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(54) ALLOY AND SEPARATION PROCESS

(57) An alloy in particulate form for use in metal recycling industries and mining industries in dense media separation processes.

EP 3 115 112 A1

Description

Technical field

[0001] The invention relates to an alloy, and more specifically an iron based alloy that is preferably in particulate form. The invention further relates to dense media separation, particularly the use of a new alloy in dense media separation processes, for instance in the metal recycling industries and mining industries.

Background

[0002] Dense media separation is a process in which components of a material are separated into fractions on the basis of their differing densities. Typically, the separation is performed in a liquid that has a density that is equal to or greater than that of water (999.97 kg/m^3). For example, the liquid (referred to in the art as a "heavy liquid") can be selected from tetrabromoethane, methylene iodide, lead sulfamate, thallium malonate or thallium formate. Alternatively, the addition of a solid material (referred to in the art as the "media") to a liquid carrier to form a suspension (referred to in the art as a "dense medium") can increase the density of the liquid carrier to allow separation of components that have densities that are greater than that of water or a so-called heavy liquid. A typical liquid carrier is water and typical media include ferrosilicon and magnetite. The solid material is generally in particulate form.

[0003] In practice, the material that is to be separated into its component parts is introduced into the so-called heavy liquid/dense medium, which is typically in a conventional separating device, e.g. a static separation tank or a dynamic separator. The components of the material which are less dense than the heavy liquid/dense medium will rise and float. Similarly, the components of the material which have a greater density than the heavy liquid/dense medium will sink.

[0004] The addition of solid material to a liquid carrier to form a dense medium can be problematic due to the stability of the dense medium and the proclivity of the solid material particles to settle. Ideally, the particle size of the solid material should be small enough that the particles will not settle as rapidly as the components of the material that is to be separated. The stability of the dense medium is therefore an important parameter, because it determines the consistency of the density gradient of the suspension, which directly influences the sharpness of separation of the material that is to be separated into its component parts. Furthermore, the use of ferrous metals as the solid material in a liquid carrier can present additional problems due to corrosion of the solid material and the formation of rust, which can alter the separation gradient and the sharpness of separation.

[0005] The apparent density and stability of the dense medium are influenced by factors such as specific gravity, particle shape, particle size and/or particle size distribution of the solid material added to the liquid carrier. An ideal dense medium contains media that has a high specific gravity, which increases the efficiency of separation because lower amounts of the media need to be added to the liquid carrier to achieve higher apparent densities, which means the mobility of the component parts of a material that is to be separated through the dense medium is not significantly impeded. Conversely, a dense medium that contains media with a low specific gravity is less desirable because a greater amount of the media needs to be added to the liquid carrier to achieve higher apparent densities, which has a detrimental effect on separation efficiency because it negatively impacts on the velocity at which component parts of a material that is to be separated move through the dense medium.

[0006] Accordingly, there exists a need for an alloy that can be used as media to form a dense medium that has a greater range of operating densities when compared with existing alloys that are used as media in a dense media separation process. There also exists a need for an alloy that retains its magnetic properties, such that it can be recovered easily, which reduces the overall consumption of the alloy during a dense media separation process. There is also a need for an alloy that is resistant to corrosion, which results in a more consistent density gradient of the dense medium.

Disclosure of the invention

[0007] The present invention provides a novel alloy that finds particular utility in particulate form in a dense media separation process.

The alloy

[0008] According to the present invention, there is provided an alloy comprising:

i) at least about 80% iron;
ii) no more than about 8.5% silicon; and
iii) from about 2 to about 7% chromium.

[0009] Herein, the amount of a given component in a composition is the percentage weight (wt%) of that component relative to the total weight of the composition, unless otherwise stated.

[0010] Preferably, the iron content in the alloy is at least about 81%, preferably at least about 82%, preferably at least about 83%, preferably at least about 84%, preferably at least about 85%, preferably at least about 86%, preferably at least about 87%, preferably at least about 88%, preferably at least about 89%, and preferably at least about 90%.

[0011] Preferably, the silicon content in the alloy is no more than about 8.4%, preferably no more than about 8.3%, preferably no more than about 8.2%, preferably no more than about 8.1%, and preferably no more than about 8.0%. Preferably, silicon is present in the alloy in an amount of at least about 7.0%, preferably at least about 7.1%, preferably at least about 7.2%, preferably at least about 7.3%, preferably at least about 7.4%, and preferably at least about 7.5%. Thus, it is preferred that the silicon content in the alloy is preferably from about 7.0% to about 8.5%, preferably from about 7.1%% to 8.4%, preferably from about 7.2% to about 8.3%, preferably from 7.3% to about 8.2%, and preferably about 7.4% to about 8.1%, preferably about 7.5% to about 8.0%.

[0012] Preferably, the chromium content is less than 7%. Preferably, the chromium content in the alloy is from about 3% to about 7%, preferably from about 4% to less than 7%, and preferably from about 5% to about 6%.

[0013] The alloy may further comprise one or more additional components, such as carbon, phosphorus and/or sulfur, and combinations thereof.

[0014] Where the alloy comprises carbon, the carbon is present in an amount of no more than about 1.5%, preferably no more than about 1.4%, preferably no more than about 1.3%, preferably no more than about 1.2%, preferably no more than about 1.1 %, and preferably no more than about 1%. Carbon may be present in the alloy in an amount of at least about 0.3%, or at least about 0.4%, or at least about 0.5%, or at least about 0.6%, or at least about 0.7%, or at least about 0.8%. Thus, the carbon content in the alloy may be from about 0.3% to about 1.5%, or from about 0.4% to about 1.4%, or from about 0.5% to about 1.3%, or from about 0.6% to about 1.2%, or from about 0.7% to about 1.1 %, or from about 0.8% to about 1.1 %, or from about 0.8% to about 1%.

[0015] Where the alloy comprises phosphorus, the phosphorous content in the alloy is no more than about 0.15%, preferably no more than about 0.14%, preferably no more than about 0.13%, preferably no more than about 0.12%, preferably no more than about 0.11%, and preferably no more than about 0.10%. Phosphorous may be present in the alloy in an amount of at least about 0.01%. Thus, the phosphorous content in the alloy is typically from about 0.01% to about 0.15%, preferably from about 0.01% to about 0.14%, preferably from about 0.01% to about 0.13%, preferably from about 0.01% to about 0.12%, preferably from about 0.01% to about 0.11%, and preferably from about 0.01% to about 0.10%.

[0016] Where the alloy comprises sulfur, the sulfur content in the alloy is no more than about 0.07%, preferably no more than about 0.06%, and preferably no more than about 0.05%. Sulfur may be present in the alloy in an amount of at least about 0.01%. Thus, the sulfur content in the alloy is typically from about 0.01% to about 0.07%, preferably from about 0.01% to about 0.06%, and preferably from about 0.01% to about 0.05%.

[0017] The features disclosed above are also disclosed in combination. For example, alloys are disclosed which comprise at least about 80% iron, no more than about 8.5% silicon, and from about 3% to about 6% chromium. Similarly, alloys are disclosed which comprise at least about 80% iron, no more than about 8.3% silicon, from about 3% to about 7% chromium, and from about 0.3% to about 1.5% carbon.

[0018] The alloy is preferably in particulate form. In particular, the particles of the alloy preferably have a particle size such that at least about 70%, preferably at least about 80%, preferably at least about 90%, preferably at least about 95%, preferably at least about 97% of the particles of the alloy pass through a sieve having a mesh aperture of about 1 mm, preferably a mesh aperture of about 900 μm, preferably a mesh aperture of about 800 μm, preferably a mesh aperture of about 700 μm, preferably a mesh aperture of about 600 μm, preferably a mesh aperture of about 500 μm, preferably a mesh aperture of about 400 μm and preferably a mesh aperture of about 300 μm, preferably at mesh aperture of about 250 μm, preferably a mesh aperture of about 212 μm. Preferably, the particle size is such that at least about 90%, preferably at least about 95%, preferably at least about 97% pass through a sieve having a mesh aperture of about 212 μm.

[0019] The shape of the alloy particles depends upon the way in which the particles are made. For example, the particles may be substantially round if the alloy is made by an atomization technique, or sharp-edged if the alloy is made by a milling technique. Preferably, the particles are made by an atomization technique.

[0020] The alloy particles are preferably substantially round.

[0021] The alloy of the invention can be supplied in various forms depending on the intended use and the form of the material that is to be separated into its constituent parts. The different forms of the alloy can have different particle size distributions. Within the generic ranges set out above, suitable particle size distributions can be selected from:

i) at least about 70% of particles of the alloy pass through sieves having a mesh size of about 300 μm to about 20 μm, and preferably of from about 212 μm to about 20 μm; or

ii) at least about 70% of the particles of the alloy pass through sieves having a mesh aperture of no more than about 80 μm, preferably no more than about 70 μm, and preferably no more than about 60 μm; or

iii) at least about 80% of the particles of the alloy pass through a sieve having a mesh aperture of no more than about 80 μm, preferably no more than about 70 μm, preferably no more than about 60 μm, and preferably no more than about 50 μm; or

iv) at least about 85% of the particles of the alloy pass through a sieve having a mesh aperture of no more than about 150 μm, preferably no more than about 140 μm, preferably no more than about 130 μm, preferably no more than about 120 μm, and preferably no more than about 110 um.

[0022] The specific gravity (as defined herein) of the alloy of the invention is preferably in the range of from about 6.5 g/cm^3 to about 7.3 g/cm^3, preferably from about 6.6 g/cm^3 to about 7.2 g/cm^3, and preferably from about 6.7 g/cm^3 to about 7.1 g/cm^3.

Methods of making the alloy

[0023] The alloy disclosed herein is produced in a furnace at a temperature of preferably at least about 1,500°C, and preferably at least about 1,600°C. Maintaining the temperature above 1,500°C ensures good melting, it assists in fluxing and it helps achieve a homogeneous alloy prior to atomization or milling. The particles of the alloy are preferably obtained by atomization, but there are other methods that could be used that are familiar to the skilled person, e.g. such as milling. Atomization is preferred, because particles obtained typically have a high degree of roundness.

[0024] An example of an atomization technique involves feeding the molten alloy into an atomizing nozzle. Particles of the alloy can then be obtained by introducing a stream of the molten alloy from the atomizing nozzle into a cone of steam, an inert gas or a stream of high pressure water. The molten alloy is broken into fine particles that are substantially round. The particles of the alloy can be subsequently dried and/or filtered to remove any oversize material. Optionally, the particles and/or any oversize material can be crushed or milled to produce sharp-edged particles.

[0025] Alternatively, the alloy can be obtained by a milling method in which the molten alloy is subsequently water-cooled or air-cooled, dried, milled and classified into various grades. Unlike an atomization process, the milled particles are sharp-edged and they are not uniform in shape.

Uses of the alloy

[0026] The alloy described herein finds particular utility in separation processes, particularly so-called dense media separation processes. The alloy is suitably used in particulate form as the solid that is present in a liquid carrier to form a dense medium for use in such processes.

[0027] The alloy described herein is particularly advantageous because it provides compositions having a specific gravity similar to that of corresponding iron-containing compositions. Moreover, it retains its magnetic properties and the chromium content should make it more resistant to corrosion (e.g. rust) when compared with an existing alloy comprising 15% silicon and 85% iron. When compared to existing alloys, lower amounts of the alloy of the present invention can be used to achieve a greater range of operating densities, which improves separation efficiency because the viscosity of the resultant suspension is reduced.

[0028] Thus, according to a second aspect of the invention, there is provided a composition comprising the particulate alloy as described herein and further comprising a liquid carrier, preferably wherein the liquid carrier is water. Preferably, said composition is a suspension of said particulate alloy in said liquid carrier.

[0029] The composition of the second aspect of the invention comprises preferably from about 8 wt% to about 58 wt% of the particulate alloy relative to the total weight of the composition, preferably 11 wt% to about 58 wt%, preferably from about 15 wt% to about 58 wt%, preferably from about 29 wt% to about 58 wt%, preferably from about 31 wt% to about 56 wt%, preferably from about 32 wt% to about 55 wt%, preferably from about 34 wt% to about 53 wt%, preferably from about 35 wt% to about 52 wt%, and preferably from about 37 wt% to about 50 wt%. Within these generic ranges, suitable amounts of the particulate alloy relative to the total weight of the composition of the second aspect of the invention include:

i) preferably in the range of from about 37 wt% to about 53 wt%, preferably from about 42 wt% to about 52 wt%, and preferably from about 44 wt% to about 50 wt%; or

ii) preferably in the range of from about 34 wt% to about 53 wt%, preferably from about 35 wt% to about 52 wt%, and preferably from about 37 wt% to about 50 wt%; or

iii) preferably in the range of from about 8 wt% to about 42 wt%, preferably from about 11 wt% to about 39 wt%, and preferably from about 15 wt% to about 42 wt%; or

iv) preferably in the range of from about 8 wt% to about 21 wt%, preferably from about 10 wt% to about 19 wt%, preferably from about 11 wt% to about 18 wt%, and preferably from about 13 wt% to about 16 wt%; or

v) preferably in the range of from about 27 wt% to about 40 wt%, preferably from about 29 wt% to about 39 wt%, preferably from about 31 wt% to about 37 wt%, and preferably from about 32 wt% to about 35 wt%.

[0030] The apparent density of the composition of the second aspect of the invention is preferably in the range of from about 1.5 g/cm^3 to about 4.6 g/cm^3, preferably from about 1.7 g/cm^3 to about 4.6 g/cm^3, preferably from about 1.9 g/cm^3 to about 4.6 g/cm^3, preferably from about 2.8 g/cm^3 to about 4.6 g/cm^3, preferably from about 2.9 g/cm^3 to about 4.5 g/cm^3, preferably from about 3.0 g/cm^3 to about 4.4 g/cm^3, preferably from about 3.1 g/cm^3 to about 4.3 g/cm^3, preferably from about 3.2 g/cm^3 to about 4.2 g/cm^3, preferably from about 3.3 to about 4.1 g/cm^3. Within these generic ranges, suitable apparent densities of the composition of the second aspect of the invention (and corresponding to the compositions (i) to (v) above), are:

i) preferably in the range of from about 3.5 g/cm^3 to about 4.3 g/cm^3, preferably from about 3.6 g/cm^3 to about 4.2 g/cm^3, and preferably from about 3.7 g/cm^3 to about 4.1 g/cm^3; or

ii) preferably in the range of from about 3.1 g/cm^3 to about 4.3 g/cm^3, preferably from about 3.2 g/cm^3 to about 4.2 g/cm^3, and preferably from about 3.3 g/cm^3 to about 4.1 g/cm^3; or

iii) preferably in the range of from about 1.5 g/cm^3 to about 3.6 g/cm^3, preferably from about 1.7 g/cm^3 to about 3.4 g/cm^3, and preferably from about 1.9 g/cm^3 to about 3.6 g/cm^3; or

iv) preferably in the range of from about 1.5 g/cm^3 to about 2.3 g/cm^3, preferably from about 1.6 g/cm^3 to about 2.2 g/cm^3, preferably from about 1.7 g/cm^3 to about 2.1 g/cm^3, and preferably from about 1.8 g/cm^3 to about 2.0 g/cm^3; or

v) preferably in the range of from about 2.7 g/cm^3 to about 3.5 g/cm^3, preferably from about 2.8 g/cm^3 to about 3.5 g/cm^3, preferably from about 2.9 g/cm^3 to about 3.3 g/cm^3, and preferably from about 3.0 g/cm^3 to about 3.2 g/cm^3.

[0031] According to a third aspect of the invention, there is provided a separation process comprising the steps of contacting a separating means with a feed material, and separating at least one component of said feed material from at least one other component of said feed material, wherein said separating means is a composition comprising the particulate alloy described herein and a liquid carrier.

[0032] Preferably the separation process is a dense media separation process. Preferably, the separation process comprises the steps of:

i) providing a composition *(i.e.* the dense medium) comprising the particulate alloy as described herein and further comprising a liquid carrier, typically wherein said composition is a suspension of said particulate alloy in said liquid carrier;
ii) providing a feed material that is to be separated, optionally wherein said feed material is in said liquid carrier;
iii) contacting the composition of step i) with the feed material of step ii), typically in a dense media separation vessel;
iv) separating at least one component from said feed material; and
v) collecting said at least one separated component.

[0033] Optionally, the dense media separation vessel comprises two chambers, each comprising a dense medium having two different apparent densities. Preferably the apparent density of the first chamber is lower than the apparent density of the second chamber. The apparent density of the dense medium in the first chamber is preferably from about 1.5 g/cm^3 to about 2.3 g/cm^3, preferably from about 1.6 g/cm^3 to about 2.2 g/cm^3, preferably from about 1.7 g/cm^3 to about 2.1 g/cm^3, preferably from about 1.8 g/cm^3 to about 2.0 g/cm^3. The apparent density of the dense medium in the second chamber is preferably from about 2.7 g/cm^3 to about 3.5 g/cm^3, preferably from about 2.8 g/cm^3 to about 3.4 g/cm^3, preferably from about 2.9 g/cm^3 to about 3.3 g/cm^3, preferably from about 3.0 g/cm^3 to about 3.2 g/cm^3.

[0034] The apparent densities disclosed above are also disclosed in combination. For example, a dense media separation vessel having two chambers is disclosed which comprises a first chamber in which is contained a dense medium having an apparent density of from about 1.5 g/cm^3 to about 2.3 g/cm^3 and a second chamber in which is contained a dense medium having an apparent density of from about 2.7 g/cm^3 to about 3.5 g/cm^3. Similarly, a dense media separation vessel having two chambers is disclosed which comprises a first chamber in which is contained a dense medium having an apparent density of from about 1.8 g/cm^3 to about 2.0 g/cm^3 and a second chamber in which is contained a dense medium having an apparent density of from about 3.0 g/cm^3 to about 3.2 g/cm^3, or a first chamber in which is contained a dense medium having an apparent density of from about 1.6 g/cm^3 to about 2.2 g/cm^3 and a second chamber in which is contained a dense medium having an apparent density of from about 2.9 g/cm^3 to about 3.3 g/cm^3.

[0035] Optionally, the process comprises a step in which the particulate alloy is separated from the components separated from the feed material, and the particulate alloy is collected and reintroduced into the dense media separation vessel.

[0036] Preferably, at least one component of the feed material has a specific gravity that is less than the apparent density of said composition *(i.e.* the dense medium).

[0037] Preferably, the dense media separation vessel is a tank, a drum, or it is substantially conical in shape. The dense media separation vessel may be static. Preferably, the dense media separation vessel is dynamic to aid separation of the feed material into its component parts.

[0038] Said composition *(i.e.* the dense medium) and said feed material may be added to the dense media separation vessel sequentially or simultaneously. Typically, said composition is added to the dense media separation vessel before the feed material.

[0039] Preferably, said composition *(i.e.* the dense medium) and said feed material are agitated to aid separation of the material into its component parts and minimize or prevent sedimentation. Agitation may be achieved by any suitable or conventional means, for instance by stirring or by rotation of the dense media separation vessel. Alternatively, agitation may be achieved by centrifugal force using a cyclone.

[0040] In a fourth aspect of the invention, there is provided the use of the particulate alloy or composition described herein as a separating means in a separation process for the separation of a feed material, wherein at least one component of the feed material is separated from at least one other component of said feed material. Preferably, the separation process is dense media separation, preferably as described herein.

[0041] It is particularly advantageous to use the alloy disclosed herein in such separation processes, particularly a dense media separation process, because the alloy has higher operating densities when compared with existing alloys, and it retains its magnetic properties. The liquid carrier is preferably water, and a further advantage of the alloy of the present invention is that the chromium content should make it more resistant to corrosion (e.g. rust) when compared with an existing alloy comprising 15% silicon and 85% iron.

[0042] Thus, the particulate alloy disclosed herein forms a stable suspension in the liquid carrier (particularly water), which results in a consistent density gradient and a sharp degree of separation. Moreover, the alloy can be recovered easily, which reduces the overall consumption of the alloy when used in a dense media separation process.

[0043] As used herein, the following terms, unless otherwise indicated, shall be understood to have the following meanings:

Specific gravity (g/cm^3) in the context of the present invention refers to the amount of material per unit volume occupied by the material in water when measured at room temperature (23°C) and atmospheric pressure (101.325 kPa ± the variations caused by changing weather patterns). The specific gravity is measured by the following protocol.

[0044] The specific gravity is measured using a specific gravity flask (also called a Le Chatelier Flask). The body of the flask holds approximately 250 cm^3. The oval bulb of the flask holds 17 cm^3. The volume below the bulb is graduated from 0 to 1.0 cm^3 in 0.1 cm^3 subdivisions, with an additional subdivision below the 0 cm^3 mark and an additional subdivision above the 1.0 cm^3 mark. The neck of the flask is graduated from 18 to 24 cm^3 in 0.1 cm^3 subdivisions above the bulb and sealed with a stopper. Preferably, the stopper has a tapered portion that is 23mm long with a diameter ranging from 14mm to 12mm along the tapered portion.

[0045] The flask, water and material to be tested must be allowed to equalise at room temperature (*Supra*) and atmospheric pressure (*Supra*) for at least 24 hours prior to the test. The flask is filled with water to the 0 cm^3 mark on the neck of the flask. The inside of the flask will be dried above the level of the liquid (water).

[0046] The material to be tested (the alloy) is weighted at 140g and added to the flask containing water to the zero mark on the flask. As material is added to the flask, the water level will rise as it is displaced. The material should not be allowed to adhere to the sides of the flask above the level of the liquid. Once the total amount of material has been added to the flask (140g), the stopper is placed in the flask and the flask is rolled. To remove air from the material, the flask is gently agitated by for example tapping until no further air bubbles rise to the surface of the liquid. After no further air bubbles are seen, the level of the liquid will be in its final position, which can be measured by reading the bottom of the meniscus of the liquid against the series of graduation marks in the neck of the flask.

[0047] The difference between the first and final readings on the stem of the flask represents the volume of liquid displaced by the mass of the material used in the test.

[0048] The specific gravity can then be determined by the following calculation:

$$Specific\ Gravity = \frac{mass\ of\ sample\ (g)}{displaced\ volume\ (cm^3)}$$

[0049] Apparent density (g/cm^3) in the context of the present invention refers to the weight of a sample of the composition *(i.e.* the dense medium) per unit volume. The apparent density can be determined by the following protocol.

[0050] A dry vessel of known volume (e.g. a 1 L measuring cylinder) is weighed. A sample of the composition *(i.e.* the dense medium) is added to the measuring cylinder up to the 1 L mark. The measuring cylinder containing 1 L the sample is re-weighed. The difference between the weight of the measuring cylinder and the weight of the measuring cylinder containing the sample is calculated. The apparent density is determined by the mass of material divided by the volume of the cylinder.

$$Apparent\ Density = \frac{mass\ of\ sample\ (g)}{volume\ of\ vessel\ (cm^3)}$$

[0051] The term "media" refers to a solid material that is added to a liquid carrier to alter the density of the liquid carrier and form a suspension. The resulting suspension is referred to as a "dense medium".

[0052] The term "heavy liquid" refers to a liquid that is used in a dense media separation process that has a density greater than that of water (999.97 kg/m^3).

[0053] It is to be understood that the disclosure herein is not limited in its application to the details of construction and the arrangement of the components or steps or methodologies set forth in the following description or illustrated in the Figure. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0054] The term "round" includes shapes that are substantially spherical and those that are substantially spheroidal.

[0055] Unless otherwise defined herein, technical terms used in connection with the invention have the meanings that are commonly understood by those of ordinary skill in the art. Further, unless otherwise required by context, singular terms shall include pluralities and plural terms shall include the singular.

[0056] While the alloys, compositions, processes and/or uses of the invention have been described in terms of particular embodiments, it will be apparent to those of skill in the art that variations may be applied to the alloys, compositions, processes and/or uses and in the steps or in the sequence of steps of the methods and/or uses described herein without departing from the concept, spirit and scope of the presently disclosed and claimed invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the presently disclosed and claimed invention as defined by the appended claims.

[0057] The use of the word "a" or "an" when used in conjunction with the term "comprising" in the claims and/or the specification may mean "one," but it is also consistent with the meaning of "one or more," "at least one," and "one or more than one". Throughout this application, the term "about" is used to indicate that a value includes the inherent variation of error for the device, the method being employed to determine the value.

[0058] The words "comprising" (and any form of comprising, such as "comprise" and "comprises"), "having" (and any form of having, such as "have" and "has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, un-recited elements or method steps.

[0059] The term "comprising" encompasses "including" as well as "consisting" e.g. an alloy or composition "comprising" X may consist exclusively of X or may include something additional e.g. X + Y.

[0060] The term "or combinations thereof" as used herein refers to all permutations and combinations of the listed items preceding the term. For example, "A, B, C, or combinations thereof" is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, AAB, BBC, AAABCCCC, CBBAAA, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

[0061] As used herein, the term "substantially" means that the subsequently described event or circumstance completely occurs or that the subsequently described event or circumstance occurs to a great extent or degree. For example, the term "substantially" means that the subsequently described event or circumstance occurs at least 90% of the time, or at least 95% of the time, or at least 98% of the time. Where necessary, the word "substantially" may be omitted from the definition of the invention.

[0062] "May" means that the subsequently described event of circumstances may or may not occur, and that the description includes instances where said event or circumstance occurs and instances in which it does not.

Brief Description of the Drawings

[0063] Fig. 1 - shows a schematic of a typical apparatus used in dense media separation.

[0064] The invention is illustrated by the following non-limiting example.

Example 1

[0065] A bulk alloy comprising no more than about 8.5% silicon and from about 2 to about 7% chromium and a balance of iron was melted in a furnace at a temperature of at least about 1,500°C. The molten alloy was poured through the nozzle of an atomizer. The stream of molten alloy interacts with a spray of high pressure water to produce substantially round particles. The particles were quenched and filtered and found to have a particles size such that at least about 90% of the particles of the alloy pass through a sieve having a mesh aperture of about 1 mm.

[0066] The particles of the alloy were found to be excellent when used in a suspension with water to form a heavy liquid for dense media separation.

[0067] The particles of the alloy are mixed with water to form a composition that has an apparent density between the specific gravities of the two materials for separation. When the materials are mixed into the composition, the lighter one floats and can be collected separately from the heavy fraction, which sinks and can be collected separately.

Example 2

[0068] An alloy of the present invention comprising 8% silicon, 85% iron and 7% chromium has a specific gravity as set out below.

$$S.G._{Si} = density\ of\ silicon\ \times percentage\ silicon\ content$$

$$S.G._{Si} = 2.33\ \times 0.08$$

$$S.G._{Si} = 0.1864\ g/cm^3$$

$$S.G._{Fe} = density\ of\ iron\ \times percentage\ iron\ content$$

$$S.G._{Fe} = 7.85 \times 0.85$$

$$S.G._{Fe} = 6.6725\ g/cm^3$$

$$S.G._{Cr} = density\ of\ chromium \times percentage\ chromium\ content$$

$$S.G._{Cr} = 7.85 \times 0.07$$

$$S.G._{Cr} = 0.5026\ g/cm^3$$

$$S.G._{Alloy} = S.G._{Si} + S.G._{Fe} + S.G._{Cr}$$

$$S.G._{Alloy} = 0.1864 + 6.6725 + 0.5026$$

$$S.G._{Alloy} = 7.3615\ g/cm^3$$

Comparative example

[0069] An existing alloy comprising 15% silicon and 85% iron has a specific gravity of 7.022, which can be calculated as set out below.

$$S.G._{Si} = density\ of\ silicon\ \times percentage\ silicon\ content$$

$$S.G._{Si} = 2.33\ \times 0.15$$

$$S.G._{Si} = 0.3495\ g/cm^3$$

$$S.G._{Fe} = density\ of\ iron\ \times percentage\ iron\ content$$

$$S.G._{Fe} = 7.85 \times 0.85$$

$$S.G._{Fe} = 6.6725\ g/cm^3$$

$$S.G._{Alloy} = S.G._{Si} + S.G._{Fe}$$

$$S.G._{Alloy} = 0.3495 + 6.6725$$

$$S.G._{Alloy} = 7.022\ g/cm^3$$

[0070] The alloy of Comparative Example 1 has a specific gravity that is 5% lower than the alloy of Example 2, which means a lower amount of the alloy of Example 2 can be used to achieve the same apparent densities in use. The practical consequence is that the viscosity of a composition comprising the alloy of Example 2 and water is less than the viscosity of a composition comprising the alloy of Comparative Example 1, which aids separation.

Claims

1. An alloy comprising:

i) at least about 80% iron

ii) no more than about 8.5% silicon; and
iii) from about 2 to about 7% chromium.

2. The alloy of claim 1 wherein the iron content is at least 83% or at least 85%.

3. The alloy of any one of claims 1 and 2 wherein the silicon content is no more than 8.4%, or from about 7.0 to about 8.4%.

4. The alloy of any preceding claim wherein the chromium content is from about 3 to less than 7%, or from about 4 to about 6%.

5. The alloy of any preceding claim wherein the alloy further comprises carbon, preferably wherein the carbon content is no more than 1.5%.

6. The alloy of any preceding claim wherein the alloy further comprises phosphorous, preferably wherein the phosphorous content is no more than 0.15%.

7. The alloy of any preceding claim wherein the alloy further comprises sulfur, preferably wherein the sulfur content is no more than 0.07%.

8. The alloy of any preceding claim, wherein the alloy is in particulate form, preferably wherein the particles are substantially round.

9. The alloy of claim 8 wherein 70% of particles in the alloy pass through a sieve having a mesh aperture of 1 mm, or at least about 90% of the particles pass through a sieve having a mesh aperture of 212 μm.

10. A composition comprising the particulate alloy of claim 8 or 9 and further comprising a liquid carrier, preferably wherein said liquid carrier is water.

11. A separation process comprising the steps of contacting a separating means with a feed material, and separating at least one component of said feed material from at least one other component of said feed material, wherein said separating means is a composition according to claim 10.

12. The separation process according to claim 11 which is a dense media separation process.

13. The process of claim 11 or 12 comprising the steps of:

(i) providing a composition according to claim 10, preferably wherein said composition is a suspension of said particulate alloy in said liquid carrier;
(ii) providing a feed material that is to be separated, optionally wherein the feed material is in said liquid carrier;
(iii) contacting the composition of step i) with the feed material of step ii), preferably in a dense media separation vessel;
(iv) separating at least one component from said feed material; and
(v) collecting said at least one separated component.

14. The separation process of claim 13, wherein the liquid carrier is water.

15. Use of the composition as defined in claim 10 as a separating means in a separation process for the separation of a feed material, wherein at least one component of the feed material is separated from at least one other component of said feed material.

16. The composition of claim 10, or the process of claims 11 to 14 or the use of claim 15, wherein said composition has a specific gravity from about 6.5 g/cm^3 to about 7.3 g/cm^3.

17. The composition of claim 10, or the process of claims 11 to 14 or the use of claim 15, wherein said composition has an apparent density of from about 1.5 g/cm^3 to about 4.6 g/cm^3 or said composition comprises from about 8 wt% to about 58 wt% of the particulate alloy relative to the total weight of the composition.

Figures

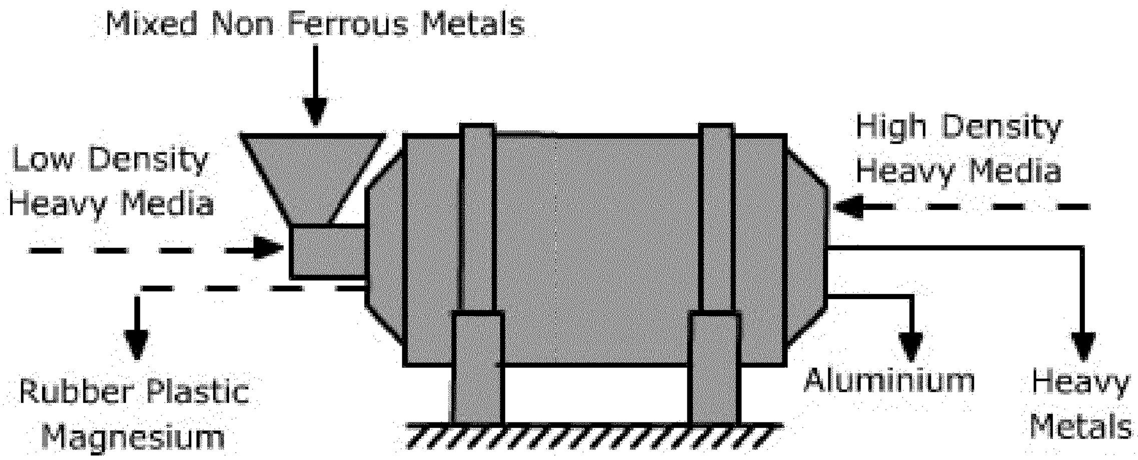

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 6162

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search	Date of completion of the search	Examiner
The Hague	12 January 2016	Morra, Valentina

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