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(54) Process and device for the separation of fragments of liberated ferrous scrap from not liberated ferrous scrap fragments by means of a static magnet

Verfahren und Gerät zur Trennung von befreiten nicht eisenhaltigen Metallteilchen von befreiten eisenhaltigen Metallteilchen mittels eines statischen Magneten

Procédé et dispositif de séparation de particules de métaux ferrugineux libérées dans de particules de métaux non-ferrugineux libérées au moyen d'un aimant statique

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EP-A- 0 455 948 **WO-A-88/05696**
DE-B- 1 051 752 **GB-A- 1 602 279**
US-A- 2 690 263 **US-A- 3 057 477**

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Description

[0001] The present invention relates to a process and device for the separation of fragments of liberated ferrous scrap from not liberated ferrous scrap fragments by means of a static magnet.

[0002] Basically, the present invention relates to the dramatic reduction of the copper content in liberated ferrous scrap in particular in steel scrap.

[0003] Steel scrap is produced, among others, from end-of-life consumer products, such as cars as well as electric and electronic appliances at car shredders and waste from energy plants.

[0004] When these products are shredded in order to recycle the steel, scrap particles are passed through a magnetic separator to recover the liberated ferrous or steel particles. The term liberated scrap means fragments which essentially do not contain materials other than iron and steel. The term not liberated ferrous scrap refers to fragments containing other materials in particular copper. Furthermore, ferrous scrap obtained from shedders contain both liberated and not liberated scrap. This "shredder steel scrap", obtained according to the prior art separation methods, is sold to steel manufacturers to be re-melted and processed into new steel products.

[0005] To date, steelmakers require the copper content of steel scrap be less than 0.2 wt-%, preferably less than 0.1 wt-%. However, shredder ferrous or steel scrap as currently produced by the magnetic separation at shredder yards often contains more copper, up to 2 wt-%. This is because end-of-life consumer products contain an increasing amount of copper containing parts, in which copper and steel are intimately integrated, and therefore not liberated, such as electric motor armatures and transformers. The average copper content of such parts is about 20 wt-%. Hence, there is a need to dramatically reduce the copper content of such liberated ferrous or steel scrap prior to re-melting.

[0006] During the last decade, the threshold value of copper in steel scrap set by steelmakers has gone down from 0.25 wt-% to 0.2 wt-%. In the same period, the amount of copper containing parts in steel scrap has substantially risen, up to about 20 wt-%, as a result of design changes of durable consumer goods and passenger vehicles.

[0007] The removal of copper from steel scrap can be achieved metallurgically, by hand sorting or by physical separation. The metallurgical method is very costly. On the other hand, despite its obvious disadvantages, hand sorting is a widely applied method today. However, the costs of hand sorting rise sharply with both throughput and copper content.

[0008] To date, two proposed methods to reduce the copper content of liberated ferrous material or steel scrap by physical separation means are known. One method is to further fragmentize the scrap so that the copper is liberated from the steel and can be separated by conventional magnetic separation devices. At current prices, this route costs approx. 20 euro/ton scrap and is very energy-intensive.

[0009] A second method, which eliminates the need of an additional shredding step, was described by Peace in GB 1.602.279.

[0010] According to this document, the liberated ferrous scrap fragments are separated from the not liberated ferrous scrap fragments by means of a static magnet wherein a mixture of said liberated ferrous and not liberated ferrous fragments is fed to a continuous conveyor belt which is driven around drums and wherein said magnet is fixed in the drum distant from the feeding point.

[0011] Said magnet is attracting liberated ferromagnetic material towards the belt as it passes around the drum, which device comprising a plurality of magnet poles extending around the interior of the drum for substantially 180°, wherein the uppermost pole being positioned at an angle of at least 15° to the vertical through the axis of the drum in the direction of belt travel.

[0012] The speed of the conveyor belt may not exceed 500 feet per minute (150m/s).

[0013] WO 88/05696 discloses a process for separating magnetic ore particles from non-magnetic particles using a short belt magnetic separator having a pulley head with axial pole permanent magnets located within said pulley head, said magnets being mounted in a fixed position within said pulley head during operation of said separator.

[0014] Said axial pole magnets within the pulley head are positioned so that said magnets extend along an arc beginning at a location spaced at least one degree beyond the point of tangency T of an upper surface of the belt with the pulley head.

[0015] US-A-3,057,477 relates to an apparatus for the sorting of tablets or pills which include a core of magnetically susceptible or paramagnetic material contained within an outer coating or shell. It is the object of US-A-3,057,477 to sort out pills having comprised therein a core of traceable small quantities of paramagnetic or magnetically susceptible material as opposed to pills without such a core. To this end US-A-3,057,477 employs a conveyor belt over which the pills are transported whereby at the end of the conveyor belt a magnetic field is applied which is established by placing electrical coils that are provided with pole pieces next to the belt and adjacent thereto. The resulting magnetic field lines follow therefore a path transverse to the conveying direction of the belt.

[0016] EP-A-0 455 948 shows a separating device for separating weakly magnetisable material from non-magnetisable material which is fed in a mixture at a feeding point to a continuous belt driven around drums for the transportation of the mixture to a separation zone. In said separation zone magnetic field lines of a magnet are present, and the magnet to be employed therefore is required to be strong in order to attract the weakly magnetisable materials such as steel-qualities that are normally not magnetisable but may have become weakly magnetisable by mechanical agitation resulting in a transition of the steel-structure from austenite to martensite. EP-A-0 455 948 is however not concerned with the separation of strongly magnetisable materials such as iron, nickel and nickel alloys.

[0017] Now, the present invention relates to a process and device for the separation of liberated ferrous scrap fragments from not liberated ferrous scrap fragments by using a single dipole magnet rather than a plurality of magnets from the above discussed prior art, wherein said magnet is fixed in the drum distant from the feeding point, having magnetic field lines in the separation zone which are predominantly parallel to the belt surface.

[0018] It appeared surprisingly that the magnetic field geometry in the separation zone is important for the separation process, in that a substantial better separation is obtained compared to any other field line orientation.

[0019] Furthermore, satisfactory results are obtained by the use of a cylindrical dipole magnet.

[0020] The invention also relates to a device for the separation of fragments of liberated ferrous scrap from not liberated ferrous scrap in a separation zone, which device is provided with a first drum and a second drum and a continuous belt for the transportation of a mixture of liberated and not liberated scrap to the separation zone, wherein said magnet is a dipole magnet in the drum distant from the feeding point. Said dipole magnet, is cylindrical and furthermore the position of said magnet in the drum is such that the magnetic field lines are predominantly parallel to the surface of said belt.

[0021] Reference is made to the table below wherein examples are given from magnetic field line orientation to belt surface. In the table, mention is made of a low-copper fraction and a copper-rich fraction.

[0022] It is noted that the copper content of the feed is 1.5 wt-%.

TABLE

magnetic field	low-copper fraction		copper-rich fraction	
line orientation	copper content	steel recovery	copper content	steel recovery
to belt surface	[wt-%]	[wt-%]	[wt-%]	[wt-%]
parallel	0.18	82.9	8.0	17.1
perpendicular	0.40	85.0	8.1	15.0
intermediate	0.55	77.6	5.0	22.4

[0023] It appears from the above table that there are used three magnetic field line orientations, i.e. parallel, perpendicular and intermediate.

[0024] As it can be seen from the table, the parallel orientation of the magnetic field line gives the best result relating to a copper content of the recovered steel fraction, i.e. only about 0,18 wt-% copper versus iron recovery of about 82.9 wt-%.

[0025] The copper content of the copper-rich fraction obtained by the centrifugal forces is about 8.0 wt-% versus about 17.1 wt-% iron recovery in the parallel orientation of the magnetic field lines.

[0026] From the table it can be seen that the perpendicular and intermediate magnetic field line orientation do result in a copper content in the low-copper fraction of 0.40 and 0.55 wt-% respectively.

[0027] From the above table it clearly follows that the parallel magnetic field line orientation is preferred.

[0028] Furthermore, the present invention will be illustrated by the enclosed Figure.

[0029] The Figure shows the preferred embodiment of the device 1 of the invention for the separation of fragments of liberated ferrous scrap from not liberated ferrous scrap.

[0030] The liberated and not liberated scrap mixture is fed to the continuous conveyor belt 4 at drum 2 for the transportation of said scrap mixture with a belt speed of 2 to 5 m/s, preferably 3 to 4 m/s, and most preferably 3.5 m/s to the separation zone 6. By means of centrifugal forces the copper-rich fraction will be separated from the liberated ferrous scrap fraction, whereas the liberated ferromagnetic fragments carried around the drum 3 will leave the conveyor belt at a later stage.

[0031] In order to obtain a more satisfactory separation according to the invention the magnetic field strength should be in balance with the speed of the conveyor belt. Usually the magnetic field strength is 0.10-0.15 Tesla at the belt surface at a belt speed of 3.5 m/s. At a lower belt speed the optimum magnetic field strength will be lower whereas at a higher speed the magnetic field strength should be higher than 0.10-0.15 Tesla. Generally the magnetic field strength is proportional to the belt speed.

[0032] The Figure further shows the separation zone 6 and some of the magnetic field lines 7. The arrow 8 shows the belt travel direction.

[0033] The magnet, preferably a dipole magnet, which is furthermore preferably a cylindrical magnet, 5 is fixed in the drum 3. The capital letters N and S refer to north and south of the dipole magnet. For an appropriate working the north and south of the dipole magnet may be interchanged, so that N is in the down and S is in the upper section, provided that the magnetic field lines are predominantly parallel to the surface of said belt.

Claims

1. A separation process for separating liberated ferrous scrap from non-liberated ferrous scrap from a mixture of said liberated and non-liberated ferrous scrap, which mixture is fed at a feeding point on a continuous conveyor belt (4) which is driven around drums (2, 3) for the transportation of said scrap mixture to a separation zone (6), and wherein a magnet (5) is used having magnetic field lines (7) in said separation zone (6), **characterized in that** the magnet (5) is a single dipole magnet placed in the drum (3) distant from the feeding point, so as to cause that the magnetic field lines (7) are predominantly parallel to the surface of the belt (4) in the separation zone (6).

2. A separation process according to claim 1, **characterized in that** the magnet (5) is a cylindrical dipole magnet.

3. A separation process according to claim 1 or 2, **characterized in that** in use the belt speed is 2 to 5 m/s, preferably 3 to 4 m/s, most preferably 3,5 m/s and that the magnetic field strength is proportional to the belt speed and arranged such that the magnet (5) has a magnetic field strength of about 0.10 - 0.15 Tesla at said belt speed of 3.5 m/s.

4. A separating-device (1) for separating liberated ferrous scrap from non-liberated ferrous scrap from a mixture of said liberated and non-liberated ferrous scrap, wherein said device has a magnet (5) end a continuous belt (4) onto which at a feeding point said mixture is fed, and which continuous belt (4) is driven around drums (2, 3) for the transportation of the scrap mixture to a separation zone (6), wherein magnetic field lines (7) of said magnet (5) are comprised in said separation zone (6), **characterized in that** the magnet (5) is a single dipole magnet placed in the drum (3) distant from the feeding point, which is arranged such that the magnetic field lines (7) are predominally parallel to the belt (4) surface in the separation zone (6).

5. A device (1) according to claim 4, **characterized in that** the magnet (5) is a cylindrical dipole magnet.

6. A device (1) according to anyone of the claims 4 or 5, **characterized in that** in use the belt speed is 2 to 5 m/s, preferably 3 to 4 m/s, most preferably 3.5 m/s and that the magnetic field strength is proportional to the belt speed and arranged such that the magnet (5) has a magnetic field strength of about 0.10 - 0.15 Tesla at said belt speed of 3.5 m/s.

Patentansprüche

1. Ein Trennverfahren für das Trennen von losgelöstem eisenhaltigen Schrott von nicht losgelöstem eisenhaltigen Schrott aus einer Mischung des losgelösten und des nicht losgelösten eisenhaltigen Schrotts, wobei die Mischung an einer Zuführstelle einem Stetigförderband (4) zugeführt wird, welches um Walzen (2, 3) herum für das Transportieren der Schrottmischung zu einer Trennzone (6) hin angetrieben wird, und wobei ein Magnet (5) mit Magnetfeldlinien (7) in der Trennzone (6) verwendet wird, **dadurch gekennzeichnet, dass** der Magnet (5) ein einzelner Dipolmagnet ist, der in der von der Zuführstelle entfernten Walze (3) platziert ist, um zu bewirken, dass die Magnetfeldlinien (7) in der Trennzone (6) überwiegend parallel zu der Oberfläche des Bandes (4) sind.

2. Ein Trennverfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** der Magnet (5) ein zylinderförmiger Dipolmagnet ist.

3. Ein Trennverfahren gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Bandgeschwindigkeit im Betrieb 2 m/s bis 5 m/s , vorzugsweise 3 m/s bis 4 m/s und am bevorzugtesten 3,5 m/s beträgt, und dass die Magnetfeldstärke proportional zu der Bandgeschwindigkeit ist und so ausgelegt ist, dass der Magnet (5) bei der Bandgeschwindigkeit von 3,5 m/s eine Magnetfeldstärke von ungefähr 0,10 Tesla bis 0,15 Tesla aufweist.

4. Eine Trennvorrichtung (1) zum Trennen von losgelöstem eisenhaltigen Schrott von nicht losgelöstem eisenhaltigen Schrott aus einer Mischung des losgelösten und des nicht losgelösten eisenhaltigen Schrotts, wobei die Vorrichtung

einen Magneten (5) und ein fortlaufendes Band (4) aufweist, welchem die Mischung an einer Zuführstelle zugeführt wird, und wobei das fortlaufende Band (4) um Walzen (2, 3) herum für das Transportieren der Schrottmischung zu einer Trennzone (6) hin angetrieben wird, wobei Magnetfeldlinien (7) des Magneten (5) in der Trennzone (6) enthalten sind, **dadurch gekennzeichnet, dass** der Magnet (5) ein einziger in der von der Zuführstelle entfernten Walze (3) platzierter Dipolmagnet ist, der so angeordnet ist, dass die Magnetfeldlinien (7) in der Trennzone (6) überwiegend parallel zu der Oberfläche des Bandes (4) sind.

5. Eine Vorrichtung (1) gemäß Anspruch 4, **dadurch gekennzeichnet, dass** der Magnet (5) ein zylinderförmiger Dipolmagnet ist.

6. Eine Vorrichtung (1) gemäß einem der Ansprüche 4 oder 5, **dadurch gekennzeichnet, dass** die Bandgeschwindigkeit im Betrieb 2 m/s bis 5 m/s, vorzugsweise 3 m/s bis 4 m/s, am bevorzugtesten 3,5 m/s beträgt, und dass die Magnetfeldstärke proportional zu der Bandgeschwindigkeit ist und so ausgelegt ist, dass der Magnet (5) bei der Bandgeschwindigkeit von 3,5 m/s eine Magnetfeldstärke von etwa 0,10 Tesla bis 0,15 Tesla aufweist.

Revendications

1. Procédé de séparation pour séparer des déchets ferreux libérés de déchets ferreux non libérés provenant d'un mélange desdits déchets ferreux libérés et non libérés, lequel mélange est acheminé en un point de chargement sur une courroie de transport continue (4) qui est entraînée autour de tambours (2, 3) pour le transport dudit mélange de déchets à une zone de séparation (6) et dans lequel on utilise un aimant (5) ayant des lignes de champ magnétique (7) dans ladite zone de séparation (6), **caractérisé en ce que** l'aimant (5) est un aimant dipolaire unique placé dans le tambour (3) éloigné du point de chargement en faisant en sorte que les lignes de champ magnétique (7) soient principalement parallèles à la surface de la courroie (4) dans la zone de séparation (6).

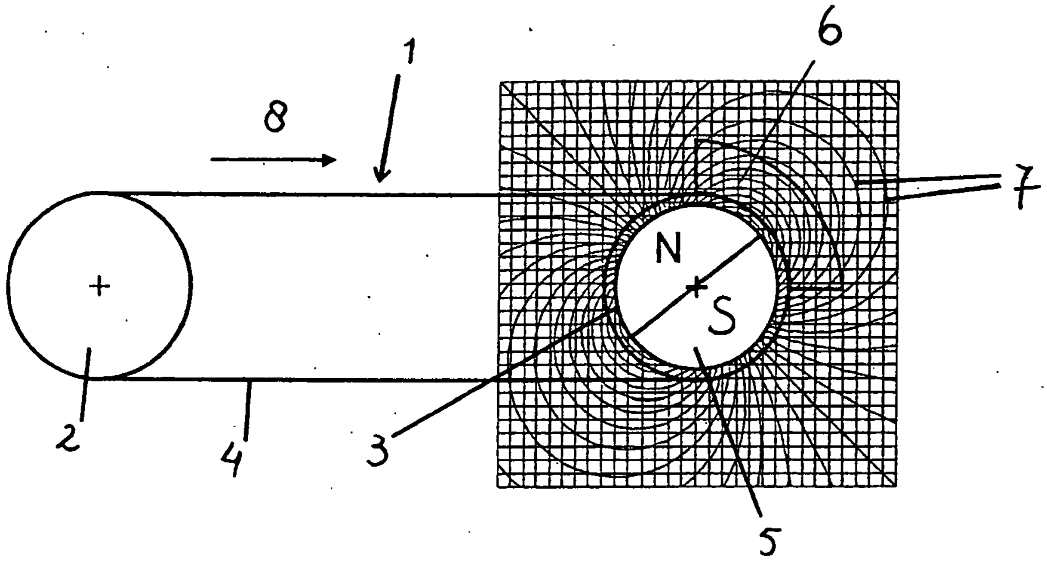
2. Procédé de séparation selon la revendication 1, **caractérisé en ce que** l'aimant (5) est un aimant dipolaire cylindrique.

3. Procédé de séparation selon la revendication 1 ou 2, **caractérisé en ce qu'**en service, la vitesse de la courroie est de 2 à 5 m/s, de préférence de 3 à 4 m/s, mieux encore de 3,5 m/s, et **en ce que** l'intensité du champ magnétique est proportionnelle à la vitesse de la courroie et est telle que l'aimant (5) présente une intensité de champ magnétique d'environ 0,10 à 0,15 Tesla à ladite vitesse de la courroie de 3,5 m/s.

4. Dispositif de séparation (1) pour séparer des déchets ferreux libérés de déchets ferreux non libérés provenant d'un mélange desdits déchets ferreux libérés et non libérés, dans lequel ledit dispositif présente un aimant (5) et une courroie continue (4) sur laquelle ledit mélange est acheminé en un point de chargement et laquelle courroie continue (4) est entraînée autour de tambours (2, 3) pour le transport du mélange de déchets à une zone de séparation (6), des lignes de champ magnétique (7) dudit aimant (5) étant comprises dans ladite zone de séparation (6), **caractérisé en ce que** l'aimant (5) est un aimant dipolaire unique placé dans le tambour (3) éloigné du point de chargement, qui est agencé de sorte que les lignes de champ magnétique (7) soient principalement parallèles à la surface de la courroie (4) dans la zone de séparation (6).

5. Dispositif (1) selon la revendication 4, **caractérisé en ce que** l'aimant (5) est un aimant dipolaire cylindrique.

6. Dispositif (1) selon l'une quelconque des revendications 4 ou 5, **caractérisé en ce qu'**en service, la vitesse de la courroie est de 2 à 5 m/s, de préférence de 3 à 4 m/s, mieux encore de 3,5 m/s et **en ce que** l'intensité du champ magnétique est proportionnelle à la vitesse de la courroie et telle que l'aimant (5) présente une intensité de champ magnétique d'environ 0,10 à 0,15 Tesla à ladite vitesse de la courroie de 3,5 m/s.



FIGURE

REFERENCES CITED IN THE DESCRIPTION

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- WO 8805696 A **[0013]**
- US 3057477 A **[0015]**
- EP 0455948 A **[0016]**