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DESCRIPTION

[0001] THIS INVENTION relates to the recovery of chromite fines. In particular, the invention relates to a process for recovery of chromite fines from a slurry.

[0002] Plants processing chromite ore ($FeCr_2O_4$) typically produce tailings or tails, usually in the form of a slurry or slimes stream, containing valuable chromite fines. Recovery of the chromite fines in a cost-effective manner from such slurry or slimes streams is difficult, particularly in respect of -75µm chromite fines. Chromite losses in the tailings from a chromite processing plant can be significant, of the order of 35 - 40 % by mass of the Cr in the chromite fed to the chromite processing plant.

[0003] A process which cost-effectively recovers chromite fines from a slurry would thus be desirable.

[0004] According to the invention, according to the appended claims, there is provided a process for recovery of chromite fines from a slurry, the process including

feeding a feed slurry comprising chromite fines such that at least 90% of the chromite fines pass through a 150µm square mesh and with a Cr_2O_3 content of the feed slurry being between 7% by mass and 11% by mass to a wet spiral concentrator stage comprising a plurality of wet spiral separators or wet spiral concentrators;

separating the slurry by means of the wet spiral separators or concentrators into a higher-grade chromite slurry with a Cr_2O_3 content of between 11% by mass and 20% by mass on a dry basis, a lower-grade chromite slurry with a Cr_2O_3 content of between 6% by mass and 11% by mass on a dry basis and a first tails stream;

magnetically separating the lower-grade chromite slurry in a wet magnetic separation stage comprising a plurality of magnetic separators into a magnetic material stream and a non-magnetic material reject stream; and

separating the higher-grade chromite slurry and the magnetic material stream in a shaking table stage comprising a plurality of shaking tables into a chromite concentrate and a second tails stream.

[0005] GRISHIN N N et al: "Primary processing of chromite ores and ore-preparation of wastes for production of refractory materials", J. of Mining Science, ISSN:1573-8736, NE, vol 40, no 4, I July 2004, p 409/16 discloses the primary processing of chromite ores and employs a feedstock in the millimetre size range.

[0006] US 4,295,881 discloses a process to recover platinum group metals, nickel, copper and

cobalt, from chromite-bearing ores, but is silent regarding the recovery of chromite fines from a slurry.Tripathy, Sunil Kumar, Ramamurthy, Y. and Singh, Veerendra, "Recovery of chromite values from plant tailings by gravity concentration", Journal of Minerals and Material Characterization and Engineering, Vol. 10, No 1, pp 13 - 25, January 2011 disclose the use of spirals and shaking tables to concentrate a chromite stream having fines of at least 50% being between 100µm and 35 µm. Tripathy, Sunil Kumar and Murthy, Y. Rama, "Multiobjective optimisation of spiral concentrator for separation of ultrafine chromite", International Journal of Mining and Mineral Engineering, Vol. 4, No 2, January 2012 also refer to spiral separation of ultrafine chromite with 70% of the chromite having a size of less than 75µm. US 3,323,900, CN 101823018 and CN 201366374 mention the use of a spiral separator to recover chromium from laterite. Magnetic separation of fines comprising chromite is disclosed by US 3,323,900, US 3,935,094, RU 2208060, CN 101823018, CN 201366374, ZA 2011/00444 and ZA 2014/004437. ZA 2005/03034 teaches mechanically cleaning the surfaces of chromite crystals present in comminuted chromite fines and magnetically separating iron oxide. Shaking tables for chromite recovery are disclosed by US 3,323,900, CN 101823018 and CN 201366374. None of these documents however teaches or suggests a process in accordance with the invention, using unit operations in the same sequence as in the process of the invention and with the same feed streams and product streams connecting the various unit operations.

[0007] The process may include subjecting the feed slurry to a feed preparation stage prior to feeding the feed slurry to the wet spiral concentrator stage.

[0008] In the feed preparation stage, the feed slurry may be screened to separate oversized material from the feed slurry. Typically, the oversized material is discharged onto a dump.

[0009] The feed preparation stage may be configured to separate +1000µm, preferably +950µm, more preferably +900µm, most preferably +850µm oversized material from the feed slurry.

[0010] In the feed preparation stage, magnetic material, e.g. tramp metal, may be magnetically separated from the feed stream in a plurality of wet medium intensity magnetic separators operating in parallel. Typically, the magnetic material is discharged onto a dump, e.g. together with the oversized material.

[0011] If necessary or desirable, the process may include adding water to the feed slurry from screens in the feed preparation stage (i.e. to an underflow from said screens) to reduce the feed slurry density prior to magnetically separating magnetic material from the feed slurry.

[0012] The wet medium intensity magnetic separators may produce a magnetic flux intensity of between about 0.2 tesla and about 0.8 tesla, preferably between about 0.3 tesla and about 0.7 tesla, most preferably between about 0.4 tesla and about 0.6 tesla, e.g. about 0.5 tesla.

[0013] The process may include subjecting at least one of the higher-grade chromite slurry and the magnetic material stream to a size separation stage to produce one or more finer

material or underflow fractions and one or more coarser material or overflow fractions, before said at least one of the higher-grade chromite slurry and the magnetic material stream, in the form of at least said one or more finer material fractions, and optionally said one or more coarser material fractions, are separated in the shaking table stage into a chromite concentrate and a second tails stream. Preferably, both the higher-grade chromite slurry and the magnetic material stream are subjected to the size separation stage.

[0014] In one embodiment of the invention, instead of separating the one or more coarser material fractions from the size separation stage in the shaking table stage, the one or more coarser material fractions from the size separation stage are discarded as tailings.

[0015] The size separation stage typically includes one or more screens to separate the higher-grade chromite slurry and the magnetic material stream into two size fractions, e.g. a +100µm fraction and a -100µm fraction, or a+90pm fraction and a -90pm fraction.

[0016] The feed slurry may have a Cr_2O_3 content of about 9 % by mass, on a dry basis.

[0017] The feed slurry fed to the wet spiral concentrator stage may comprise chromite fines such that at least 90% of the chromite fines pass through a 125µm square mesh, or through a 115µm square mesh or through a 100µm square mesh.

[0018] More than 50% or more than 60% or more than 70% or more than 80% of the chromite fines in the feed slurry fed to the wet spiral concentrator stage typically is -75 µm material.

[0019] The process may include dewatering the feed slurry prior to the feed slurry being fed to the wet spiral separators or wet spiral concentrators. Dewatering of the feed slurry may be accomplished using any suitable dewatering technique or apparatus, e.g. a dewatering cyclone. Typically, water removed from the feed slurry is fed to a thickener or the like.

[0020] The feed slurry fed to the wet spiral separators or concentrators may have a specific gravity, relative to water, of between about 1.2 and about 1.8, preferably between about 1.3 and about 1.7, more preferably between about 1.4 and about 1.6, e.g. about 1.5.

[0021] The wet spiral separators or concentrators may have a pitch of between about 4° and about 10°, preferably between about 4° and about 9°, more preferably between about 5° and about 8°, e.g. about 6.5°.

[0022] The wet spiral separators or concentrators may have a diameter of between about 50cm and about 150cm, preferably between about 60cm and about 140cm, more preferably between about 70cm and about 130cm, e.g. about 90cm.

[0023] The wet spiral separators or concentrators may have a profile of between about 1° and about 5°, preferably between about 1.5° and about 4.5°, more preferably between about 2° and about 4°, e.g. about 3°.

[0024] The wet spiral separators or concentrators may have a height of between about 2 turns and about 6 turns, preferably between about 3 turns and about 5 turns, e.g. about 4 turns.

[0025] Each wet spiral separator or concentrator may be provided with feed slurry at a rate of between about 0.5 ton/hour and about 1.5 ton/hour, preferably between about 0.6 ton/hour and about 1.4 ton/hour, more preferably between about 0.7 ton/hour and about 1.3 ton/hour, e.g. about 1 ton/hour.

[0026] The wet spiral separators or concentrators may be configured such that the higher-grade chromite slurry is a concentrate cut from the wet spiral separators or concentrators, the lower-grade chromite slurry is a middlings cut from the wet spiral separators or concentrators, and the first tails stream is a tails cut from the wet spiral separators or concentrato rs.

[0027] Typically, all of the wet spiral separators or concentrators are rougher spirals, with the process thus not employing cleaner or scavenger spirals.

[0028] The wet spiral separators or concentrators may be configured and operated such that the higher-grade chromite slurry has a Cr_2O_3 content preferably between about 12% by mass and about 19% by mass, more preferably between about 13% by mass and about 18% by mass, e.g. about 16% by mass, on a dry basis.

[0029] The wet spiral separators or concentrators may be configured and operated such that the lower-grade chromite slurry, i.e. middlings, has a Cr_2O_3 content preferably between about 7% by mass and about 9% by mass, e.g. about 8 - 10% by mass, on a dry basis.

[0030] The wet spiral separators or concentrators may be configured and operated such that the first tails stream has a Cr_2O_3 content of less than about 8% by mass, on a dry basis.

[0031] The wet spiral separators or concentrators may be configured and operated such that the mass flow ratio of the higher-grade chromite slurry to the lower-grade chromite slurry is between about 1:1.5 and about 1:2.5, e.g. about 1:2, on a dry basis.

[0032] Magnetically separating the lower-grade chromite slurry in a wet magnetic separation stage may include passing the lower-grade chromite slurry through a plurality of wet high intensity magnetic separators operating in parallel. The wet high intensity magnetic separators may be rougher separators each producing a magnetic flux density of between about 1 tesla and about 1.4 tesla, e.g. about 1.2 tesla.

[0033] Magnetically separating the lower-grade chromite slurry in a wet magnetic separation stage may include passing a non-magnetic material reject stream from the rougher magnetic separators to further or downstream wet high intensity magnetic separators operating in parallel, which are scavenger separators. The scavenger separator may each produce a magnetic flux density of between about 1 tesla and about 1.4 tesla, e.g. about 1.2 tesla.

[0034] If desired, magnetically separating the lower-grade chromite slurry in a wet magnetic separation stage may include passing a non-magnetic material reject stream from the scavenger separators to at least one further downstream set of scavenger separators operating in parallel.

[0035] In one embodiment of the invention, the wet high intensity magnetic separators of the wet magnetic separation stage are grouped together into processing units that each comprise a rougher wet high intensity magnetic separator followed in series by two downstream scavenger wet high intensity magnetic separators. Magnetic material streams from the rougher and scavenger wet high intensity magnetic separators are combined to form the magnetic material stream fed to the shaking table stage, typically via the size separation stage.

[0036] The process may include dewatering the one or more finer material fractions before the one or more finer material fractions are separated in the shaking table stage into a chromite concentrate and a second tails stream. Dewatering the one or more finer material fractions may be accomplished using any suitable dewatering technique or apparatus, e.g. a dewatering cyclone. Typically, water removed from the one or more finer material fractions is fed to a thickener or the like, possibly via a guard cyclone or the like.

[0037] Typically, there is no need to dewater the one or more coarser material fractions before the one or more coarser material fractions are separated in the shaking table stage, in the event that the one or more coarser material fractions are separated in the shaking table stage and are not discarded.

[0038] The shaking table stage may employ a plurality of shaking tables or Wilfley tables for the one or more finer material fractions and, in one embodiment of the invention, a plurality of shaking tables or Wilfley tables for the one or more coarser material fractions. Thus, the one or more finer material fractions may be processed separately from the one or more coarser material fractions in the shaking table stage. The number of shaking tables required for the one or more finer material fractions may be higher than the number of shaking tables required for the one or more coarser material fractions.

[0039] Instead of separating the one or more coarser material fractions from the size separation stage in the shaking table stage, the one or more coarser material fractions from the size separation stage may be discarded, e.g. as tailings.

[0040] The shaking table stage may include rougher shaking tables upstream of cleaner shaking tables. Typically, in this embodiment of the invention, only the one or more finer material or underflow fractions from the size separation stage are thus fed to the rougher shaking tables, and the one or more coarser material fractions from the size separation stage are discarded, e.g. as tailings, and are not processed in the shaking table stage.

[0041] The one or more finer material fractions fed to the shaking tables may have a specific

gravity, relative to water, of between about 1.1 and about 1.6, preferably between about 1.2 and about 1.5, more preferably between about 1.3 and about 1.4, e.g. about 1.35.

[0042] In one embodiment of the invention, a concentrate fraction from the shaking tables processing the one or more finer material fractions and the shaking tables processing the one or more coarser material fractions form or constitute the chromite concentrate. The concentrate fraction is thus made up of the densest material from the shaking tables. Typically, the chromite concentrate is dewatered, e.g. using dewatering cyclones, and stacked in stockpiles. Water obtained from dewatering the chromite concentrate may be fed to a thickener, possibly via a guard cyclone or the like.

[0043] A middlings fraction and a tails fraction from each shaking table may form the second tails stream. The middlings fraction and the tails fraction from each shaking table are less dense fractions than the concentrate fraction.

[0044] The process may include combining the first tails stream and the second tails stream and a non-magnetic material reject stream from the wet magnetic separator stage into a tailings stream, and treating the tailings stream to recover water, e.g. for use as process water. The tailings stream typically also includes water from any dewatering operations conducted. Treatment of the tailings stream typically includes the use of a thickener and possibly also a clarifier. If desired or necessary, treatment of the tailings stream may include first passing the tailings stream through a guard cyclone, separating the tailings stream into an oversize material stream and an undersize material stream, with the oversize materials stream being fed to the thickener and the undersize material stream being disposed of in a tailings storage facility.

[0045] In another embodiment of the invention, in which the process includes processing only the one or more finer material or underflow fractions from the size separation stage on the rougher shaking tables and the cleaner shaking tables, the process includes a further processing stage for processing at least a middlings fraction from the cleaner shaking tables, with a concentrate fraction from the cleaner shaking tables constituting the chromite concentrate.

[0046] Preferably, also a middlings fraction from the rougher shaking tables, and a tailings fraction from the cleaner shaking tables, are processed in the further processing stage.

[0047] The further processing stage may include rougher wet magnetic separators receiving material from the shaking table stage.

[0048] Typically, the rougher wet magnetic separators of the further processing stage receive the middlings fraction from the rougher shaking tables, the middlings fraction from the cleaner shaking tables and the tailings fraction from the cleaner shaking tables.

[0049] The further processing stage may include cleaner wet magnetic separators receiving

magnetic material from the rougher wet magnetic separators. Non-magnetic material from the rougher magnetic separators may be discarded, e.g. as tailings.

[0050] The process may include, in the further processing stage, dewatering magnetic material from the cleaner wet magnetic separators, and recycling the dewatered magnetic material from the cleaner wet magnetic separators to the cleaner shaking tables. Dewatering of the magnetic material from the cleaner wet magnetic separators may be accomplished using any suitable dewatering technique or apparatus, e.g. a dewatering cyclone. Typically, water removed from the magnetic material from the cleaner wet magnetic separators is fed to a thickener or the like, possibly via a guard cyclone or the like.

[0051] The invention will now be described by way of example with reference to the accompanying drawings in which

Figure 1 shows one embodiment of a process in accordance with the invention for recovery of chromite fines from a slurry; and

Figure 2 shows another embodiment of a process in accordance with the invention for recovery of chromite fines from a slurry.

[0052] Referring to Figure 1 of the drawings, reference numeral 10 generally indicates a process in accordance with the invention for recovery of chromite fines from a slurry. The process 10 generally includes a feed preparation stage 12, a wet spiral concentrator stage 14, a size separation stage 16, a shaking table stage 18, a concentrate handling stage 20, a tailings treatment stage 22 and a wet magnetic separation stage 24.

[0053] The feed preparation stage 12 is provided with a screen 26 and a plurality, e.g. ten, wet medium intensity magnetic separators 28 operating in parallel.

[0054] The wet spiral concentrator stage 14 is provided with a plurality of dewatering cyclones 30 and a plurality, for example one hundred and sixty, rougher wet spiral separators or wet spiral concentrators 32.

[0055] The wet magnetic separation stage 24 includes a first set of fourteen wet high intensity magnetic rougher separators 34 acting in parallel, a second set of wet high intensity magnetic scavenger separators 36 (also fourteen, operating in parallel), and a third set of wet high intensity magnetic scavenger separators 38 downstream of the second set of wet high intensity magnetic scavenger separators 36. There are also fourteen wet high intensity magnetic scavenger separators 38 in the third set of wet high intensity magnetic scavenger separators 38.

[0056] The size separation stage 16 comprises a pair of screens, 40, 42, although it is possible to use a single screen. Typically, in the embodiment illustrated in Figure 1, the screen 42 is in

fact a pair of screens, taking into account the higher load of the screen 42 compared to the load of the screen 40. The screens 40, 42 in the embodiment shown in Figure 1 are 100µm screens. In another embodiment of the invention, the screens are 90µm screens.

[0057] The shaking table stage 18 has a plurality of dewatering cyclones 44, a plurality, e.g. forty-two, -100µm shaking tables 46, and a plurality, e.g. twenty-four, +100µm shaking tables 48.

[0058] The concentrate handling stage 20 includes dewatering cyclones (not shown) and a chromite stacker 50.

[0059] The tailings treatment stage 22 includes a thickener 52 and a clarifier 54.

[0060] The process 10 is configured to treat about 420 tons/hour of a feed slurry comprising chromite fines, i.e. tailings, produced by a chrome recovery plant (not shown) processing run-of-mine chromite ore. The feed slurry typically has a Cr_2O_3 content of about 8-10% by mass, on a dry basis. The chromite fines in the feed slurry are such that at least 90% of the chromite fines pass through a 115 µm square mesh.

[0061] The feed slurry is fed by means of a slurry feed line 60 to the screens 26, where +850µm oversized trash material is removed by means of an overflow line 62. Underflow from the screens 26 is fed by means of an underflow line 64 to the wet medium intensity magnetic separators 28. Magnetic tramp material, such as iron, is removed by means of the wet medium intensity magnetic separators 28 and combined with the oversized material from the screens 26 by means of a magnetics material line 66. The oversized material and the magnetic tramp material are then dumped.

[0062] The wet medium intensity magnetic separators 28 each produces a magnetic flux intensity of about 0.5 or about 0.6 tesla, which is sufficiently high to remove magnetic tramp material such as iron, but which is sufficiently low to produce a non-magnetic material slurry stream which includes the chromite fines, which is then removed by a slurry line 68 and pumped to the dewatering cyclones 30 of the wet spiral concentrator stage 14.

[0063] The dewatering cyclones 30 remove some water from the slurry, producing a slurry with a specific gravity, relative to water, of about 1.5. Water removed from the slurry by means of the dewatering cyclones 30 is withdrawn through an overflow line 70 and pumped to the thickener 52.

[0064] Densified slurry is removed from the dewatering cyclones 30 by means of an underflow line 72 and fed to the rougher wet spiral separators or wet spiral concentrators 32. Each rougher wet spiral separator or concentrator 32 is provided with about 1 ton/hour of slurry with a specific gravity of 1.5. The rougher wet spiral separators or concentrators 32 each has a diameter of about 90cm, a pitch of about 5°, a profile of about 1 - 5°, and a height of about 4 turns. Three cuts are removed from each rougher wet spiral separator or concentrator 32. A

first cut, which is a radially inner cut, is a higher-grade chromite slurry which is removed by means of a concentrate line 74. A lower-grade chromite slurry is a radially intermediate middlings cut which is removed by means of a middlings line 76. A radially outer tails cut is removed as a first tails stream and is pumped through a first tails streamline 78 to the thickener 52. There are no scavenger spiral separators or concentrators in the spiral concentrator stage 14.

[0065] Although not shown in the drawing, process water is typically added to the higher-grade chromite slurry and to the lower-grade chromite slurry to reduce slurry densities before the slurries are pumped to the size separation stage 16 and the wet magnetic separation stage 24 respectively.

[0066] The middlings cut has a Cr_2O_3 content of about 8 -10% by mass on a dry basis and makes up about 40-50% by mass of the slurry fed to the rougher wet spiral separators or concentrators 32. The middlings cut is pumped through the middlings line 76 to the wet magnetic separation stage 24 where it is distributed to the first set of wet high intensity magnetic separators 34 for further processing to recover residual chromite. The wet high intensity magnetic separators 34, acting as rougher separators, each produce a magnetic flux density of about 1.2 tesla. The wet high intensity magnetic separators 34 produce a magnetic material stream which is removed by a magnetic material streamline 80. Non-magnetic reject material from the wet high intensity magnetic separators 34 is gravity-fed by a non-magnetic material feed line 82 to the second, downstream set of wet high intensity magnetic scavenger separators 36, from where magnetic material is again withdrawn by means of the magnetic material stream line 80 and non-magnetic reject material is withdrawn by means of a non-magnetic material feed line 84. The non-magnetic material feed line 84 gravity-feeds the non-magnetic reject material to the third, downstream set of wet high intensity magnetic scavenger separators 38, which again produce a magnetic material stream which is withdrawn by the magnetic material stream line 80 and a non-magnetic reject material stream which is withdrawn by means of a non-magnetic reject material withdrawal line 86 which leads to the thickener 52.

[0067] Magnetic material in the magnetic material streamline 80 is pumped to the size separation stage 16 and discharged onto the screen 42 (typically in fact two screens). If necessary, process water is added to the magnetic material (not shown) to keep the volumetric flow rate constant. Similarly, concentrate from the concentrate line 74 is fed to the size separation stage 16 and discharged onto the screen 40. The screens 40, 42 separate material discharged onto the screens into a +100µm fraction and a -100µm fraction. Process water is sprayed onto oversize material to wash the oversize material. The -100µm fraction from the screens 40, 42 are pumped to the dewatering cyclones 44 of the shaking table stage 18 by means of slurry lines 75, whereas the +100µm fraction from the screens 40, 42 are directly fed to the +100µm shaking tables 48 of the shaking table stage 18 by means of slurry lines 77.

[0068] In the shaking table stage 18, the -100µm fraction is first dewatered in the dewatering cyclones 44, with water being removed by means of an overflow line 88 which feeds the water

to the thickener 52. Underflow from the dewatering cyclones 44 has a specific gravity, relative to water, of about 1.35 and is fed to the -100µm shaking tables 46 by means of a flow line 79. The -100µm shaking tables and the +100µm shaking tables are conventional Wilfley tables separating particles on the basis of density and size, each producing a concentrate fraction, a middlings fraction and a tails fraction. The concentrate fractions from the -100µm shaking tables 46 and the concentrate fractions from the +100µm shaking tables 48 are withdrawn by means of concentrate lines 90 and fed to the concentrate handling stage 20. The middlings fractions and the tails fractions from the -100µm shaking tables 46 and from the +100µm shaking tables 48 are combined to form a second tails stream, which is fed by means of a second tails streamline 92 to the thickener 52.

[0069] In the concentrate handling stage 20, the concentrate from the concentrate lines 90 is dewatered using a dewatering cyclone (not shown), with the dewatered concentrate then being stacked by means of the chromite stacker 50 onto concentrate stockpiles 94. The concentrate stockpiles 94 typically have a Cr_2O_3 content of about 40% by mass, on a dry basis.

[0070] The thickener 52 of the tailings treatment stage 22 receives the first tails stream from the first tails streams line 78, non-magnetic reject material from the non-magnetic material withdrawal line 86, the second tails stream from the second tails stream line 92, an underflow stream from an underflow stream line 104 leading from the clarifier 54 to the thickener 52, water from the dewatering cyclones 30 withdrawn by means of the overflow line 70, water from the dewatering cyclones 44 withdrawn by means of the overflow line 88 and water from the dewatering cyclones (not shown) of the concentrate handling stage 20. The thickener 52 is provided with a flocculant by means of a flocculant feed line 96. An underflow 106 from the thickener 52, comprising about 3-4% by mass Cr_2O_3 on a dry basis is discharged and pumped to a tailings storage facility. An overflow from the thickener 52 is fed by means of an overflow line 98 to the clarifier 54, which is also provided with flocculant from the flocculant feed line 96 and with coagulant from a coagulant feed line 100. Underflow from the clarifier 54 is returned to the thickener by means of the underflow stream line 104 and an overflow from the clarifier 54 is withdrawn by means of a process water line 102 and fed to a process water tank (not shown), for use as process water in the process 10, e.g. as spray water, wash water, gland seal water, dilution water and water for flushing and hosing.

[0071] Figure 2 shows another embodiment of a process, generally indicated by reference numeral 200, in accordance with the invention for recovery of chromite fines from a slurry. Figure 2 is less detailed than Figure 1, omitting many of the detail features of the various process stages, and instead serves to highlight at an overview level the differences between the process 10 and the process 200. Nevertheless, unless otherwise indicated, the same reference numerals used in the process 10 in Figure 1 are used in the process 200 in Figure 2 to indicate the same or similar process features.

[0072] Unlike the process 10, in which oversize material from the screens 40, 42 of the size separation stage 16 is processed in the shaking table stage 18, the oversize material from the size separation stage 16 of the process 200 is discarded as tailings, by means of an oversize

material withdrawal line 202. In other words, the oversize material from the screens of the size separation stage 16 in the process 200 is thus not processed further to recover chromite. The size separation stage 16 of the process 200 functions to remove oversize material that negatively affect the chromite recovery efficiency of the shaking table stage 18.

[0073] A further difference between the process 200 and the process 10 is thus that, in the shaking table stage 18, instead of undersize and oversize material from the size separation stage 16 being processed in parallel on separate shaking tables 46, 48 as in the process 10, the shaking table stage 18 of the process 200 has a plurality of rougher shaking tables 246 upstream of a plurality of cleaner shaking tables 248. Only undersize material from the size separation stage 16 is fed by means of the slurry line 75 to the shaking table stage 18, dewatered in the dewatering cyclones 44 and then processed on the rougher shaking tables 246. The rougher shaking tables 246 serve to maximise chrome recovery from the wet spiral concentrator stage 14 and from the wet magnetic separation stage 24. The density of the slurry feed to the rougher shaking tables 246 is controlled using the dewatering cyclones 44.

[0074] The rougher shaking tables 246 are triple-deck shaking tables receiving underflow from the dewatering cyclones 44, with wash water being added onto the shaking tables 246 to improve feed material separation. The rougher shaking tables 246 serve to maximise chrome recovery from the higher-grade chromite slurry obtained from the wet spiral concentrator stage 14 and from the magnetic material stream obtained from the wet magnetic separation stage 24. Three products are recovered from the rougher shaking tables 246, namely concentrate, middlings and tailings. The concentrate is fed to the cleaner shaking tables 248 for further processing, by means of a flow line 204. The middlings from the rougher shaking tables 246 is fed by means of a flow line 206 to a further processing stage 250, which is described in more detail hereinafter. Tailings from the rougher shaking tables 246 is withdrawn by means of the second tails streamline 92.

[0075] The cleaner shaking tables 248 serve to upgrade the rougher shaking tables concentrate to the required chromite grade specification for a final concentrate product. There are sixteen triple-deck cleaner shaking tables 248. The cleaner shaking tables 248 receive wash water to improve feed material separation. Three products are recovered from the cleaner shaking tables 248, namely concentrate, middlings and tailings. The middlings and tailings are fed to the further processing stage 250, by means of flow lines 208 and 210. The concentrate from the cleaner shaking tables 248 is withdrawn by means of the concentrate line 90 and dewatered using stacker cyclones (not shown), with an underflow from the stacker cyclones then being stacked by means of the chromite stacker 50 onto concentrate stockpiles 94. The concentrate stockpiles 94 typically have a Cr_2O_3 content of about 40% by mass, on a dry basis.

[0076] The further processing stage 250, which does not form part of the process 10, includes rougher wet magnetic separators 212 upstream of cleaner wet magnetic separators 214, and a dewatering cyclone 216.

[0077] Middlings from the rougher shaking tables 246 of the shaking table stage 18 is fed by means of the flow line 206 to the rougher wet magnetic separators 212. The rougher wet magnetic separators 212 also receive middlings and tailings from the cleaner shaking tables 248 of the shaking table stage 18, by means of the flow lines 208 and 210. The rougher wet magnetic separators 212 produce a non-magnetic material reject stream which is withdrawn by means of the second tails streamline 92, and a magnetic material stream which is transferred from the rougher wet magnetic separators 212 to the downstream cleaner wet magnetic separators 214 by means of a flow line 213.

[0078] The cleaner wet magnetic separators 214 also produce a non-magnetic material reject stream which is withdrawn by means of the second tails streamline 92, and a magnetic material stream which is transferred by means of a flow line 218 to the dewatering cyclone 216.

[0079] Overflow from the dewatering cyclone 216 is withdrawn by means of the second tails streamline 92. Underflow from the dewatering cyclone 216 is withdrawn by means of a flow line 220 and is recirculated back to the cleaner shaking tables 248 of the shaking table stage 18 for density control. The density of the slurry fed to the cleaner shaking tables 248 is thus controlled by operation of the rougher shaking tables 246 and by operation of the dewatering cyclone 216 of the further processing stage 250.

[0080] A further difference between the process 200 and the process 10 is that the process 200 has a guard cyclone 260 forming part of the tailings treatment stage 22. In the process 200, the first tails stream from the spiral separation stage 14 is fed by means of the first tails streamline 78 to the guard cyclone 260, and not directly to the thickener 52. Similarly, the second tails streamline 92 and the non-magnetic reject material withdrawal line 86 lead to the guard cyclone 260 and not directly to the thickener 52.

[0081] The tailings treatment stage 22 of the process 200 is shown to have a tailings pump system 270. Underflow from the guard cyclone 260 flows under gravity to the tailings pump system 270 by means of a flow line 262, whereas overflow from the guard cyclone 260 flows under gravity to the thickener 52 by means of a flow line 264. Underflow from the thickener 52 is transferred to the tailings pump system 270 by means of a flow line 266. A flow line 268 leads from the tailings pump system 270 to a tailings storage facility (not shown).

[0082] Overflow from the thickener 52 is withdrawn by means of a process water line 102 and fed to a process water tank (not shown), for use as process water in the process 200, e.g. as spray water, wash water, gland seal water, dilution water and water for flushing and hosing. The main source of process water is the thickener overflow, with provision (not shown) being made for raw water make-up if required.

[0083] The process 200 is configured to treat about 500 tons/hour of a feed slurry comprising chromite fines, i.e. tailings, produced by a chrome recovery plant (not shown) processing run-of-mine chromite ore. The feed slurry typically has a Cr_2O_3 content of about 8-10% by mass,

on a dry basis. The chromite fines in the feed slurry are such that at least 90% of the chromite fines pass through a 115 µm square mesh.

[0084] The process 10, 200 as illustrated, cost-effectively recovers a chromite concentrate with a Cr_2O_3 content of up to about 40% by mass on a dry basis. Only a relatively small portion of the Cr_2O_3 in the feed slurry, e.g. about 4 - 5% on a dry basis, is discharged as waste material from the thickener 52. The process 10, 200 as illustrated, can thus advantageously recover a significant portion of the chrome, as Cr_2O_3, even when the bulk of the chromite fines is -75µm.

REFERENCES CITED IN THE DESCRIPTION

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GENVINDING AF CHROMITFINPARTIKLER

Patentkrav

1. Fremgangsmåde (10, 200) til genvinding af chromitfinpartikler fra en opslæmning, hvilken fremgangsmåde (10, 200) indbefatter

tilførsel af en tilførselsopslæmning (68), der omfatter chromitfinpartikler, således at mindst 90 % af chromitfinpartiklerne passerer gennem et 150 µm kvadratisk net, og hvor et Cr_2O_3-indhold af tilførselsopslæmningen er på mellem 7 masseprocent og 11 masseprocent, til et vådspiralkoncentratortrin (14), der omfatter en flerhed af vådspiralseparatorer eller vådspiralkoncentratorer (32),

separation af opslæmningen ved hjælp af vådspiralseparatorerne eller -koncentratorerne (32) i en højkvalitetschromitopslæmning (74) med et Cr_2O_3-indhold på mellem 11 masseprocent og 20 masseprocent tørvægt, en lavkvalitetschromitopslæmning (76) med et Cr_2O_3-indhold på mellem 6 masseprocent og 11 masseprocent tørvægt og en første reststrøm (78),

magnetisk separation af lavkvalitetschromitopslæmningen (76) i et vådmagnetisk separationstrin (24), der omfatter en flerhed af magnetiske separatorer (34, 36, 38), i en magnetisk materialestrøm (80) og en ikke-magnetisk materialefrasorteringsstrøm (86), og

separation af højkvalitetsopslæmningen (74) og den magnetiske materialestrøm (80) i et rystebordstrin (18), der omfatter en flerhed af rysteborde (46, 48, 246, 248), i et chromitkoncentrat (90) og en anden reststrøm (92).

2. Fremgangsmåde (10, 200) ifølge krav 1, hvor tilførselsopslæmningen (68), der tilføres til vådspiralkoncentratortrinnet (14), omfatter chromitfinpartikler, således at mindst 90 % af chromitfinpartiklerne passerer gennem et 125 µm kvadratisk net eller gennem et 115 µm kvadratisk net eller gennem et 100 µm kvadratisk net.

3. Fremgangsmåde (10, 200) ifølge krav 1 eller krav 2, hvor magnetisk separation af lavkvalitetschromitopslæmningen (76) i et vådmagnetisk separationstrin (24) indbefatter at føre lavkvalitetschromitopslæmningen gennem en flerhed af våde højintensitetsgrovmagnetiske separatorer (34), der fungerer parallelt, og føre en ikke-magnetisk materialefrasorteringsstrøm (82) fra de grovmagnetiske separatorer (34) til yderligere nedstrøms våde højintensitetsmagnetiske separatorer (36),

der fungerer parallelt, og som er opfangningsseparatorer.

4. Fremgangsmåde (10, 200) ifølge et hvilket som helst af kravene 1 til 3, der indbefatter udsættelse af mindst én af højkvalitetschromitopslæmningen (74) og den magnetiske materialestrøm (80) for et størrelsesseparationstrin (16) med henblik på at fremstille én eller flere finmateriale- eller underløbsfraktioner (75) og én eller flere grovmateriale- eller overløbsfraktioner (77, 202), før nævnte mindst ene af højkvalitetschromitopslæmningen (74) og den magnetiske materialestrøm (80), i form af i det mindste nævnte ene eller flere finmaterialefraktioner (75), og eventuelt nævnte ene eller flere grovmaterialefraktioner (77), separeres i rystebordstrinnet (18) i chromitkoncentratet (90) og den anden reststrøm (92).

5. Fremgangsmåde (10) ifølge krav 4, hvor rystebordstrinnet (18) anvender en flerhed af rysteborde (46) til den ene eller de flere finmaterialefraktioner (75) og en flerhed af rysteborde (48) til den ene eller de flere grovmaterialefraktioner (77), idet den ene eller de flere finmaterialefraktioner (75) således forarbejdes separat fra den ene eller de flere grovmaterialefraktioner (77) i rystebordstrinnet (18).

6. Fremgangsmåde (200) ifølge krav 4, hvor, i stedet for at separere den ene eller de flere grovmaterialefraktioner (202) fra størrelsesseparationstrinnet (16) i rystebordstrinnet (18), den ene eller de flere grovmaterialefraktioner (202) fra størrelsesseparationstrinnet (16) kasseres som spildkvalitetsprodukter.

7. Fremgangsmåde (200) ifølge krav 6, hvor rystebordstrinnet (18) indbefatter grovrysteborde (246) opstrøms for renrysteborde (248), idet den ene eller de flere finmaterialefraktioner (75) fra størrelsesseparationstrinnet (16) tilføres til grovrystebordene (246).

8. Fremgangsmåde (200) ifølge krav 7, der indbefatter et yderligere forarbejdningstrin (250) til forarbejdning af i det mindste en mellemkvalitetsfraktion (208) fra renrystebordene (248), idet en koncentratfraktion fra renrystebordene (248) udgør chromitkoncentratet (90).

9. Fremgangsmåde (200) ifølge krav 8, hvor også en mellemkvalitetsfraktion (206) fra grovrystebordene (246) og en spildkvalitetsfraktion (210) fra renrystebordene (248) forarbejdes i videreforarbejdningstrinnet (250).

10. Fremgangsmåde (200) ifølge krav 8 eller krav 9, hvor videreforarbejdningstrinnet (250) indbefatter grovvådmagnetiske separatorer (212), der modtager materiale fra rystebordstrinnet (18).

11. Fremgangsmåde (200) ifølge krav 10, hvor videreforarbejdningstrinnets (250) grovvådmagnetiske separatorer (212) modtager mellemkvalitetsfraktionen (206) fra grovrystebordene (246), mellemkvalitetsfraktionen (208) fra renrystebordene (248) og spildkvalitetsfraktionen (210) fra renrystebordene (248).

12. Fremgangsmåde (200) ifølge et hvilket som helst af kravene 8 til 11, hvor videreforarbejdningstrinnet (250) indbefatter renvådmagnetiske separatorer (214), der modtager magnetisk materiale (213) fra de grovvådmagnetiske separatorer (212), idet ikke-magnetisk materiale (92) fra de grovmagnetiske separatorer (212) kasseres som spildkvalitetsprodukter (92).

13. Fremgangsmåde (200) ifølge krav 12, som i videreforarbejdningstrinnet (250) indbefatter afvanding (216) af magnetisk materiale fra de renvådmagnetiske separatorer (214) og recirkulering af det afvandede magnetiske materiale (220) fra de renvådmagnetiske separatorer (214) til renrystebordene (248).

14. Fremgangsmåde (10, 200) ifølge et hvilket som helst af kravene 1 til 13, hvor vådspiralseparatorerne eller -koncentratorerne (32) er konfigureret og drives således, at den første reststrøm (78) har et Cr_2O_3-indhold på mindre end 8 masseprocent tørvægt.

15. Fremgangsmåde (10, 200) ifølge et hvilket som helst af kravene 1 til 14, hvor mere end 50 % eller mere end 60 % eller mere end 70 % eller mere end 80 % af chromitfinpartiklerne i tilførselsopslæmningen (68), der tilføres til vådspiralkoncentratortrinnet (14), er -75 µm materiale.

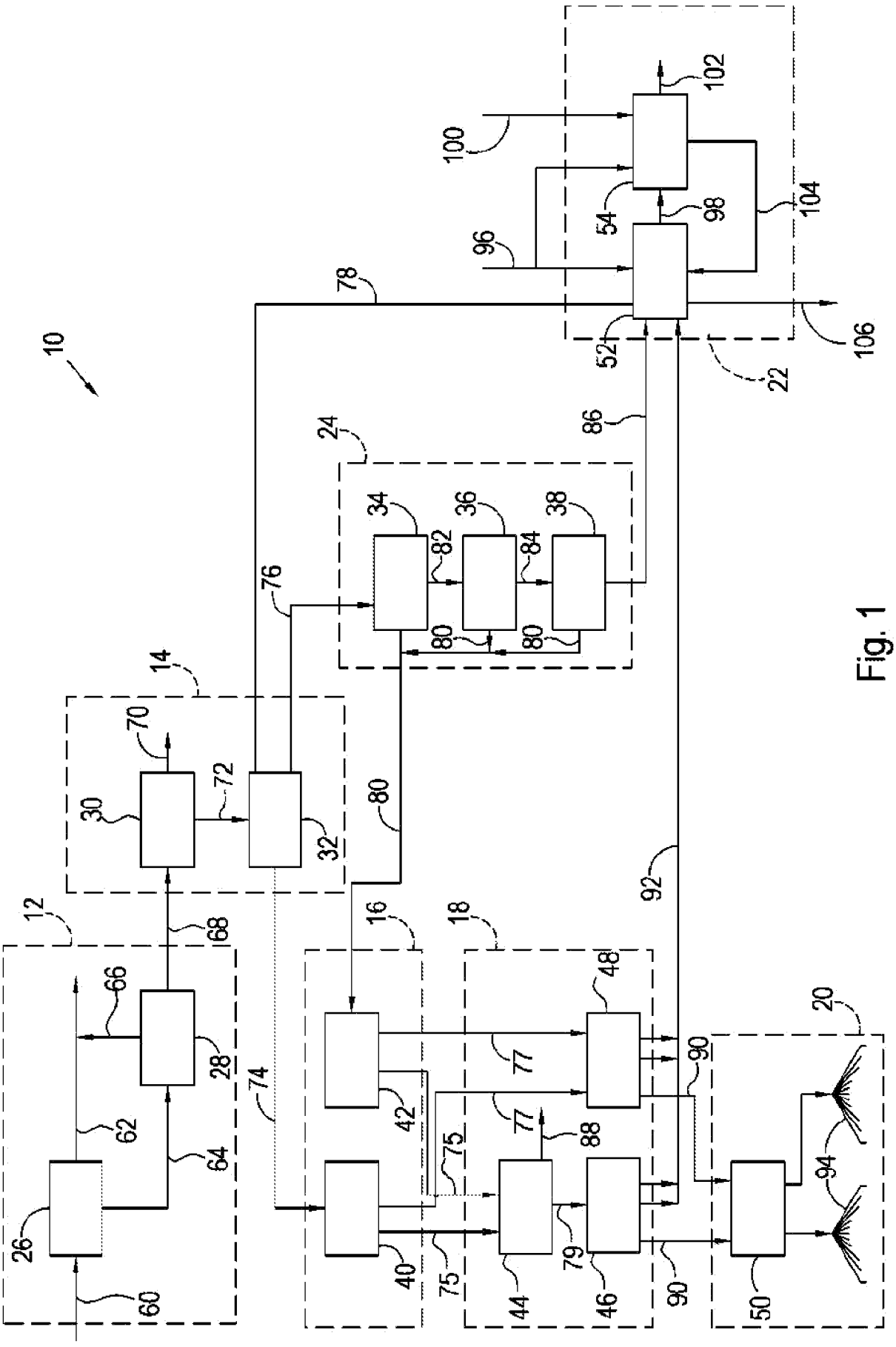
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Fig. 1

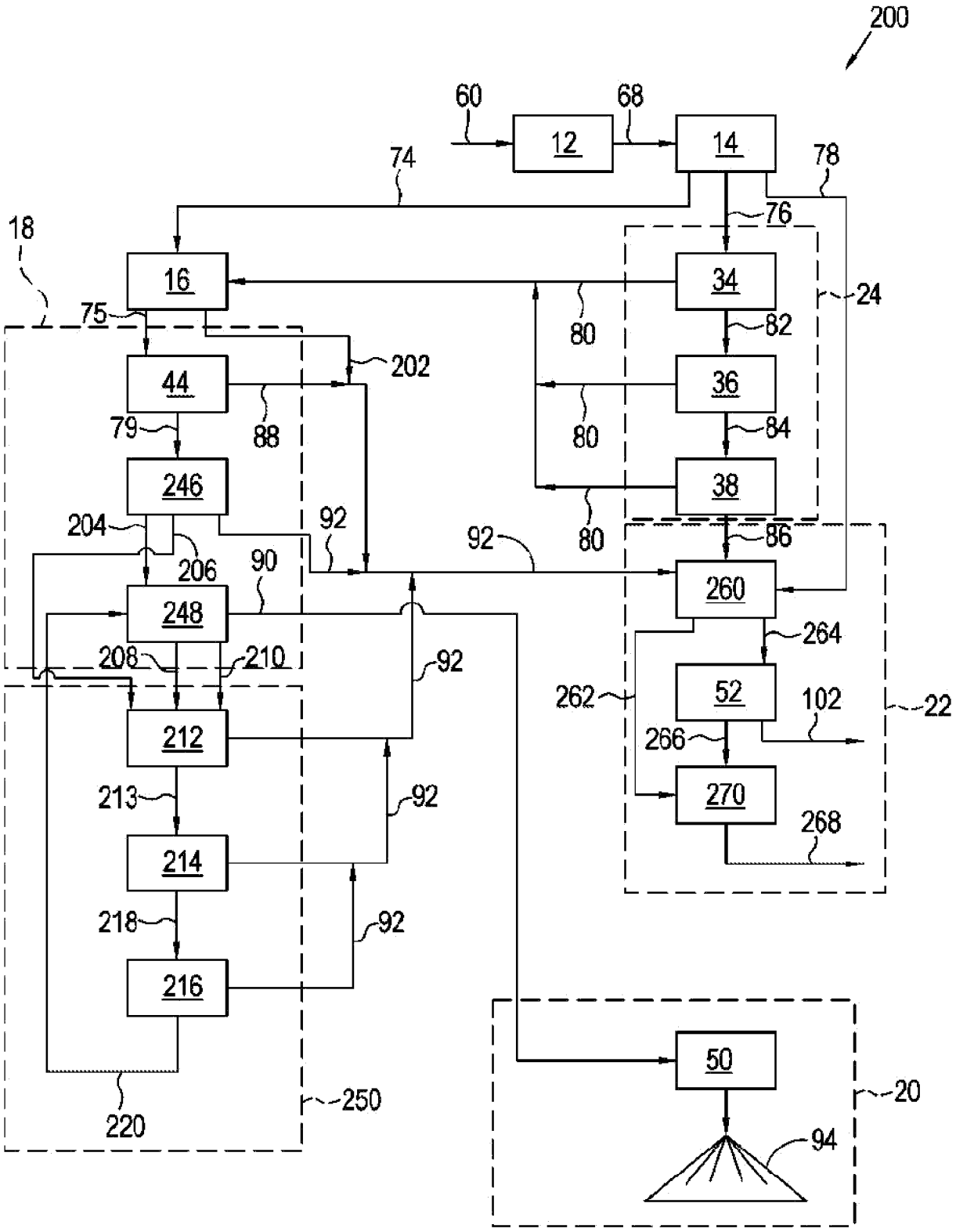
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Fig. 2

DRAWINGS

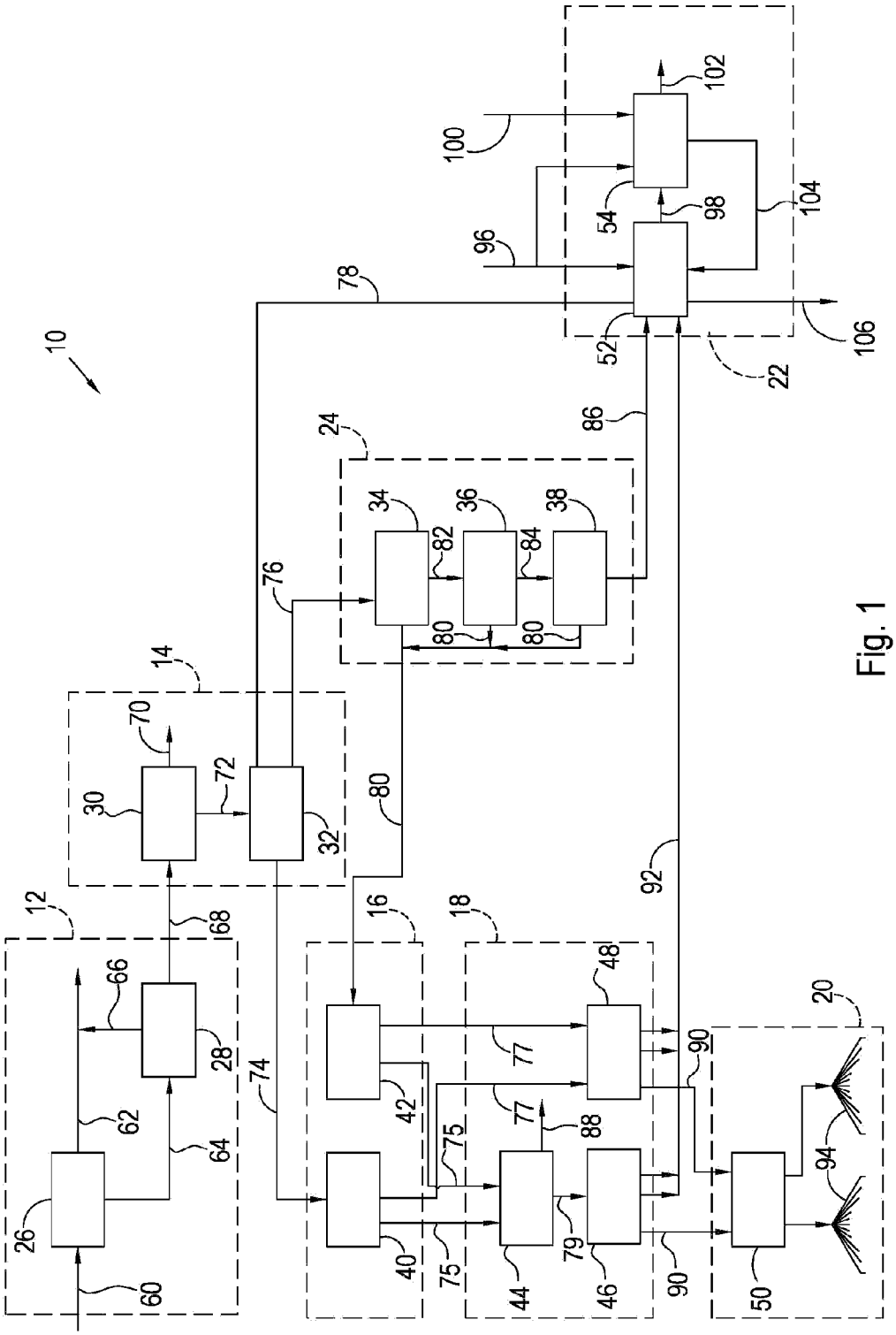

Fig. 1

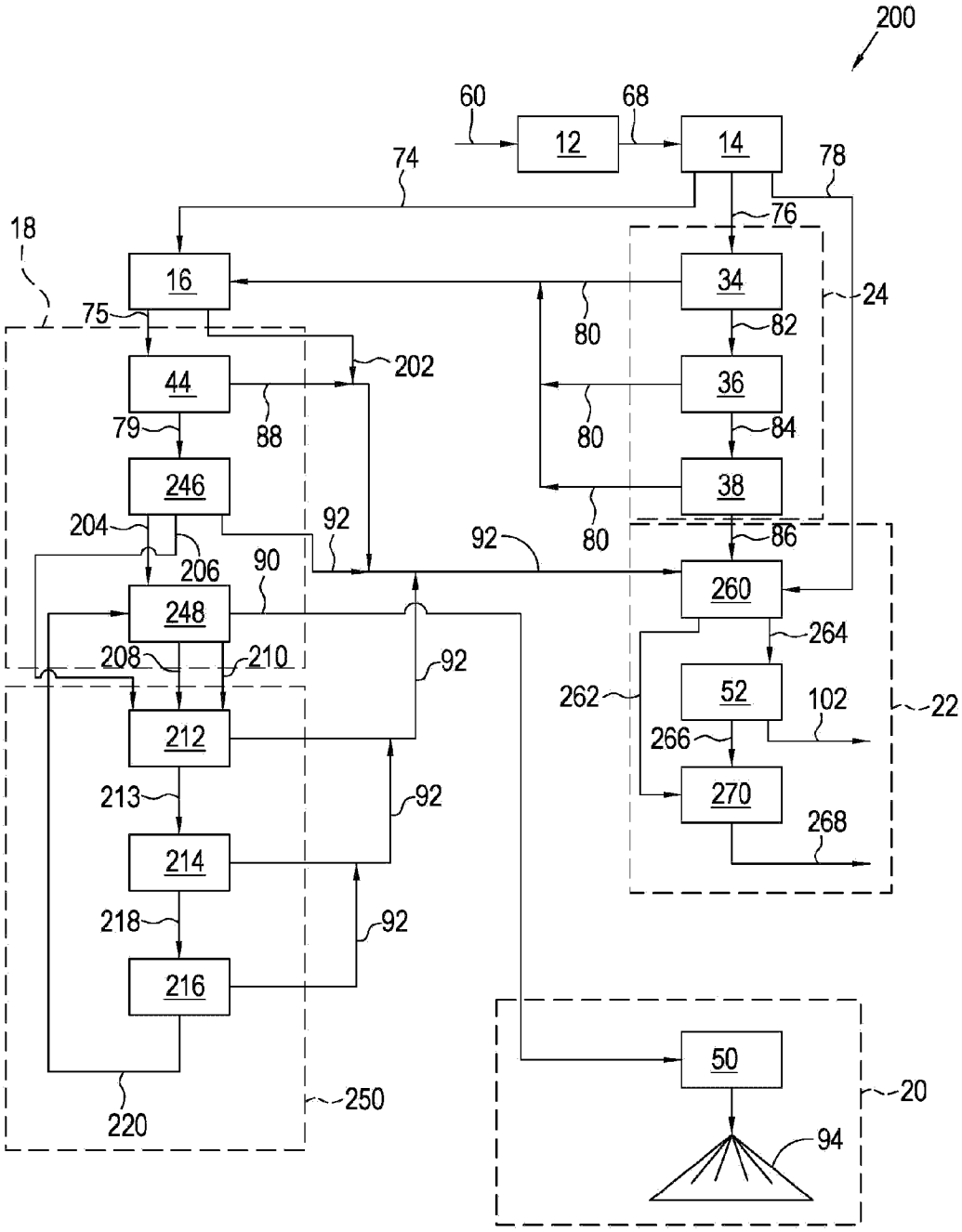
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Fig. 2