Summary of the invention

According to a first aspect of the present invention, there is provided an eddy current separation apparatus for separating particles from a particle stream, the eddy current separation apparatus comprising: a separator drum adapted to create out of the particle stream at least a first particle fraction moving from the separator drum along a first trajectory and a second particle fraction moving from the separator drum along a second trajectory; a feeding device upstream of the separator drum for supplying particles to said separator drum; a splitter element provided downstream of the separator drum for splitting the first particle fraction from the second particle fraction; and a sensor device arranged for detecting particles and arranged for at least one of counting the detected particles to determine a counted number of detected particles or detecting material properties of the detected particles from at least part of one of the particle fractions, wherein said splitter element is movably mounted to the eddy current separation apparatus such that at least one of a distance between the splitter element and the separator drum, an orientation of the splitter element with respect to the separator drum or a transporting velocity of the feeding device is adjustable in dependence of a signal from the sensor device based on at least one of the counted number of detected particles or the material properties of the detected particles, wherein the sensor device comprises a first sensor part, wherein the first sensor part is a transmitter part adapted to transmit beam shaped energy, and a second sensor part, wherein the second sensor part is a receiver part to measure at least one of reflection or attenuation when a particle is passing the energy beam, wherein the sensor device is arranged to count particles to determine a total counted number of particles passing said first and second sensor part, wherein the sensor device comprises a third sensor part configured to detect an electromagnetic response of the particles passing said third sensor part, wherein the sensor device is arranged to count metal particles to determine a counted number of metal particles passing said third sensor part, wherein the

sensor device comprises a detection section configured to allow to pass a sample of the first particle fraction, wherein the sensor device is configured to calculate a metal grade of the first particle fraction based on the total counted number of the detected particles passing said first and second sensor part, the counted number of metal particles passing said third sensor part, and a given average particle mass ratio between non-metal and metal particles, wherein the eddy current separation apparatus is configured to adjust the position of the splitter element substantially continuously based on the signal from the sensor device.

According to a second aspect of the present invention, there is provided a method for separating particles from a stream of particles, wherein the method comprises: providing an eddy current separating apparatus according to the first aspect; providing a particle stream to the separator drum of the eddy current separation apparatus; detecting a number of particles of at least part of one of the particle fractions coming from the separator drum and counting said number of particles; determining a number of metal particles of at least part of said particle fraction and counting said number of metal particles; and displacing the splitter element based on the particle count and on the metal particle count to adjust at least one of the distance between the splitter element and an outer circumference of the separator drum, the orientation of the splitter element with respect to the outer circumference of the separator drum or the transporting velocity of the feeding device, based on the counted number of particles.

An embodiment~~According to one aspect~~ of the invention relates to an eddy current separation apparatus for separating particles from a particle stream of the above type~~is provided~~. The separation apparatus further comprises a sensor device arranged to detect particles, at least a number and/or material properties thereof, from at least part of one of the particle fractions, wherein the separation apparatus is configured to adjust, in use, a position and/or orientation of the splitter element with respect to the separator

drum and/or a transporting velocity of the feeding device in dependence of a signal from the sensor device based on the number and/or the material properties of the detected particles, for instance based on a counted number of particles passing through the sensor device.

By automatically adjusting the position and/or orientation of the splitter element based on objective sensor measurements, the optimal position and/or orientation of the splitter element with respect to the separator drum may be determined for the specific waste stream. The splitter element is movably mounted to the apparatus such that a distance between the splitter element and the separator drum and/or an orientation of the splitter element with respect to the separator drum is adjustable in dependence of said signal from the sensor device. The sensor device is adapted to count the number of different types of particles passing the sensor device and based on the gathered data determine a specific splitter element position. The position of the splitter element may be adjusted automatically, preferably in real-time. For instance, a waste stream may be subjected to changes of the moisture content thereof. In case the feeding rate of the waste stream remains constant, upon a change of moisture content thereof the first trajectory followed by the first particle fraction changes relatively to the second trajectory followed by the second particle fraction. For instance, if the waste stream becomes moister, the number of particles of the first particle fraction that is detected near the current splitter element position changes. In that case, the position of the

It is noted that US 2004/0040894 discloses an eddy current separation device comprising a drum with a rotating magnet rotor for separating out of a particle stream a first particle fraction from a second particle fraction. Downstream of the drum a separation apex is provided, which separation apex may be adjusted. The device further comprises a camera that is adapted to recognize the composition of the separated fraction. An adjusting device is provided that may adjust the separation apex based on the recognition of the composition of the fraction by the camera to a position that corresponds to a concentrated graded composition of the separated fraction. It is noted that a sensor device according to the invention can also be used to advantage for monitoring quality.

Preferably, the sensor device according to the invention is arranged at a side of the splitter element facing away from the separator drum. For instance, the first, second and third sensor part may be provided in a housing, which may be coupled to the splitter element for effective sampling of the first particle stream.

To be able to split the respective separated particle fractions, the separation apparatus may comprise, in further elaboration of the invention, a control unit operatively connected to the sensor device, the particle feeding device and/or the splitter element, wherein the control unit is configured to control at least one of a feeding device velocity, such as conveyor velocity, displacement and/or orientation of the splitter element with respect to the separator drum.

It may be advantageous, according to a further ~~aspect~~embodiment of the invention, if the control unit comprises a memory to store a predetermined relation between at least a number of detected particles and the splitter element position and/or the feeding device velocity. The control unit may then enable relocation of the splitter element easily in case the number of detected particles changes during operation of the eddy current separation apparatus. Dependent on the measured data, the distance between the separator drum

and the splitter element and/or the optimal velocity of the feeding device may be known from the stored relation. Consequently, the new position of the splitter element results automatically when the number of particles passing the sensor device is known. Such a system provides real time adjustment of the splitter element during operation of the separation apparatus.

According to another ~~aspect~~embodiment of the invention, the separation apparatus may comprise a frame that slidably receives the splitter element, for instance by means of a guide provided on the frame. This results in a simple construction of the movable splitter element and provides for easy displacement of said element to and from the separator drum. In further elaboration of the invention, the separation apparatus may comprise a frame that rotatably receives the splitter element, for instance further comprising a motor operatively coupled to the splitter element such that said splitter element can be rotated by a rotating axis of said motor. This results in a simple construction of the rotatable splitter element and provides for easy rotation of said element with respect to the separator drum.

It is noted that the splitter element throughout this application should be interpreted in a broad way. For instance the splitter element may be a separate part that is provided on a frame, movably and/or rotatably as above described. Instead, the splitter element may comprise a wall of a container or receptacle provided downstream the particle trajectories. Said container or receptacle may be displaceably provided with respect to the separator drum to enable adjustment of the splitter element position.

In further elaboration of the invention, the separation apparatus may contain more than one splitter element. The respective splitter elements may be provided at mutual distance such that more than two particle fractions may be separated from the particle stream. The respective splitter elements may be controlled simultaneously or independently. In the latter case, more than one sensor device may be provided, each device operatively coupled to the

control unit to control the respective splitter elements based on signals from the respective sensor devices.

The sensor device may have different configurations and be provided in different manners with respect to the splitter element to accurately determine the number of particles passing. For instance, the transmitter part of the sensor device may be arranged such that in use the transmitted energy travels towards the splitter element surface in a direction substantially perpendicular to said splitter element surface. Alternatively, the transmitter part of the sensor device may be arranged such that in use the transmitted energy travels substantially parallel to the splitter element surface and thus substantially parallel to a central axis of the separator drum.

Furthermore, in either configuration of the transmitter part, the receiver part of the sensor device may be arranged at a distance from the splitter element surface. Alternatively, the receiver part of the sensor device may be arranged such that in use the transmitted energy is received from a direction substantially parallel to a plane extending through the splitter element surface.

To protect the sensor device from fouling, the sensor device may be at least partly surrounded by a cover. According to a further ~~aspect~~embodiment of the invention, the cover may comprise at least one sheet shaped element, wherein the sheet shaped element is provided at an angle with respect to a displacement direction of the metal particle fraction.

The invention further relates to a separating module for use with an eddy current separation apparatus, such as a known eddy current separation apparatus as described before. According to the invention, the separating module at least comprises the above described splitter element, the sensor device and the control unit. The invention also relates to a method for modifying an eddy current separation apparatus into an eddy current separation apparatus according to the invention. The method comprises

Claims

1. Eddy current separation apparatus for separating particles from a particle stream, wherein the separation apparatus comprises a separator drum (4) adapted to create out of the particle stream at least a first particle fraction (21) moving from the drum along a first trajectory (6) and a second particle fraction (23) moving from the drum along a second trajectory (8), a feeding device (2) upstream of the separator drum for supplying particles to said separator drum, and a splitter element (14) provided downstream of the separator drum for splitting the first particle fraction from the second particle fraction, wherein the separation apparatus further comprises a sensor device (11, 111, 211) arranged for detecting particles, at least a number and/or material properties thereof, from at least part of one of the particle fractions, wherein said splitter element is movably mounted to the apparatus such that a distance (d) between the splitter element and the separator drum and/or an orientation of the splitter element with respect to the separator drum (4) and/or a transporting velocity of the feeding device (2) is adjustable in dependence of a signal from the sensor device based on the number and/or the material properties of the detected particles, characterized in that the sensor device comprises a transmitter part (12, 112, 212), such as an optical emitter, adapted to transmit beam shaped energy, and a receiver part (13, 113, 213), such as an optical receiver, to measure reflection and/or attenuation when a particle is passing the energy beam, wherein the sensor device comprises a third sensor part (218), such as an electric coil, configured to detect an electromagnetic response of the particles passing said third sensor part, wherein the sensor device comprises a detection section configured to allow to pass a sample (i.e. a small percentage) of the first particle fraction, wherein the sensor device is configured to calculate a metal grade of the first particle

fraction based on the sensor counts and a given average particle mass ratio between non-metal and metal particles, wherein the apparatus is configured to adjust the position of the splitter element substantially continuously, for instance every few seconds, based on the signal from the sensor device., ,

2. Eddy current separation apparatus according to claim 1, wherein the sensor device is arranged at a side of the splitter element facing away from the separator drum.

3. Eddy current separation apparatus according to any one of the preceding claims, wherein the respective particle fractions comprise one of a ferrous metal particle fraction, a non-ferrous metal particle fraction (21) and a non-metal particle fraction (23).

4. Eddy current separation apparatus according to any one of the preceding claims, wherein the separator drum (4) comprises a permanent magnet or an electromagnet, which is configured to be switched on and off during the separation process.

5. Eddy current separation apparatus according to any one of the preceding claims, wherein the separation apparatus comprises a control unit (16) operatively connected to the sensor device, the particle feeding device and/or the splitter element, wherein the control unit is configured to control at least one of a feeding device velocity, displacement and/or orientation of the splitter element with respect to the separator drum.

6. Eddy current separation apparatus according to any one of the preceding claims, wherein the control unit comprises a memory to store a predetermined relation between at least a number of detected particles and the splitter element position and/or the feeding device velocity.

7. Eddy current separation apparatus according to any one of claims 5-6, wherein the apparatus further comprises a device for determining a particle feed rate of the feeding device to the separator drum, wherein the control unit is operatively coupled to said device.

8. Eddy current separation apparatus according to any one of the preceding claims, wherein the separation apparatus comprises a frame that slidably receives the splitter element, for instance by means of a guide (15) provided on the frame.

9. Eddy current separation apparatus according to any one of the preceding claims, wherein the separation apparatus comprises a frame that rotatably receives the splitter element, for instance further comprising a motor operatively coupled to the splitter element such that said splitter element can be rotated by a rotating axis of said motor.

10. Eddy current separation apparatus according to any one of the preceding claims, wherein the transmitter part of the sensor device is arranged such that in use the transmitted energy travels towards the splitter element surface in a direction substantially perpendicular to said splitter element surface.

11. Eddy current separation apparatus according to any one of claims 1-9, wherein the transmitter part of the sensor device is arranged such that in use the transmitted energy travels substantially parallel to the splitter element surface.

12. Eddy current separation apparatus according to claim 10 or 11, wherein the receiver part of the sensor device is arranged at a distance from the splitter element surface.

13. Eddy current separation apparatus according to claim 10 or 11, wherein the receiver part of the sensor device is arranged such that in use the transmitted energy is received from a direction substantially parallel to the splitter element surface.

14. Eddy current separation apparatus according to any one of the preceding claims, wherein the sensor device is at least partly surrounded by a cover (219), for instance comprising at least one sheet shaped element (219a, b).

15. Eddy current separation apparatus according to any one of the preceding claims, wherein upstream and downstream of the splitter element a respective receiving area, for instance a container, is provided.

16. Method for separating particles from a stream of particles, using an eddy current separating apparatus according to any one of claims 1-15 wherein the method comprises:

- supplying a particle stream to the separator drum;
- detecting a number of particles of at least part of one of the particle fractions coming from the drum counting said number of particles;
- determining a number of metal particles of at least part of said particle fraction;
- displacing the splitter element based on the particle count and on the metal particle count to adjust the distance (d) and/or orientation of the splitter element with respect to an outer circumference of the drum and/or adjusting

the transporting velocity of the feeding device based on the counted number of particles.

Claims

1. An eddy current separation apparatus for separating particles from a particle stream, the eddy current separation apparatus comprising:

a separator drum adapted to create out of the particle stream at least a first particle fraction moving from the separator drum along a first trajectory and a second particle fraction moving from the separator drum along a second trajectory;

a feeding device upstream of the separator drum for supplying particles to said separator drum;

a splitter element provided downstream of the separator drum for splitting the first particle fraction from the second particle fraction; and

a sensor device arranged for detecting particles and arranged for at least one of counting the detected particles to determine a counted number of detected particles or detecting material properties of the detected particles from at least part of one of the particle fractions,

wherein said splitter element is movably mounted to the eddy current separation apparatus such that at least one of a distance between the splitter element and the separator drum, an orientation of the splitter element with respect to the separator drum or a transporting velocity of the feeding device is adjustable in dependence of a signal from the sensor device based on at least one of the counted number of detected particles or the material properties of the detected particles,

wherein the sensor device comprises a first sensor part, wherein the first sensor part is a transmitter part adapted to transmit beam shaped energy, and a second sensor part, wherein the second sensor part is a receiver part to measure at least one of reflection or attenuation when a particle is passing the energy beam, wherein the sensor device is arranged to count particles to determine a total counted number of particles passing said first and second sensor part, wherein the sensor device comprises a third sensor part configured to detect an electromagnetic response of the particles passing said third sensor part, wherein the sensor device is arranged to count metal particles to determine a counted number of metal particles passing said third sensor part, wherein the sensor device comprises a detection section configured to allow to pass a sample of the first particle fraction, wherein the sensor device is configured to calculate a metal grade of the first particle fraction based on the total counted number of the detected particles passing said

first and second sensor part, the counted number of metal particles passing said third sensor part, and a given average particle mass ratio between non-metal and metal particles,

wherein the eddy current separation apparatus is configured to adjust the position of the splitter element substantially continuously based on the signal from the sensor device.

2. The eddy current separation apparatus according to claim 1, wherein the sensor device is arranged at a side of the splitter element facing away from the separator drum.

3. The eddy current separation apparatus according to claim 1, wherein the respective particle fractions comprise one of a ferrous metal particle fraction, a non-ferrous metal particle fraction and a non-metal particle fraction.

4. The eddy current separation apparatus according claim 1, wherein the separator drum comprises a least one of a permanent magnet or an electromagnet, any electromagnet being configured to be switched on and off during the separation process.

5. The eddy current separation apparatus according to claim 1, wherein the eddy current separation apparatus comprises a control unit operatively connected to at least one of the sensor device, the particle feeding device or the splitter element, wherein the control unit is configured to control at least one of a feeding device velocity, displacement or orientation of the splitter element with respect to the separator drum.

6. The eddy current separation apparatus according to claim 5, wherein the control unit comprises a memory to store at least one of a predetermined relation between at least a number of detected particles and the splitter element position or the feeding device velocity.

7. The eddy current separation apparatus according to claim 5, wherein the eddy current separation apparatus further comprises a device for determining a particle feed rate of the feeding device to the separator drum, wherein the control unit is operatively coupled to said device.

8. The eddy current separation apparatus according to claim 1, wherein the eddy current separation apparatus comprises a frame that slidably receives the splitter element.

9. The eddy current separation apparatus according to claim 1, wherein the eddy current separation apparatus comprises a frame that rotatably receives the splitter element.

10. The eddy current separation apparatus according to claim 1, wherein the transmitter part of the sensor device is arranged such that in use the transmitted energy travels towards a splitter element surface in a direction substantially perpendicular to said splitter element surface.

11. The eddy current separation apparatus according to claim 1, wherein the transmitter part of the sensor device is arranged such that in use the transmitted energy travels substantially parallel to a splitter element surface.

12. The eddy current separation apparatus according to claim 10, wherein the receiver part of the sensor device is arranged at a distance from the splitter element surface.

13. The eddy current separation apparatus according to claim 11, wherein the receiver part of the sensor device is arranged such that in use the transmitted energy is received from a direction substantially parallel to the splitter element surface.

14. The eddy current separation apparatus according to claim 1, wherein the sensor device is at least partly surrounded by a cover.

15. The eddy current separation apparatus according to claim 1, wherein upstream and downstream of the splitter element a respective receiving area is provided.

16. A method for separating particles from a stream of particles, wherein the method comprises:

providing an eddy current separating apparatus according to claim 1;

providing a particle stream to the separator drum of the eddy current separation apparatus;

detecting a number of particles of at least part of one of the particle fractions coming from the separator drum and counting said number of particles;

determining a number of metal particles of at least part of said particle fraction and counting said number of metal particles; and

displacing the splitter element based on the particle count and on the metal particle count to adjust at least one of the distance between the splitter element and an outer circumference of the separator drum, the orientation of the splitter element with respect to the outer

circumference of the separator drum or the transporting velocity of the feeding device, based on the counted number of particles.