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(54) **SINTERING OF BRIQUETTES BY DFI BURNERS**

SINTERN VON BRIKETTS ANHAND VON DFI-BRENNERN

FRITTAGE DE BRIQUETTES PAR DES BRULEURS DFI

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Database accession no. 8926654 & ACTA
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Description

[0001] The invention relates to a method for sintering a green body briquette of a metal powder, which is heated by means of at least one DFI burner and is directly exposed to the flame(s) of said DFI burner.

[0002] The invention relates to the field of sintering of briquettes from metal powder. Sintering is defined as the thermal treatment of a powder or compact at a temperature below the melting point of the main constituent, for the purpose of increasing its strength by bonding together of the particles.

[0003] The metal powder is pressed into so called green body briquettes and these are sintered at an elevated temperature. During the sintering process atomic diffusion takes place and the powder particles are welded together. The reason for the sintering is to produce a briquette that has enough strength to resist transportation to and handling by the end user. A typical weight of such a briquette is 100 g.

[0004] It is state of the art to sinter metal briquettes, for example nickel briquettes, at a temperature between 700 and 1000 °C. A long continuous mesh belt furnace is normally used. As an example, such a furnace can be 30 m long and consists of three temperature zones, a 5 m pre-heating zone, a 10 m sintering zone and a 15 m cooling zone. The furnace is electrically heated. The mesh belt transports the briquettes through the furnace at e.g. a speed of 10 m/hour, that is the total process time is about 3 hours.

[0005] Thus, the prior art sintering is a slow process. Due to the inefficient heating the mesh belt has to be operated at a low speed of and the furnace must have a long length, for example 30 m. Such large furnaces represent a significant investment. In order to increase the productivity of such a furnace, the furnace would have to be built even longer.

[0006] JP 2000-026903 relates to a sintering method of noble metal-containing clay. A plastic clay composition obtained by kneading a metallic powder and a binder with water is formed. The formed body is sintered by applying the flame of a gas burner wherein the flame is controlled to be reducing.

[0007] It is an object of the invention to provide a method for sintering metal briquettes which is faster than the prior art sintering processes and which requires less investments.

[0008] The Ni briquettes start to oxidize in air at temperatures over 400 °C. As oxidation is time dependent a long exposure time to temperatures over 400 °C as it is necessary in the prior art furnaces is a disadvantage. Therefore, depending on quality requirements, in the prior art sintering furnaces a nitrogen rich atmosphere is sometimes being used to protect the briquettes from oxidation.

[0009] Thus, a further object of the invention is to provide a method for sintering metal briquettes which avoids or at least reduces the oxidation of the briquettes during

sintering.

[0010] These objects are achieved by the method of claim 1.

[0011] The invention relates to the method of claim 1 for sintering of metal powders which are pressed into so called green body briquettes. The term "briquette" shall also cover any kind of a body or compact of metal powder. In the following the invention will be explained with reference to the preferred embodiment of sintering briquettes of metal powders. However, for the man skilled in the art it is obvious that the invention as described in the following can also be used for sintering of metal powders in any other form rather than briquettes.

[0012] According to the invention this is achieved by heating the metal powder or the briquette by means of DFI burners where "DFI" is an abbreviation for "direct flame impingement". The DFI burners are located such that the metal powder or the briquette are exposed to the flame (DFI flame) of the DFI burner, that is the DFI flame directly impinges the surface of the briquette. The DFI flame or the DFI flames completely enclose the briquette such that the whole briquette is within the DFI flame.

[0013] According to a preferred embodiment said DFI burner(s) are fed with a gaseous or liquid fuel and an oxidant containing more than 80% per weight of oxygen, preferably more than 90 %, more preferred more than 95 %. Thus, preferably an oxyfuel burner is used as DFI burner.

[0014] Preferably, the heat treatment by means of the DFI burners is carried out while the briquettes are in motion. Therefore, the briquettes are loaded on a transport system, especially on a conveyor belt, mesh belt or link belt, and passed through the flame(s) of said DFI burner (s).

[0015] For heating the briquette one or more DFI burners can be used. The number of DFI burners depends among others on the required or desired heating power.

[0016] Preferably, the sintering process is carried out in a short furnace and said DFI burner(s) are located at the roof of the furnace. The dimensions of a typical furnace for carrying out the invention are: length between 2 and 4 m, width between 0.5 and 1.5 m and height between 1.5 and 2.5 m.

[0017] The flame of the DFI burner directly hits the surface of the briquette or metal powder and heats it up. Thereby a high heat transfer to the metal powder and a high heating rate are achieved. As a consequence the exposure time, that is the time the metal powder or briquette is subjected to heat, can be considerably decreased. As an example a load of 1 ton briquettes per hour can be heated using DFI burners with a heating power of 100 to 300 kW.

[0018] According to a preferred embodiment the metal powder is exposed to the flame(s) of said DFI burner(s) for less than 2 minutes, more preferred between 30 and 90 seconds. It has been found that within that during that heating time and during the subsequent cooling to room temperature the sintering process can be completed and

briquettes are produced which have enough strength to resist transportation and further handling by the end user.

[0019] Due to the short exposure time oxidation of the metal powder does not constitute a problem. Consequently it becomes possible to carry out the heating by means of said DFI burner(s) in an atmosphere containing the products of combustion.

[0020] After the inventive heating process by means of the DFI burners the sintered briquette is preferably transported to a silo or other storage system for cooling and storage. Since the briquette might leave the DFI flames at a temperature above 400 °C there is a certain risk that the briquette starts to oxidize. Therefore, it is preferred to inert that silo or storage system by an inert gas, preferably nitrogen or argon.

[0021] The invention can be used for sintering of any kinds of metal powders, however the preferred field of application is the sintering of briquettes of nickel powder. The Ni powder is for example produced via reduction of NiSO₄ with hydrogen. A typical weight of such nickel briquettes is between 50 and 500 grams, preferably between 100 and 200 grams.

[0022] The inventive heating process is preferably used to carry out the complete sintering process. That is the briquettes leaving the DFI flames have received and/or accumulated enough energy to achieve the required strength. However, it is also possible to use the DFI burners only for pre-heating the metal powder or briquettes and subsequently pass the pre-heated briquettes to a conventional sintering furnace which might be heated by electrical means as described in the introductory part of this specification.

[0023] The invention as well as preferred embodiments of the invention will be described in more detail below with reference to the attached drawings, where:

- figure 1 shows a first embodiment of the invention and
- figure 2 shows an alternative embodiment of the invention.

[0024] Nickel powder is produced by reduction of NiSO₄ with hydrogen. The nickel powder is then pressed to green body briquettes 1. The green body briquettes 1 are placed onto a conveyor belt 2 and transported to a short furnace 3 with a length of 2 to 4 m. The furnace 3 is heated by means of DFI oxyfuel burners 4 which are fed with a fuel gas and an oxidant containing more than 90 weight-% oxygen.

[0025] The DFI oxyfuel burners 4 are located in the roof of the furnace 3 and its flame is directed vertically from above onto the conveyor belt 2. The briquettes 1 pass through the furnace 3. Within the furnace 3 the surface of the briquettes 1 is directly impinged by the flame of the DFI burner 4. The speed of the conveyor belt 2 is such that the briquettes 1 are exposed to the flames of the DFI burners 4 for about 1 minute. After that time the sintering process is completed. The sintered briquettes

5 leave the furnace 3 and fall off the conveyor belt 2.

[0026] Figure 2 shows an alternative embodiment of the invention. In both figures the same reference numbers refer to the same parts. The embodiment according to figure 2 differs from the one according to figure 1 in that the sintered briquettes 5 fall into a silo 6 for cooling and storage. Within the silo 6 an inert atmosphere is created by feeding gaseous nitrogen from a nitrogen storage container 7 into the silo 6. Thus, the sintered briquettes 5 are kept in an inert atmosphere in order to avoid oxidation.

[0027] Example:

Tests were made in lab scale to pre-heat loads of 2 kg briquettes using DFI oxyfuel burners with a heating power of 20 to 50 kW. The residence times of the briquettes in the flame were between 12 and 54 seconds.

[0028] The abrasive strength of the heated briquettes was evaluated. The abrasive strength was found to be the same as for briquettes sintered in a furnace according to prior art. It was found that the DFI process had not only preheated the briquettes but had also completed the sintering process. Surprisingly the complete sintering process could be made during this exceptional short time by using the DFI process. This was also confirmed by studying the macro structure of cut through briquettes. Also no significant oxidation occurred, there was only a slight discoloration of the surface.

Claims

1. Method for sintering a green body briquette of a metal powder (1), which is heated by means of at least one DFI burner (4) and is directly exposed to the flame (s) of said DFI burner (4) **characterized in that** the flame or the flames of said DFI burner(s) (4) completely enclose the briquette such that the whole briquette is within the the flame or the flames of said DFI burner(s).
2. Method according to claim 1 **characterized in that** said metal powder (1) is loaded on a transport system (2), especially a conveyor belt, mesh belt or link belt, and passed through the flame(s) of said DFI burner (s) (4).
3. Method according to any of claims 1 or 2 **characterized in that** said DFI burner(s) (4) are located at the roof of a furnace (3).
4. Method according to any of claims 1 to 3 **characterized in that** said metal powder (1) is exposed to the flame(s) of said DFI burner(s) (4) for less than 2 minutes, more preferred between 30 and 90 seconds.

5. Method according to any of claims 1 to 4 **characterized in that** nickel powder is sintered by means of said DFI burner(s) (4).
6. Method according to any of claims 1 to 5 **characterized in that** said heating by means of said DFI burner (s) (4) is carried out in air atmosphere.
7. Method according to any of claims 1 to 6 **characterized in that** said metal powder (1) are subjected to an inert atmosphere (6, 7) after being heated by means of said DFI burner(s) (4).
8. Method according to any of claims 1 to 7 **characterized in that** said metal powder (1) is first heated by means of said DFI burner(s) (4) and then heated in an electrically heated furnace.
9. Method according to any of claims 1 to 8 **characterized in that** said DFI burner(s) (4) are fed with a gaseous or liquid fuel and an oxidant containing more than 80% per weight of oxygen.

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6. Verfahren nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** das Erhitzen mittels des DFI-Brenners (4) (der DFI-Brenner (4)) in Luftatmosphäre durchgeführt wird.
7. Verfahren nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** das Metallpulver (1) nach Erhitzen mittels des DFI-Brenners (4) (der DFI-Brenner (4)) einer inerten Atmosphäre (6, 7) ausgesetzt wird.
8. Verfahren nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** das Metallpulver (1) zunächst mittels des DFI-Brenners (4) (der DFI-Brenner (4)) erhitzt wird und dann in einem elektrisch beheizten Ofen erhitzt wird.
9. Verfahren nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** dem DFI-Brenner (4) (den DFI-Brennern (4)) ein gasförmiger oder flüssiger Brennstoff und ein mehr als 80 Gew.-% Sauerstoff enthaltendes Oxidationsmittel zugeführt wird (werden).

Patentansprüche

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1. Verfahren zum Sintern eines Grünkörperbriketts aus einem Metallpulver (1), das mittels mindestens eines DFI-Brenners (4) (DFI - direct flame impingement/ direkter Flammenaufprall) erhitzt wird und der (den) Flamme (n) des DFI-Brenners (4) direkt ausgesetzt ist, **dadurch gekennzeichnet, dass** die Flamme (n) des DFI-Brenners (4) (der DFI-Brenner (4)) das Brikkett vollständig umschließt (umschließen), so dass das ganze Brikkett in der (den) Flamme(n) des DFI-Brenners (der DFI-Brenner) liegt.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Metallpulver (1) auf ein Transportsystem (2), insbesondere ein Förderband, Maschenband oder Gliederband, geladen wird und durch die Flamme(n) des DFI-Brenners (4)(der DFI-Brenner (4)) hindurchgeführt wird.
3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der (die) DFI-Brenner (4) am Dach eines Ofens (3) positioniert wird (werden).
4. Verfahren nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das Metallpulver (1) für weniger als 2 Minuten, vorzugsweise zwischen 30 und 90 Sekunden, der (den) Flamme(n) des DFI-Brenners (4) (der DFI-Brenner (4)) ausgesetzt wird.
5. Verfahren nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** Nickelpulver mittels des DFI-Brenners (4) (der DFI-Brenner (4)) gesintert wird.

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Revendications

1. Procédé de frittage d'une brique de corps vert d'une poudre métallique (1), qui est chauffée au moyen d'au moins un brûleur DFI (à impact direct de flamme) (4) et qui est exposée directement à la flamme ou aux flammes dudit brûleur DFI (4), **caractérisé en ce que** la flamme ou les flammes dudit ou desdits brûleurs DFI (4) enveloppent complètement la brique de telle sorte que l'ensemble de la brique se trouve à l'intérieur de la flamme ou des flammes dudit ou desdits brûleurs DFI.
2. Procédé selon la revendication 1, **caractérisé en ce que** ladite poudre métallique (1) est chargée sur un système de transport (2), en particulier une courroie transporteuse, une courroie à mailles ou une courroie à chaînons, et passe à travers la ou les flammes dudit ou desdits brûleurs DFI (4).
3. Procédé selon l'une quelconque des revendications 1 ou 2, **caractérisé en ce que** ledit ou lesdits brûleurs DFI (4) sont situés sur le toit d'un four (3).
4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** ladite poudre métallique (1) est exposée à la ou aux flammes dudit ou desdits brûleurs DFI (4) pendant moins de 2 minutes, de préférence entre 30 et 90 secondes.
5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** de la poudre de nickel est frittée au moyen dudit ou desdits brûleurs DFI (4).

6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** ledit chauffage au moyen dudit ou desdits brûleurs DFI (4) est effectué dans une atmosphère d'air. 5
7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** ladite poudre métallique (1) est soumise à une atmosphère inerte (6, 7) après avoir été chauffée au moyen dudit ou desdits brûleurs DFI (4). 10
8. Procédé selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** ladite poudre métallique (1) est d'abord chauffée au moyen dudit ou desdits brûleurs DFI (4), puis est chauffée dans un four chauffé électriquement. 15
9. Procédé selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** ledit ou lesdits brûleurs DFI (4) sont alimentés en un carburant gazeux ou liquide et en un oxydant contenant plus de 80% en poids d'oxygène. 20

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Fig. 1

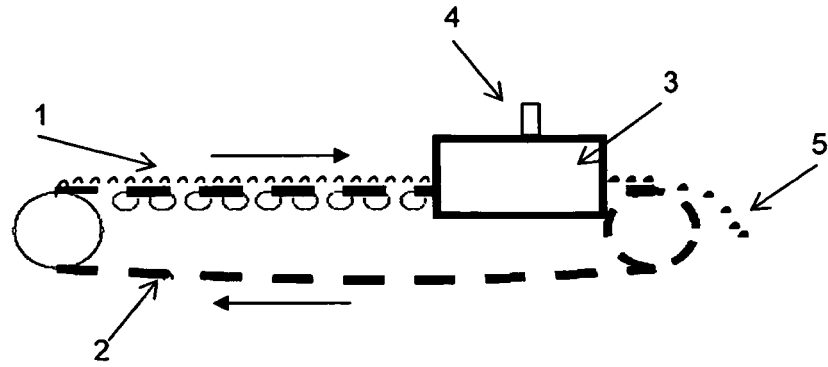
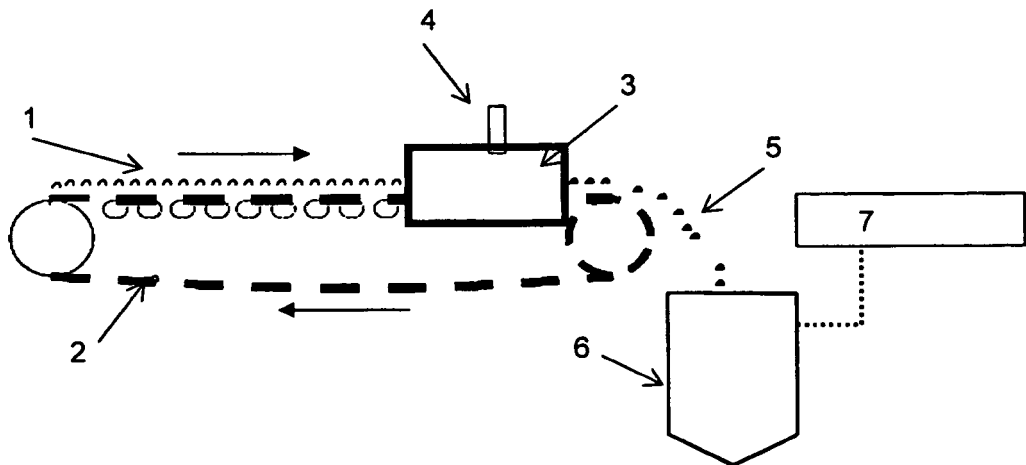


Fig. 2



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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