount of fructose may be 2 parts by weight to 4 parts by weight. When the amount of fructose is too low, cold strength of the coal briquette may be deteriorated. When the amount of fructose is too high, the mixture cannot be easily shaped into coal briquette and the fructose is attached to a roll. Therefore, the amount of fructose is adjusted within the above-stated range.

[0043] As a binder, a raw sugar solution including inexpensive sucrose may be used to manufacture coal briquettes. In this case, the raw sugar solution includes a solid content of 45 wt% or more. More preferably, the raw sugar solution includes a solid content of about 45 wt% to about 85 wt%. Sucrose, glucose, fructose may be included in the solid content. When the amount of solid content included in the raw sugar solution is too low, cold strength of the coal briquettes may be deteriorated. In addition, when the amount of solid content included in the raw sugar solution is too high, moisture lacks in manufacturing of a mixture, thereby causing the mixture to be non-uniformly mixed. Thus, the amount of solid content included in the raw sugar solution is adjusted within the above-stated range.

[0044] The amount of raw sugar solution mixed with respect to 100 parts by weight of pulverized coal may be about 3 parts by weight to about 10 parts by weight. Preferably, the amount of raw sugar solution may be 6 parts by weight to 10 parts by weight. More preferably, the amount of raw sugar solution may be 7 parts by weight to 10 parts by weight. When the amount of raw sugar solution is too low, cold strength of coal briquettes may be deteriorated. When the amount of raw sugar solution is too high, the mixture is not easily shaped to coal briquettes and easily attached to a roll. Therefore, the amount of raw sugar solution is adjusted within the above-stated range.

[0045] As a hardener, quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, and sulfuric acid may be used. Preferably, quicklime is used as a hardener, together with the raw sugar binder to manufacture coal briquette having excellent cold strength and hot strength. When sugarcane syrup is used as a binder, quicklime and slaked lime can remove carbon dioxide in the sugarcane syrup thereby assuring volume stability of the sugarcane syrup.

[0046] Referring back to FIG. 1, coal briquettes are provided by shaping the mixture in S40. For example, although it is not illustrated in FIG. 1, the mixture is charged between a pair of rolls, each rotating in the opposite direction so as to manufacture pocket-type or strip-type coal briquette. In this case, the coal briquette can be manufactured at a temperature

of about 3°C to about 300°C. Since the coal briquette is manufactured at the above-stated temperature range, hot strength and cold strength of the coal briquettes can be improved. In addition, since a raw sugar binder is included in the coal briquette, cold strength of the coal briquette can be improved.

[0047] Meanwhile, components of a binder included in the coal briquette can be analyzed as follows. First, coal briquette of 100g is finely crushed. Then, ethanol of 500mL is added, and liquid and coal are separated. Next, solids are separated by filtering liquid, the liquid is removed by using a rotary evaporator, and the remainder is dissolved in water to measure 0.01% of sucrose is measured. Since a general ratio of sucrose in molasses is about 30 wt% to about 40 wt%, when the amount of sucrose exceeds the general ratio, raw sugar and sugarcane syrup may be expected to be used as coal briquette binders.

[0048] FIG. 3 is a graph schematically illustrating variation of compression strength of coal briquettes according to use of a raw sugar binder and use of a molasses binder. That is, compression strengths of coal briquettes when the amount of raw sugar binders and molasses binders included in the coal briquettes are respectively 2 wt%, 4 wt%, 6 wt%, 8 wt%, and 10 wt% are shown in the graph. Here, as the raw sugar binder, a raw sugar solution of about 60% to about 80% is used.

[0049] As shown in FIG. 3, coal briquette manufactured using the raw sugar solution as a binder has higher compression strength compared to coal briquette manufactured using a molasses binder. Thus, when the raw sugar is used as a binder of coal briquette, cold strength of the coal briquette is improved compared to coal briquette where molasses is used as a binder. In addition, when the raw sugar is used as a binder, cold strength of coal briquette is improved, and accordingly, the amount of use of binder can be more reduced.

[0050] Meanwhile, raw sugar can be used not only for manufacturing coal briquette but also for manufacturing a pellet. In addition, apart from the raw sugar, raw sugar may be used in manufacturing of cement or feedstuff using a pellet. In addition to the above-stated raw sugar components, lactose, maltose, and raffinose may also be used. Such a disaccharide or trisaccharide indicates cold strength using salt formation according to independent use or mixing with a hardener.

[0051] A hardener used in manufactured of coal briquette may include quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, sulfuric acid, and the like. The hardener is combined with raw sugar such that hot strength and cold strength of the coal briquettes can be significantly improved. The amount of hardener may be about 0.1 parts by weight to 6 parts by weight with respect to 10 parts by weight of pulverized coal. Combination of the hardener of the above-stated range and the above-stated raw sugar can significantly improve cold strength of the coal briquettes.

[0052] The amount of sucrose included in the coal briquette may be 0 to 4 parts by weight with respect to 100 parts by weight of pulverized coal. More preferably, the amount of sucrose may be 2 parts by weight to 4 parts by weight. When the amount of sucrose is adjusted within the above-stated range, a mixture is not easily attached to a roll during shaping and cold strength and hot strength of the coal briquettes can be improved.

[0053] FIG. 4 schematically illustrates a raw sugar manufacturing apparatus 15 for providing a raw sugar binder. The raw sugar manufacturing apparatus 15 of FIG. 4 is an exemplary raw sugar manufacturing apparatus, and the present invention is not limited thereto. Therefore, the raw sugar manufacturing apparatus 15 can be variously modified.

[0054] As shown in FIG. 4, the raw sugar manufacturing apparatus 15 includes a crusher 151, a juice extractor 152, a sugarcane juice storage bin 153, a vacuum fan 154, an impurity remover 155, a centrifugal separator 156, a sugarcane extractor 157, and a quicklime storage bin 159. The raw sugar manufacturing apparatus 15 may further include other constituent elements as necessary.

[0055] The crusher 151 has protrusions and depressions formed at the surface thereof such that sugarcane finely charged thereinto together with water can be crushed. Sugarcane juice is extracted from the finely crushed sugarcane in the juice extractor 152. The sugarcane juice is stored in the sugarcane juice storage bin 153. The sugarcane juice is manufactured by crushing the sugarcane, but many impurities are mixed in the sugarcane during cultivation thereof. Thus, quicklime is injected into the sugarcane juice transferred to the impurity remover 155 from the quicklime storage bin 159 so as to manufacture sugarcane syrup after removing the impurities in the sugarcane juice. The sugarcane syrup may be used as a coal briquette binder by being directly used or by being concentrated. The sugarcane syrup has an advantage over molasses in pipeline transport because the sugarcane syrup has very low viscosity. In addition, since the sugarcane syrup has excellent mixing efficiency, a cold strength deviation of coal briquettes can be reduced by uniform mixing. Further, the sugarcane syrup stably maintains the cold strength of coal briquettes without regard to a change in coal type.

[0056] A solid content in the sugarcane syrup may be 50 wt% to 90 wt%. Preferably, the solid content may be 50 wt% to 80 wt%. More preferably, the solid content included in the sugarcane syrup may be 65 wt% to 85 wt%. Further more preferably, the solid content included in the sugarcane syrup may be 70 wt% to 78 wt%.

[0057] When the solid content is too low, sufficient strength of coal briquettes cannot be assured and breeding of microorganisms cannot be suppressed. Particularly, microorganisms plentifully included in the sugarcane syrup reduce sugar components by fermenting sucrose included in the sugarcane syrup into alcohol components so that cold strength

of the coal briquettes is deteriorated. Thus, fermentation of the sugarcane syrup due to the microorganisms needs to be prevented. In addition, when the solid content is too high, transfer, storage, and discharge of the sugarcane syrup may be difficult. Therefore, the amount of solid contents is preferably adjusted by adjusting the amount of water and the amount of sugarcane. For long-term storage of the sugarcane syrup for transfer, 1 wt% or less of paraffin may be added to the sugarcane syrup. Paraffin may prevent generation of foam in the sugarcane syrup due to organic acids. That is, foam is generated when carbon dioxide in the sugarcane syrup is discharged to the outside. When the sugarcane syrup is stirred, a container storing the sugarcane syrup may explode due to an increase of volume or generation of foam because of existence of an organic material, which is a surfactant that generates foam. Accordingly, paraffin is used to prevent the generation of foam.

[0058] Table 2 shows a solid content and viscosity of the solid content according to a total amount of reducing sugar of the sugarcane syrup.

(Table 2)

NO.	Solid content (wt%)	Total reducing sugar (wt%)	Viscosity (cp, 25 °C)
1	16	15	100
2	48	46	110
3	58	54	150
4	68	65	300
5	78	73	500
6	88	83	2,000
7	96	90	500,000

[0059] As shown in Table 2, when the solid content is 78 wt%, viscosity of sugarcane syrup is 500 cp, which satisfies the viscosity condition of less than 25,000 cp so as to be used as a coal briquette binder. Thus, the sugarcane syrup can be industrially used. In further detail, the amount of total reducing sugar in the sugarcane syrup is preferably 65 wt% to 90 wt%. When the amount of the total reducing sugar is too low, the sugarcane syrup may be fermented. Thus, for stable storage and use of the sugarcane syrup within a year, quicklime or slaked lime is added to the sugarcane syrup to separate precipitates. In addition, when the amount of total reducing sugar is too high, viscosity of the sugarcane syrup is increased so that it cannot be applied to a substantial process. Accordingly, the amount of total reducing sugar is adjusted within the above-stated range.

[0060] The slaked lime used to remove the impurity shown in FIG. 4 may be collected to be reused. Impurity-removed sugarcane juice is concentrated by being heated in the sugarcane extractor 157 and then used as a raw sugar binder. That is, the sugarcane syrup manufactured from the raw sugar manufacturing apparatus 15 of FIG. 4 is directly used as a raw sugar binder so as to manufacture coal briquettes. The sugarcane syrup is extracted to be distilled and recrystallized with a vacuum fan 154 such that massecuite is extracted therefrom. Massecuite includes raw sugar crystals and solid contents of 90 wt% or more. In addition, raw sugar is extracted through a centrifugal process in the centrifugal separator 156. Such a process is continuously repeated in the vacuum fan 154 and the centrifugal separator 156 to extract raw sugar and discharge molasses, which is a by-product.

[0061] The amount of moisture in the raw sugar binder acquired through the above-stated process can be easily adjusted. Thus, a type of coal having a large amount of moisture may also be used. When the amount of moisture in the sugarcane syrup is too high, strength of coal briquettes may be deteriorated due to the excessive amount of moisture. On the contrary, when the amount of moisture in the sugarcane syrup is too low, for example, when the amount of moisture in the sugarcane syrup is 10 wt% or less, a transfer problem may occur and the strength of coal briquettes may be deteriorated due to the lack of moisture. In addition, various types of coal may be used when the raw sugar binder is used instead of using molasses. Table 3 shows a result of component analysis of sugarcane juice, sugarcane syrup, and raw sugar acquired by the raw sugar manufacturing apparatus 15 of FIG. 4.

(Table 3)

NO.	Substance	Disaccharides /monosaccharides	Disaccharides (%) sucrose	Monosaccharides (%) glucose + fructose	Impurities (%)
1	Sugarcane juice	2-20	10-20	1-5	-

(continued)

NO.	Substance	Disaccharides /monosaccharides	Disaccharides (%) sucrose	Monosaccharides (%) glucose + fructose	Impurities (%)
2	Sugarcane syru p	4-60	40-60	1-10	-
3	Raw sugar	≥ 90	90-99	0-1	0-1

[0062] As shown in Table 3, all of the sugarcane juice, sugarcane syrup, and raw sugar acquired from the raw sugar manufacturing apparatus 15 of FIG. 4 include sucrose, glucose, or fructose. Here, sucrose is a disaccharide, and glucose and fructose are monosaccharides.

[0063] Thus, the raw sugar binder can provide coal briquettes with the same degree of strength even through being used in a lesser amount compared to a molasses binder. As a result, cost for manufacturing coal briquettes can be reduced. That is, in order to acquire the above-stated degree of strength of the coal briquettes, a ratio of disaccharide compared to monosaccharide is preferably 4 to 1000. More preferably, the ratio of disaccharide compared to monosaccharide is 10 to 1000.

[0064] Meanwhile, since the sugarcane syrup can be produced by juicing and concentrating sugarcane, a producing process is simple and a crystal production process that requires expensive investment can be omitted. In addition, a process for making a substance in a solution state can also be omitted. That is, the entire process can be simplified, thereby improving process efficiency. In addition, when a sugarcane producing area and a coal briquette manufacturing area are close to each other, transport cost can be saved, and since cost of sugarcane is cheaper than raw sugar, a price of the binder can be reduced, thereby saving manufacturing cost. Further, since the sugarcane syrup is not well-attached to a surface of the pair of rollers, shaping failure can be prevented, and as viscosity of the sugarcane syrup is lower than that of molasses, the sugarcane syrup can be uniformly coated to coal briquettes. Meanwhile, since the sugarcane syrup has excellent adhesive strength compared to molasses, cold strength of the coal briquettes can be improved, and therefore deterioration of cold strength and hot strength due to variation of types of coal briquettes can be prevented.

[0065] FIG. 5 schematically illustrates a molten iron manufacturing apparatus 100 using the coal briquettes manufactured in FIG. 1. A structure of the molten iron manufacturing apparatus 100 of FIG. 5 is an exemplarily structure, and the present invention is not limited thereto. Therefore, the structure of the molten iron manufacturing apparatus 100 of FIG. 5 can be variously modified.

[0066] As shown in FIG. 5, the molten iron manufacturing apparatus 100 includes a melter-gasifier 10, fluidized bed reducing furnaces 22, a reduced iron compressor 40, and a compressed reduced iron storage bin 50. Here, the compressed reduced iron storage bin 50 may be omitted.

[0067] The manufactured coal briquettes are charged into the melter-gasifier 10 and form a coal-packed bed in the melter-gasifier 10. Here, the coal briquettes cause generation of a reduction gas in the melter-gasifier 10, and the reduction gas is supplied to the fluidized-bed reduction furnaces 22. Fine iron ores are supplied to the plurality of fluidized-bed reduction furnaces 22 having fluidized beds, and are fluidized by the reduction gas supplied to the fluidized-bed reduction furnaces 22 from the melter-gasifier 10 such that reduced iron is manufactured. The reduced iron is compressed by the reduced iron compressor 40 and then stored in the compressed reduced iron storage bin 50. The compressed reduced iron is supplied to the melter-gasifier 10 from the compression reduced iron storage bin 50 and then melted in the melter-gasifier 10.

[0068] A dome portion 101 is provided in an upper portion of the melter-gasifier 10. That is, a space that is wider than other portions of the melter-gasifier 10 is formed, and high-temperature reduction gas exists in the space. Thus, the coal briquettes charged into the dome portion 101 can be easily divided by the high-temperature reduction gas. That is, since the coal briquettes are charged into the upper portion of the melter-gasifier 10 maintained at 1000 °C, the coal briquettes are subjected to rapid thermal impact. Accordingly, the coal briquettes may be differentiated while moving to the lower portion of the melter-gasifier 10.

[0069] However, coal briquettes manufactured by the method of FIG. 1 have high hot strength, and therefore the coal briquettes are not differentiated at the dome portion of the melter-gasifier 10 and fall to the bottom of the melter-gasifier 10 while being maintained as char. The char generated from thermal decomposition of coal briquettes moves to the bottom of the melter-gasifier 10 and then exothermically reacts with oxygen supplied through a tuyere 30. Thus, the coal briquettes can be used as a heat source that maintains the melter-gasifier 10 at a high temperature. Meanwhile, since char provides ventilation, a large amount of gas generated from the lower portion of the melter-gasifier 10 and reduced iron supplied from the fluidized-bed reduction furnace 22 can more easily and uniformly pass through the coal-packed bed in the melter-gasifier 10.

[0070] In addition to the above-stated coal briquettes, lump carbon ash or coke may be charged into the melter-gasifier 10, as necessary. The tuyere 30 is provided in an outer wall of the melter-gasifier 10 for injection of oxygen. Oxygen is injected into the coal-packed bed such that a fire zone is formed. The coal briquettes may be burned in the fire zone to generate the reduction gas.

[0071] Cold strength of the coal briquette can be maximized by using a raw sugar binder including sucrose, and manufacturing cost of the coal briquette can be reduced. In addition, the efficiency of the operation of the fluidized bed reduction furnace can be maximized, and the distribution cost for long-distance transportation of molasses can be reduced.

[0072] FIG. 6 schematically illustrates another molten iron manufacturing apparatus 200 using the coal briquettes manufactured in FIG. 1. A structure of the molten iron manufacturing apparatus 200 of FIG. 6 is an exemplarily structure, and the present invention is not limited thereto. Therefore, the structure of the molten iron manufacturing apparatus 200 of FIG. 6 can be variously modified. The structure of the molten iron manufacturing apparatus 200 of FIG. 6 is similar to the structure of the molten iron manufacturing apparatus 100 of FIG. 5, and therefore like reference numerals designate like elements in the molten iron production apparatus 100 of FIG. 5, and a detailed description thereof will be omitted.

[0073] The molten iron manufacturing apparatus 200 of FIG. 6 includes a melter-gasifier 10 and packed-bed reduction furnaces 20. The molten iron manufacturing device 200 may include other devices as necessary. Iron ore is charged into the plurality of packed-bed reduction furnaces 22 and then reduced. The iron ore charged into each packed-bed reduction furnace 22 is dried in advance and then passed through the packed-bed reduction furnace 22 such that reduced iron is manufactured. The packed-bed reduction furnace 22 receives the reduction gas from the melter-gasifier 10 and thus forms a packed bed therein.

[0074] Hereinafter, the present invention will be described in further detail with reference to experimental examples. The experimental examples are used only to illustrate the present invention, and are not meant to be restrictive.

Experimental Example

Experiment of manufacturing coal briquette using raw sugar solution as binder

[0075] Coal briquette including coal, a binder, a hardener, and moisture was manufactured. First, coal and the hardener were mixed for about 1 minute to about 20 minutes and the binder was mixed to the mixture of the coal and the hardener for about 1 minute to about 20 minutes. As the binder, raw sugar including sucrose, glucose, and fructose was used. Each binder was manufactured as a raw sugar solution of about 50 wt% to about 90wt% of raw sugar solution. The raw sugar solution was manufactured by being agitated at a temperature of about 60°C to about 90°C, and no component change occurred. As a binder, a solution in which raw sugar was completely dissolved or a solution in which raw sugar was not completely dissolved was usable. The binder was added at a temperature of about 10°C to about 80°C with viscosity of about 1cp to 60,000cp. The amount of sucrose, glucose, and fructose included in the raw sugar were calculated with respect to a weight ratio of coal and then added.

[0076] Table 4 shows components of a raw sugar solution according to the amount of raw sugar added to the raw sugar solution and components of molasses. In further detail, in Table 4, components of raw sugar solutions of 75 wt%, 65 wt%, 55 wt%, 45 wt% and components of molasses are compared. In Table 4, viscosity of the binder is increased as a concentration of raw sugar included in the binder is high or a manufacturing temperature is low.

(Table 4)

Section		Raw sugar 75 wt% solution	Raw sugar 65 wt% solution	Raw sugar 55 wt% solution	Raw sugar 45 wt% solution	Molasses
Brix (%)		74.7	64.8	54.9	44.9	81.8
Ratio of sucrose		100	100	100	100	35.0
Total reduced		75.5	65.6	55.7	45.6	51.0
sugar						
Manufacturing temperature (°C)	70	43 m·Pa	30.1 m·Pa	10.2 m·Pa	5.4 m·Pa	-
	60	48 m·Pa	28.7 m·Pa	9.8 m·Pa	5.2 m·Pa	-
	50	61 m·Pa	27.5 m·Pa	8.7 m·Pa	5.2 m·Pa	-
	40	148 m·Pa	26.4 m·Pa	7.6 m·Pa	5.6 m·Pa	-

(continued)

Section		Raw sugar 75 wt% solution	Raw sugar 65 wt% solution	Raw sugar 55 wt% solution	Raw sugar 45 wt% solution	Molasses
5	30	171 m·Pa	26.2 m·Pa	6.8 m·Pa	5.4 m·Pa	-

Experimental Example 1

10 [0077] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 10 parts by weight of 75% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as the above-stated experimental example.

Experimental Example 2

15 [0078] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 8 parts by weight of 75% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experimental Example 3

20 [0079] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 6 parts by weight of 75% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experimental Example 4

25 [0080] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 10 parts by weight of 65% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experimental Example 5

30 [0081] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 8 parts by weight of 65% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experimental Example 6

35 [0082] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 10 parts by weight of 55% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experimental Example 7

40 [0083] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 10 parts by weight of 45% raw sugar solution were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Comparative Example 1

45 [0084] Coal briquettes were manufactured by using 2.7 parts by weight of CaO as a hardener and 10 parts by weight of molasses were mixed with respect to 100 parts by weight of coal. The remaining experiment processes were the same as Experimental Example 7.

Experiment result of coal briquette manufacturing using raw sugar solution as binder

50 [0085] Cold strength and hot strength of coal briquettes manufactured according to Experimental Example 1 to Ex-

perimental Example 7 and Comparative Example 1 were measured, and a technical analysis was performed. Such an experiment process can be easily understood by those skilled in the art, and therefore the detailed description is omitted.

[0086] Table 5 shows an experiment result of coal briquettes manufactured according to Experimental Example 1 to Experimental Example 7 and Comparative Example 1. As shown in Table 5, when the raw sugar binder was used as a binder instead of molasses, cold strength and hot strength of the coal briquettes were improved.

(Table 5)

Section		Comp arative Ex. 1	Exper imental Ex. 1	Exper imental Ex. 2	Exper imental Ex. 3	Exper imental Ex. 4	Exper imental Ex. 5	Exper imental Ex. 6	Exper imental Ex. 7
Mi	CaO	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
xing ratio	(wt%)								
	Molasses (solid content)	10	0	0	0	0	0	0	0
	Raw sugar 75% solution (solid content)	0	10 (7.5)	8 (8)	6 (6)	0	0	0	0
	Raw sugar 65% solution (solid content)	0	0	0	0	10 (6.5)	8 (5.2)	0	0
	Raw sugar 55% solution (solid content)	0	0	0	0	0	0	10 (5.5)	0
	Raw sugar 45% solution (solid content)	0	0	0	0	0	0	0	10 (5.5)

(continued)

Section		Comp arative Ex. 1	Exper imental Ex. 1	Exper imental Ex. 2	Exper imental Ex. 3	Exper imental Ex. 4	Exper imental Ex. 5	Exper imental Ex. 6	Exper imental Ex. 7
Qualit y ev aluati on	Compre ssion strength (kg·f)	50.5	83.8	64.8	52.4	70.2	56.2	50.1	51.6
	Drop strength (4 times)	97.5	98.1	97.1	97.2	97.1	97.1	96.1	96.3
	Drop strength (8 times)	94.1	96.6	93.3	93.4	95.6	93.3	93.1	93.7
	HTS 16	12.0	12.1	14.7	14.6	12.4	14.7	11.1	11.5
	HTS 13	64.4	63.6	61.3	61.2	63.3	61.3	62.1	63.5
	HTS 10	92.6	92.1	91.5	92.4	91.1	91.5	90.8	91.8
	I-Drum	80.5	78.6	78.3	79.5	78.6	78.3	79.5	80.5

Coal briquette manufacturing experiment using sugarcane syrup as binder

[0087] Coal briquettes including pulverized coal, sugarcane syrup concentrate, a hardener, and moisture were manufactured. The pulverized coal was crushed such that particle sizes of 90 wt% or more were 3mm or less, and the amount of moisture was controlled to be 12 wt% or less. The pulverized coal and the hardener were mixed for about 20 minutes and the sugarcane syrup concentrate was added to the mixture and then mixed for about 20 minutes. The sugarcane syrup concentrate included a solid content of about 65 wt% to about 90 wt%. Sugarcane syrup of solid content of 50 wt% generated from raw sugar manufacturing process was concentrated by being distilled at 10 mbar to 30 mbar under vacuum at a temperature of 80°C to 200°C such that the sugarcane syrup concentrate was made. When the sugarcane syrup was concentrated, a liquid-state paraffin of 0.1 wt% to 0.5 wt% was added to remove foams generated during an early concentration stage.

Experimental Example 8

[0088] 2.7 parts by weight of CaO and 10 parts by weight of solution of sugarcane syrup 78 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes can be can be easily understood by those skilled in the art, and therefore the detailed description is omitted.

Experimental Example 9

[0089] 2.7 parts by weight of CaO and 9 parts by weight of solution of sugarcane syrup 78 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 10

[0090] 2.7 parts by weight of CaO and 8 parts by weight of solution of sugarcane syrup 78 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 11

[0091] 2.7 parts by weight of CaO and 6 parts by weight of solution of sugarcane syrup 78 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the

same as Experimental Example 8.

Experimental Example 12

[0092] 2.7 parts by weight of CaO and 10 parts by weight of solution of sugarcane syrup 68 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 13

[0093] 2.7 parts by weight of CaO and 9 parts by weight of solution of sugarcane syrup 68 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 14

[0094] 2.7 parts by weight of CaO and 8 parts by weight of solution of sugarcane syrup 68 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 15

[0095] 2.7 parts by weight of CaO and 7 parts by weight of solution of sugarcane syrup 68 % were mixed with respect to 100 parts by weight of pulverized coal to manufacture coal briquettes. The remaining experiment processes were the same as Experimental Example 8.

Experiment result of coal briquette manufacturing using sugarcane syrup as binder

[0096] Compression strength of coal briquettes manufactured according to the above-stated Experimental Example 8 to Experimental Example 15 were measured. Since such an experiment process can be easily understood by those skilled in the art, the detailed description is omitted.

[0097] Table 6 shows an experiment result of coal briquettes manufactured according to the above-stated Experimental Example 8 to Experimental Example 15. In Table 6, compression strengths of coal briquettes are shown.

(Table 6) (*Ex. is short for Experimental Example)

Section		Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12	Ex. 13	Ex. 14	Ex. 15
Mixing ratio	Moisture in coal (wt%)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
	CaO (wt%)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	Sugarcane	10	9	8	6	0	0	0	0
	syrup 78%								
	Sugarcane syrup 68%	0	0	0	0	10	9	8	7
Quality evaluation	Compression strength (kg·f)	80	72	66	50	70	63	56	50
	Drop strength	99	95	95	93	95	95	93	90
Shaping failure rate		-	-	-	-	2%	2%	2%	2%

[0098] As shown in Table 6, coal briquettes manufactured in Experimental example 8 to Experimental Example 15 had excellent compression strength and drop strength. In particular, compression strength and drop strength were more excellent when a solution of sugarcane syrup 78% was used instead of using a solution of sugarcane syrup 68%. As shown in Experimental Example 11 and Experimental Example 15, although a smaller amount of sugarcane syrup compared to the molasses binder of Comparative Example 1 was used, coal briquette having almost the same compression strength could be manufactured. That is, when the sugarcane syrup 78% solution was used in Experimental Example 11, a usage amount of binder could be reduced by about 40% compared to molasses of Comparative Example 1. In addition, when the sugarcane syrup 68% solution was used in Experimental Example 15, a usage amount of binder

could be reduced by about 30% compared to Comparative Example 1.

[0099] As described above, when the raw sugar binder was used, an alkali component was not piled in the fluid-bed reducing furnace such that nozzles could be prevented from being blocked. In addition, cold strength and hot strength of the coal briquettes were increased. Meanwhile, coal briquette having excellent strength could be manufactured by using a small amount of sugarcane syrup as a binder.

Experiment of manufacturing coal briquette according to solid content variation of sugarcane syrup

Experimental Example 16

[0100] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 16 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 17

[0101] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 48 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 18

[0102] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 58 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 19

[0103] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 68 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 20

[0104] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 78 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 21

[0105] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 88 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 22

[0106] Coal briquettes were manufactured using sugarcane syrup which has been concentrated and thus the amount of solid content was 96 wt%. The remaining experiment processes were the same as Experimental Example 8.

Experiment result of coal briquette manufacturing according to solid content variation of sugarcane syrup

[0107] Compression strength and drop strength of coal briquettes manufactured according to the above-stated Experimental Example 16 to Experimental Example 22 were measured. That is, the coal briquette was left for about 1 hour at a room temperature and then compression strength and drop strength of the coal briquette were measured, and the coal briquette was dried for about 15 minutes at 80°C, and the compression strength and drop strength were measured again. The results are shown in Table 7.

(Table 7)

Experimental Example	Viscosity (cp)	TS	Ash	1 Hr. at room temperature		Dried for 15 min. at 80 °C	
				Compression strength	Drop strength	Compression strength	Drop strength
Experimental Ex. 16	100	15	1	26	85	75	85
Experimental Ex. 17	110	46	2	55	90	100	95
Experimental Ex. 18	150	54.4	3	60	95	100	95
Experimental Ex. 19	300	64.5	4	70	95	100	95
Experimental Ex. 20	500	73	5	80	95	120	99
Experimental Ex. 21	2,000	82.5	5.5	90	99	130	99
Experimental Ex. 22	5,000	90	6	100	99	140	99

[0108] As shown in Table 7, as the amount of solid content included in the sugarcane syrup used as a binder in Experimental Example 16 to Experimental Example 22 is increased, compression strength and drop strength of the coal briquettes are increased. Thus, cold strength of the coal briquettes can be improved by increasing the amount of solid content included in the sugarcane syrup. In addition, compared to the coal briquette left for about 1 hour at a room temperature, the coal briquette dried for about 15 minutes at 80°C has more excellent cold strength. This is because that moisture included in the coal briquette is evaporated such that the cold strength of the coal briquette is improved.

Experiment result of coal briquette manufacturing using sugarcane syrup and low-grade coal

Experimental Example 23

[0109] Coal briquettes were manufactured by mixing 2.7 parts by weight of CaO and 10 parts by weight of a solution of sugarcane syrup 78% with respect to 100 parts by weight of pulverized coal that include 20 wt% of thermal coal and 80 wt% of weak coking coal. The remaining experiment processes were the same as Experimental Example 8.

Experimental Example 24

[0110] Coal briquettes were manufactured by mixing 2.7 parts by weight of CaO and 10 parts by weight of a solution of sugarcane syrup 78% with respect to 100 parts by weight of pulverized coal that include 50 wt% of thermal coal and 50 wt% of weak coking coal. The remaining experiment processes were the same as Experimental Example 23.

Experimental Example 25

[0111] Coal briquettes were manufactured by mixing 2.7 parts by weight of CaO and 7 parts by weight of a solution of sugarcane syrup 78% with respect to 100 parts by weight of pulverized coal that include 50 wt% of thermal coal and 50 wt% of weak coking coal. The remaining experiment processes were the same as Experimental Example 23.

Comparative Example 3

[0112] Coal briquettes were manufactured by mixing 2.7 parts by weight of CaO and 10 parts by weight of molasses with respect to 100 parts by weight of pulverized coal that include 20 wt% of thermal coal and 80 wt% of weak coking coal. The remaining experiment processes were the same as Experimental Example 23.

Comparative Example 4

[0113] Coal briquettes were manufactured by mixing 2.7 parts by weight of CaO and 10 parts by weight of molasses with respect to 100 parts by weight of pulverized coal that include 50 wt% of thermal coal and 50 wt% of weak coking coal. The remaining experiment processes were the same as Experimental Example 23.

Experiment result of manufacturing coal briquette using sugarcane syrup and low-grade coal

[0114] Compression strength, drop strength, and hot strength of coal briquettes manufactured according to the above-stated Experimental Example 23 to Experimental Example 25, Comparative Example 2, and Comparative Example 3 were measured. The experiment result is shown in Table 8.

(Table 8)

Experimental example	Cold strength			Hot strength		
	Compression strength		Drop strength	HTS10	HTS13	HTS16
	Compression strength	Deviation				
Experimental example 23	80	1	99	74	33	4
Experimental example 24	80	1	99	74	33	4
Experimental example 25	50	2	90	70	27	3
Comparative example 2	45	3	80	71	17	2
Comparative example 3	40	3	80	65	13	0

[0115] As shown in Table 8, coal briquettes manufactured according to Experimental Example 23 to Experimental Example 25 were relatively superior to coal briquettes manufactured according to Comparative Example 2 and Comparative Example 3 in cold strength. In addition, coal briquettes manufactured according to Experimental Example 23 to Experimental Example 25 were relatively superior to coal briquettes manufactured according to Comparative Example 2 and Comparative Example 3 in hot strength. Therefore, although low-grade coal is used, coal briquette having excellent characteristic can be manufactured by using sugarcane syrup.

[0116] While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

Claims

1. A method for manufacturing coal briquettes being charged into a dome portion of a melter-gasifier and then quickly heated therein in a molten iron manufacturing apparatus that includes the melter-gasifier into which reduced iron is charged and a reducing furnace connected with the melter-gasifier and providing the reduced iron, comprising:
 - providing pulverized coal;
 - providing a raw sugar binder of 0 to 10 parts by weight with respect to 100 parts by weight of the pulverized coal;
 - providing a mixture by adding the raw sugar binder to the pulverized coal; and
 - providing coal briquettes by shaping the mixture.
2. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the raw sugar binder, the raw sugar binder is provided as a raw sugar solution, and the raw sugar solution includes raw sugar at about 35 wt% to about 85 wt%.
3. The method for manufacturing the coal briquettes of claim 2, wherein the raw sugar solution includes raw sugar at about 65 wt% to about 85 wt%.

4. The method for manufacturing the coal briquettes of claim 1, wherein the providing the raw sugar binder comprises:
crushing sugarcane while injecting water;
providing sugarcane juice by juicing the crushed sugarcane; and
providing sugarcane syrup by removing impurities from the sugarcane juice and concentrating the sugarcane juice.
5. The method for manufacturing the coal briquettes of claim 4, wherein, in the providing the sugarcane juice, the amount of solid content included in the sugarcane juice is about 10 wt% to about 30 wt%.
6. The method for manufacturing the coal briquettes of claim 4, wherein, in the providing the sugarcane syrup as the raw sugar binder, the amount of solid content included in the sugarcane juice is about 50 wt% to 90 wt%.
7. The method for manufacturing the coal briquette of claim 6, wherein the amount of solid content included in the sugarcane syrup is about 65 wt% to about 85 wt%.
8. The method for manufacturing the coal briquettes of claim 7, wherein the amount of solid content included in the sugarcane syrup is about 70 wt% to about 78 wt%.
9. The method for manufacturing the coal briquettes of claim 4, further comprising adding paraffin to the sugarcane syrup, wherein the amount of paraffin is greater than 0 and less than 1 wt% with respect to the amount of sugarcane syrup.
10. The method for manufacturing the coal briquettes of claim 4, wherein, in the providing the mixture, the mixture is mixed for about 5 minutes to about 7 minutes at a temperature of about 50°C to about 100°C.
11. The method for manufacturing the coal briquettes of claim 4, wherein, in the providing the sugarcane syrup as the raw sugar binder, the amount of total reducing sugar included in the sugarcane syrup is about 65wt% to about 90wt%.
12. The method for manufacturing the coal briquettes of claim 4, wherein, in the providing the pulverized coal, the pulverized coal is at least one selected from a group consisting of thermal coal, weak coking coal, brown coal, and anthracite coal.
13. The method for manufacturing the coal briquettes of claim 1, wherein the providing the raw sugar binder comprises:
providing a melted solution by melting the raw sugar with steam of about 70°C to about 120°C; and
providing the raw sugar binder as a raw sugar solution by adding water to the melted solution and agitating the water-added melted solution at a temperature about 60°C to about 70°C.
14. The method for manufacturing the coal briquettes of claim 1, further comprising providing at least one hardener selected from a group consisting of quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, and sulfuric acid,
wherein, in the providing the mixture, the hardener is added more to the pulverized coal and the amount of hardener with respect to 100 parts by weight of the pulverized coal is 1 part by weight to 6 parts by weight.
15. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the raw sugar binder, a ratio of solid content with respect to the amount of total reducing sugar included in the raw sugar binder is greater than 1 and less than 1.2.
16. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the raw sugar binder, the raw sugar binder comprises at least one selected from a group consisting of sucrose, glucose, and fructose.
17. The method for manufacturing the coal briquettes of claim 16, wherein the raw sugar binder comprises the sucrose and the amount of sucrose with respect to 100 parts by weight of the pulverized coal is greater than 0 and less than 4 parts by weight.
18. The method for manufacturing the coal briquettes of claim 17, wherein the amount of sucrose is 2 parts by weight to 4 parts by weight.

19. The method for manufacturing the coal briquettes of claim 16, wherein the raw sugar binder comprises the glucose and the amount of glucose with respect to 100 parts by weight of the pulverized coal is greater than 0 and less than 4 parts by weight.
- 5 20. The method for manufacturing the coal briquettes of claim 19, wherein the amount of glucose is 2 parts by weight to 4 parts by weight.
21. The method for manufacturing the coal briquettes of claim 16, wherein the raw sugar binder comprises the fructose and the amount of fructose with respect to 100 parts by the pulverized coal is greater than 0 and less than 4 parts by weight.
- 10 22. The method for manufacturing the coal briquettes of claim 21, wherein the amount of fructose is 2 parts by weight to 4 parts by weight.
- 15 23. The method for manufacturing the coal briquettes of claim 1, wherein the reducing furnace is a fluidized bed reduction furnace or a packed bed reduction furnace.
24. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the raw sugar binder, the raw sugar binder is provided as a raw sugar solution and the amount of raw sugar solution with respect to 100 parts by weight of the pulverized coal is 3 parts by weight to 10 parts by weight.
- 20 25. The method for manufacturing the coal briquettes of claim 24, wherein the amount of raw sugar solution is 6 parts by weight to 10 parts by weight.
- 25 26. The method for manufacturing the coal briquettes of claim 25, wherein the amount of raw sugar solution is 8 parts by weight to 10 parts by weight.
27. The method for manufacturing the coal briquettes of claim 24, wherein the amount of sucrose included in the raw sugar solution is 45 wt% to 75 wt%.
- 30 28. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the raw sugar binder, viscosity of the raw sugar binder is 100cp to 10,000cp.
29. The method for manufacturing the coal briquettes of claim 1, wherein, in the providing the pulverized coal, the amount of moisture in the pulverized is 3 wt% to 12 wt%.
- 35 30. Coal briquette being charged into a dome portion of a melter-gasifier and then quickly heated therein in a molten iron manufacturing apparatus that includes the melter-gasifier into which reduced iron is charged and a reducing furnace connected with the melter-gasifier and providing the reduced iron, wherein the coal briquette comprises pulverized coal and a raw sugar binder, the amount of raw sugar binder with respect to 100 parts by weight of pulverized coal is greater than 0 and less than 10 parts by weight, and the raw sugar binder comprises at least one selected from a group consisting of sucrose, glucose, and fructose.
- 40 31. The coal briquette of claim 30, wherein, when the raw sugar binder comprises sucrose, the amount of sucrose is greater than 0 and less than 4 parts by weight with respect to 100 parts by weight of the pulverized coal.
- 45 32. The coal briquette of claim 31, wherein the amount of sucrose is 2 parts by weight to 4 parts by weight.
- 50 33. The coal briquette of claim 30, wherein, when the raw sugar binder comprises fructose, the amount of fructose is greater than 0 and less than 4 parts by weight with respect to 100 parts by weight of the pulverized coal.
34. The coal briquette of claim 33, wherein the amount of fructose is 2 parts by weight to 4 parts by weight.
- 55 35. The coal briquette of claim 30, further comprising at least one hardener selected from a group consisting of quicklime, slaked lime, calcium carbonate, cement, bentonite, clay, silica, dolomite, phosphoric acid, and sulfuric acid, wherein the amount of hardener is 0.1 part by weight to 6 parts by weight with respect to 100 parts by weight of the pulverized coal.

36. The coal briquette of claim 30, wherein the amount of solid content included in the raw sugar is 16 wt% to 96 wt%.

37. The coal briquette of claim 36, wherein the amount of solid content is 78 wt% to 96 wt%.

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FIG. 1

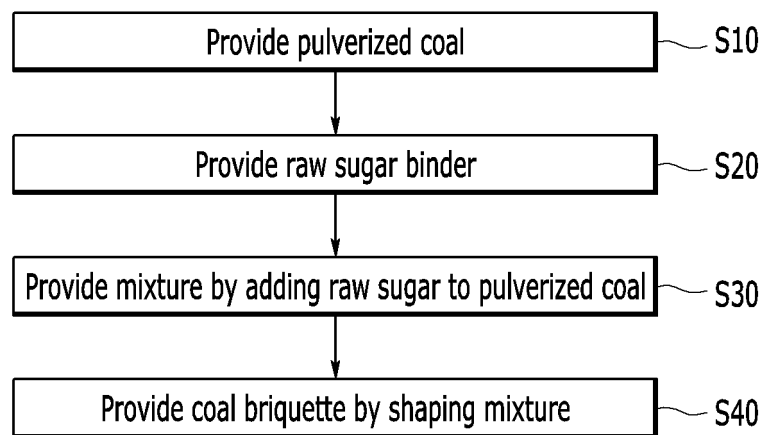


FIG. 2

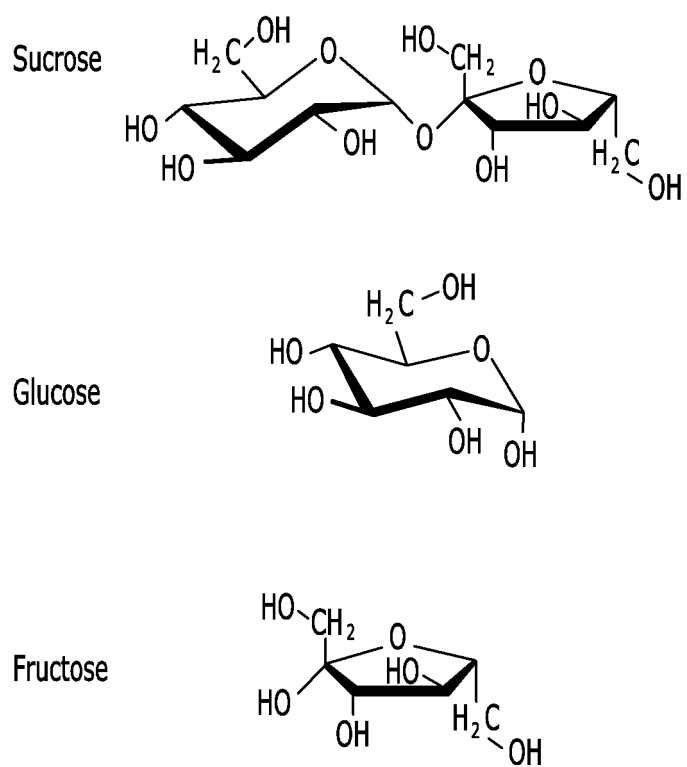


FIG. 3

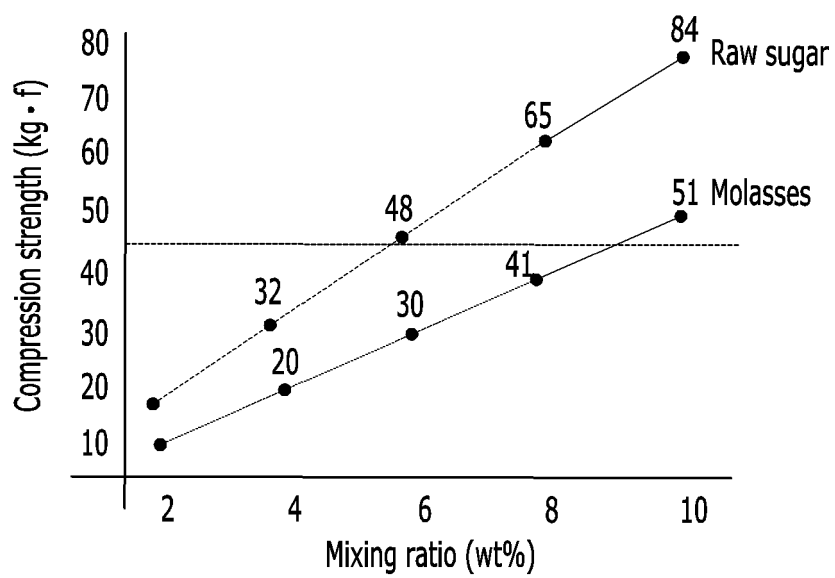
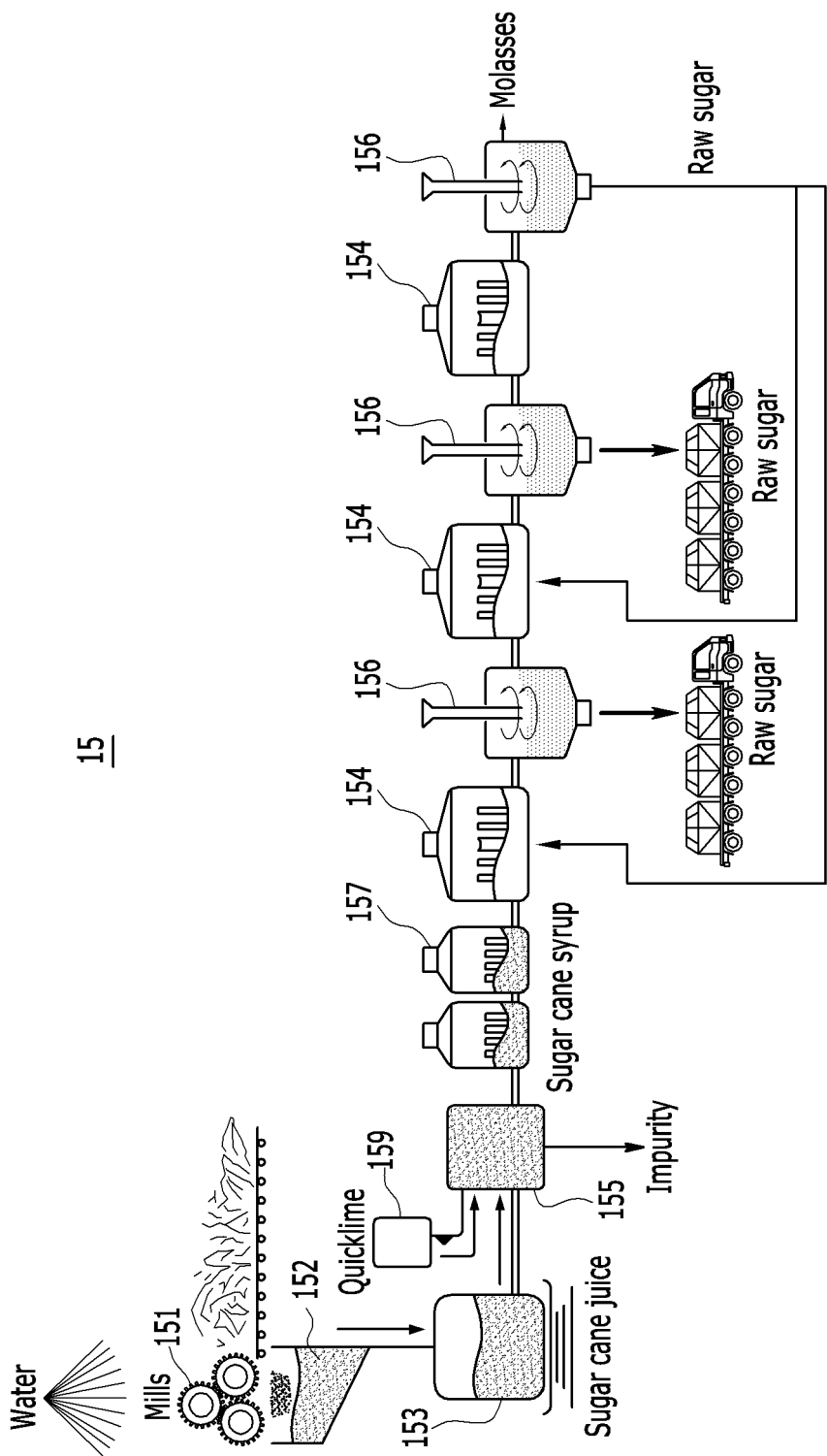


FIG. 4



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FIG. 5

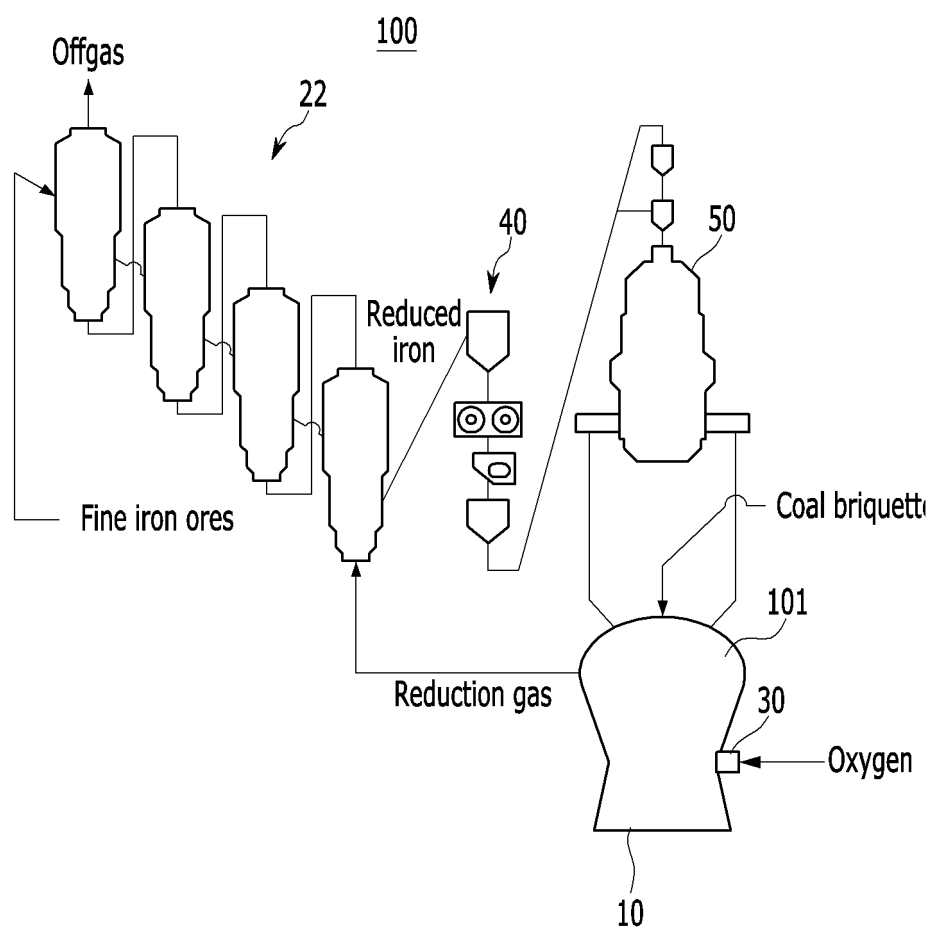
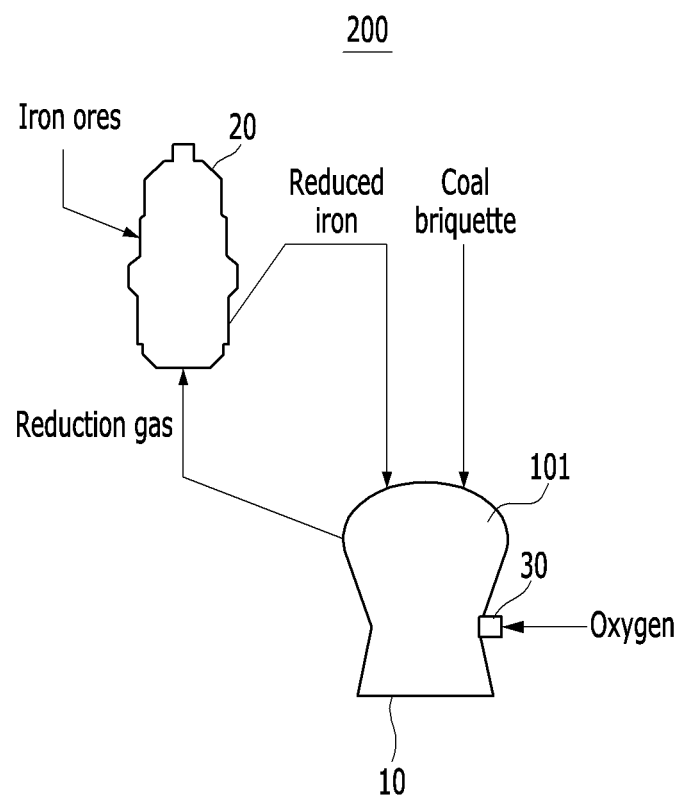


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2014/012784

A. CLASSIFICATION OF SUBJECT MATTER

C10L 5/16(2006.01)i, C10L 9/10(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10L 5/16; C22B 1/20; C10L 5/44; C10B 53/02; C21B 13/00; C22B 1/16; C10L 5/48; C10L 9/10Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as aboveElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: syrup, sugar, sucrose, fine coal, coal briquette and other similar keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2005-0077103 A (POSCO) 01 August 2005 See page 3, line 20 - page 6, line 26; claims 1-22 and figures 1-4.	1-37
Y	JP 2007-332274 A (HYTOOD CO LTD et al.) 27 December 2007 See paragraphs [0012]-[0043]; claims 1-9 and figures 1-3.	1-37
Y	JP 2008-144256 A (CHINA STEEL CORP et al.) 26 June 2008 See paragraphs [0011]-[0026]; claims 1-19 and figures 1-2.	1-37
Y	KR 10-2003-0052954 A (POSCO et al.) 27 June 2003 See page 3, line 2 - page 4, line 42; claims 1-9 and figure 1.	1-37

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

* Special categories of cited documents:

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"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

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Date of the actual completion of the international search

25 MARCH 2015 (25.03.2015)

Date of mailing of the international search report

27 MARCH 2015 (27.03.2015)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2014/012784

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REFERENCES CITED IN THE DESCRIPTION

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- KR 1020140187759 [0001]