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(54) **METHOD FOR ADJUSTING PRECURSOR POWDER FOR SINTERING, AND PRECURSOR
POWDER FOR SINTERING**

VERFAHREN ZUR HERSTELLUNG EINES PRECURSOR-PULVERS ZUM SINTERN UND
PRECURSOR-PULVER ZUM SINTERN

PROCÉDÉ D'AJUSTEMENT D'UNE POUDRE DE PRÉCURSEUR POUR FRITTAGE, ET POUDRE
DE PRÉCURSEUR POUR FRITTAGE

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a method for adjusting a precursor powder for sintered ore to be used in a blast furnace, and to a precursor powder for sintered ore produced by the method.

BACKGROUND ART

10 **[0002]** For stable and highly efficient operation of a blast furnace, it is important to use high-quality sintered ore with excellent properties, such as cold strength, reducibility, and anti-reduction-disintegration properties. However, such sintered ore has many control requirements to be met in production, which presents difficulties in improving the yield and productivity of products.

[0003] Sintered ore is generally produced as follows.

15 Firstly, coke which is a condensation material, a CaO-containing auxiliary raw material such as limestone, a SiO₂-containing auxiliary raw material such as nickel slag, and the like are added to and mixed with iron ore having particles with a particle size of about 10 mm or less, and the mixture is mixed and granulated in a drum mixer or the like with the addition of a proper amount of water. Thereafter, the granular raw materials for sintered ore thus obtained are charged, along with coke breeze, to a pallet of a sintering machine and a raw material layer for sintered ore is formed on the
20 pallet. Then, the raw material layer for sintered ore is ignited with solid fuels on the surface layer part thereof. Then, under the influence of air, solid fuels in the raw material layer for sintered ore are sequentially combusted and sintered to form a sinter cake. The sinter cake is crushed to more uniformly-sized particles and those particles having a particle size above a certain level are fed to a blast furnace as sintered ore.

That is, sintered ore results from agglomeration of iron ore in response to the iron ore being fused by reaction with fluxes, or slag components, such as CaO and SiO₂.
25

[0004] Here, recent years have seen a tremendous growth in demand for steel materials, particularly, in emerging markets such as in Asia. As the demand for steel materials grows, there is an increasing need for sintered ore to be used in a blast furnace and for iron ore as the raw material thereof.

[0005] The increase in demand for iron ore is presenting a new challenge that has not been faced before. That is, it is becoming more difficult to freely choose the quality of iron ore to be supplied. In particular, for example, more iron ore supplied to the industry show considerable variations in particle size distribution.
30 Additionally, as mentioned above, conventional problems of improving product yield, productivity, and the like still remain unsolved. This means that there is an increasing demand for higher sintered ore production efficiency, despite large variations in particle size distribution of iron ore.

35 **[0006]** In producing sintered ore, coke breeze contained in a raw material is combusted with air passing through a raw material layer for sintered ore. This means that the productivity of sintered ore can be determined by the air flow rate (air permeability) through the raw material layer for sintered ore. In addition, air permeability is generally divided into two categories: air permeability under cold condition before sintering, which is determined by the particle size of iron ore and the like; and air permeability under hot condition during and/or after sintering, which is determined by the
40 size of pores in sinter cake that are air passages formed by the flow of a melt. The former, which is determined by the particle size of iron ore and the like, is susceptible to the aforementioned variations in the quality of iron ore raw materials, which has posed, in particular, a major challenge to recent efforts to improve productivity.

[0007] JP 2008-019455 discloses a method for producing a half-reduced sintered ore using iron ore, carbonaceous material and auxiliary raw material as a sintering raw material. The method includes a step of forming grains using part
45 of the sintering raw material by compression-forming and making pelletized grains using the remaining of the sintering raw material.

SUMMARY OF INVENTION

50 (Technical Problem)

[0008] The solutions that have been proposed to date, however, are not necessarily effective for solving the aforementioned problems.

55 **[0009]** The present invention has been made in view of the above situations, and an object thereof is to provide a method for adjusting a precursor powder for sintered ore to be used in a blast furnace and a precursor powder for sintered ore that are excellent in sintered ore production efficiency, despite variations in the particle size of iron ore raw materials.

(Solution to Problem)

[0010] The inventors of the present invention have made intensive studies on solutions to the aforementioned problem. As a result, the inventors discovered that for improved sintered ore production efficiency it is effective to adjust, in a precursor powder for sintered ore, the mixing ratio of the mass of particles of a predetermined shape in coke breeze to the mass of particles of a predetermined shape in an iron ore raw material within a certain range. That is, according to the present invention, in particular, air permeability under cold condition before sintering may be provided by changing the properties of the coke breeze depending on the quality of the iron ore raw material (with variations in particle size), to provide excellent air permeability (JPU index) in a precursor powder for sintered ore (a raw material for sintered ore after granulation and pseudo-granulation) in a sintering pallet, thereby offering improved sintered ore production efficiency.

[0011] The present invention is based on the above discoveries and the primary features thereof are as follows.

[1] A method for adjusting a precursor powder for sintered ore, comprising:

mixing and granulating an iron ore raw material, coke breeze, and an auxiliary raw material in a drum mixer to obtain a precursor powder for sintered ore; and
charging the precursor powder to a sintering machine where the precursor powder is sintered to produce sintered ore to be used in a blast furnace,

wherein the mixing and the granulating are performed with a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material being adjusted in the range of 2 % to 3 %.

[2] The method for adjusting a precursor powder for sintered ore according to the aspect [1], wherein the mixing ratio $[(C/F) \times 100]$ is set in the range of 2.2 % to 2.8 %.

[3] A precursor powder for sintered ore to be used in a blast furnace, the precursor powder comprising:

an iron ore raw material;
coke breeze; and
an auxiliary raw material,

wherein a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material is set in the range of 2 % to 3 %.

[4] The precursor powder for sintered ore according to the aspect [3], wherein the mixing ratio $[(C/F) \times 100]$ is set in the range of 2.2 % to 2.8 %.

(Advantageous Effect of Invention)

[0012] According to the present invention, even if there are variations in the quality (particle size distribution) of iron ore raw materials, it is possible to reliably obtain excellent air permeability (JPU index) in a precursor powder for sintered ore in a sintering pallet, thereby effectively improving sintered ore production efficiency.

BRIEF DESCRIPTION OF DRAWINGS

[0013] The present invention will be further described below with reference to the accompanying drawings, wherein:

FIG. 1 is a graph showing the relationship between the JPU and the mixing ratio $[(C/F) \times 100]$ of coke breeze to iron ore raw material.

DESCRIPTION OF EMBODIMENTS

[0014] The present invention will now be described in detail below.

The present invention involves: mixing an iron ore raw material, coke breeze, and an auxiliary raw material in a drum mixer to obtain a precursor powder for sintered ore; and then charging the precursor powder to a sintering machine for sintering the precursor powder to thereby produce sintered ore to be used in a blast furnace. In this case, in particular, an appropriate combination of the iron ore raw material and the coke breeze with a particular focus on the respective particle sizes, as described later, ensures high productivity at the time of sintering, namely, high air permeability (JPU

index, which will be simply referred to as "JPU") of a precursor powder for sintered ore in a sintering pallet, which is given by Equation (1) below. Note that a larger JPU represents better air permeability; a JPU of about 22 or more is a particularly good result in terms of the productivity of producing sintered ore.

$$\text{JPU} = [\text{air flow rate (m}^3/\text{min)} / \text{sintering area (m}^2)] \cdot [\text{layer thickness (mm)} / \text{negative pressure (mmAq)}]^{0.6} \quad \text{Equation (1)}$$

where "air flow rate" is an air flow rate through a precursor powder for sintered ore for a certain sintering area; "sintering area" is a loading area of the precursor powder for which the aforementioned air flow rate is measured; "layer thickness" is a layer thickness of the precursor powder where the air flow rate is measured; and "negative pressure" is an atmospheric pressure in a wind box below the precursor powder.

Note that 1 mmAq = 9806.38 Pa.

[0015] In the present invention, particle size is measured by a sieve classification method (JIS R6001 (1998)).

Note that examples of the iron ore raw material used in the present invention include hematite ore from South America, magnetite ore from North America, magnetite ore from South America, pisolite ore and Marra Mamba ore from Australia, and the like.

[0016] In the present invention, a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material is adjusted in the range of 2 % to 3 %. It should be noted that to determine F, the mass of the iron ore raw material is calculated excluding the mass of return ore.

[0017] It is believed that a good JPU may be obtained by controlling the aforementioned mixing ratio $[(C/F) \times 100]$ via the following mechanism. When the aforementioned mixing ratio is small, i.e., less than 2, the particle size of the iron ore is considered to be larger than that of the coke breeze. Thus, when the particle size of the coke breeze is too small, sintering rate increases, yet a sintering molten zone becomes wider, thereby deteriorating the air permeability under hot condition. On the other hand, when the mixing ratio is large, i.e., more than 3, the particle size of the coke breeze is coarsened so much that formation of pseudoparticles for which the coke breeze serves as nuclear particles becomes apparent during the granulation process. Such pseudoparticles for which the coke breeze serves as nuclear particles cannot gain proper strength due to low wettability of the coke breeze and tend to collapse during the handling process before charged to a sintering pallet, with the result that more refined pseudoparticles are charged to the sintering pallet to deteriorate air permeability.

It is thus apparent that there is an appropriate ratio of the particle size of the coke breeze to that of the ore, which can be expressed by $C/F \times 100$ and is, as mentioned earlier, in the range of 2 % to 3 %. Note that a preferred range of the aforementioned $C/F \times 100$ is from 2.2 % to 2.8 %.

[0018] In the present invention, the auxiliary raw material is not particularly limited to a CaO-containing auxiliary raw material such as limestone, a SiO_2 -containing auxiliary raw material such as nickel slag, and the like, and may include other general, well-known auxiliary raw materials used in precursor powders for sintered ore and inevitably-incorporated impurities.

In addition, the mixing ratio thereof is defined so that CaO/SiO_2 (= basicity) is around 2.0 in the resulting sintered ore.

[0019] The drum mixer used in the present invention may be a normal drum mixer that is commonly utilized in the production of a precursor powder for sintered ore, such as a drum mixer with a cylindrical cone.

[0020] In addition, the sintering machine used in the present invention is preferably a bottom-suction Dwight Lloyd type sintering machine. Other well-known sintering machines may also be used for producing a precursor powder for sintered ore.

[0021] As described above, according to the present invention, it is possible to provide a precursor powder for sintered ore to be used in a blast furnace that comprises an iron ore raw material, coke breeze, and an auxiliary raw material and is excellent in production efficiency.

That is, a precursor powder for sintered ore may be obtained, with a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material, excluding return ore, being in the range of 2 % to 3 %, and preferably in the range of 2.2 % to 2.8 %.

No particular limitation is placed on the conditions other than those specified above, such as the material of the precursor powder, the facility and its operational conditions use, and the precursor powder may be produced according to the conventional methods.

EXAMPLES

[Example 1]

5 **[0022]** Precursor powders for sintered ore were adjusted under the following conditions. Then, the resulting precursor powders were fully charged to a bottom-suction Dwight Lloyd type sintering machine to produce sintered ore.

[0023] The inventors examined JPU during sintering of the precursor powders to identify the effect of the present invention.

10 **Iron ore raw material**

[0024]

- Basic unit of iron ore raw material: 1100 to 1200 (kg/t-sr)
- 15 - Percentage of particles having a particle size of 3 mm or more in iron ore raw material: 30 % to 40 % (of the charged raw material)

Coke breeze

20 **[0025]**

- Basic unit of coke breeze: 45 to 50 (kg/t-sr)
- Percentage of particles having a particle size of 3 mm or more in coke breeze: 5 % to 20 % (of the coke breeze)
- Mixing ratio $[(C/F) \times 100]$: 1.2 % to 3.5 %
- 25 - Auxiliary raw material (limestone): 6 % to 10 % (of the charged raw material)

[0026] FIG. 1 shows a relationship between the JPU and the mixing ratio $[(C/F) \times 100]$ of particles having a particle size of 3 mm or more in the coke breeze to particles having a particle size of 3 mm or more in the iron ore raw material. It can be seen from the figure that each precursor powder for sintered ore that was produced with a mixing ratio $[(C/F) \times 100]$ satisfying the conditions of the present invention exhibited a good result in terms of JPU, which was determined to be about 22 or more.

In contrast, each precursor powder for sintered ore produced with a mixing ratio $[(C/F) \times 100]$ not satisfying the conditions of the present invention yielded a poor result in terms of JPU, which was determined to be about 19 to 21, i.e., not more than 21, as shown in FIG. 1.

35

[Example 2]

[0027] An example in which the present invention was implemented in an actual machine will be described below.

40 **[0028]** As usual, an iron ore raw material to be used in a sintering process was subjected to automatic sampling in a raw material yard, and then measurements were made of the particle size distribution of the obtained samples in accordance with the Japanese Industrial Standards, JIS 8706.

[0029] For coke breeze, as usual, undersized lump coke, which had been produced in a coke plant, and the purchased anthracite were sent to a sintering plant, where they were milled to have a suitable particle size distribution for operation. The resulting products thus obtained were used in the sintering process.

45 **[0030]** The milling was performed in a rod mill, a cage mill, a ball mill, and the like.

[0031] Then, samples were collected from the pulverized coke breeze by a sampler provided at a belt conveyor transfer point, and dried in a dryer. A Ro-tap type sieve shaker was used to measure the particle size distribution of each sample.

[0032] According to the present invention, the milling conditions for the coke breeze were adjusted to change the presence ratio of particles having a particle size of 3 mm or more in the coke breeze depending on the particle size composition of the received iron ore, i.e., the presence ratio of particles having a particle size of 3 mm or more in the iron ore.

50 **[0033]** Table 1 shows the measurements of JPU and the mixing ratio $[(C/F) \times 100]$ of particles having a particle size of 3 mm or more in the coke breeze to particles having a particle size of 3 mm or more in the iron ore raw material (ore). Here, let X (kg/t) be coke component, Y (kg/t) be ore I component, and Z (kg/t) be ore II component, and let x (%) be the percentage of particles having a particle size of 3 mm or more in the coke component, y (%) be the percentage of particles having a particle size of 3 mm or more in the ore I component, and z (%) be the percentage of particles having a particle size of 3 mm or more in the ore II component, then $C = X \times x$, and $F = Y \times y + Z \times z$.

55

[Table 1]

[0034]

Table 1

Test No.	Coke Component (kg/t)	Ore I Component (kg/t)	Ore II Component (kg/t)	Percentage of Coke Particles with Particle Size of 3 mm or more (%)	Percentage of Ore I Particles with Particle Size of 3 mm or more (%)	Percentage of Ore II Particles with Particle Size of 3 mm or more (%)	(C/F)*100	JPU
1	49.7	678	86	18.2	44.3	34.0	2.75	24.7
2	49.2	683	96	20.3	44.3	34.0	2.98	24.0
3	47.4	710	107	22.1	44.3	34.0	2.99	23.5
4	50.0	686	80	17.3	43.4	42.0	2.61	25.1
5	45.2	805	37	24.1	43.4	42.0	2.98	23.9
6	49.9	676	86	16.0	43.4	42.0	2.42	24.5
7	45.9	797	46	23.6	43.4	42.0	2.97	23.7
8	46.8	788	0	14.0	38.5	-	2.16	22.5
9	45.8	779	40	20.6	38.5	42.0	2.98	24.1
10	45.9	688	153	21.5	38.5	42.0	3.00	23.3

[0035] It can be seen from Table 1 that those precursor powders for sintered ore that were produced with a mixing ratio $[(C/F) \times 100]$ satisfying the conditions of the present invention exhibited good results in terms of JPU, which was determined to be about 22 or more.

In contrast, other precursor powders for sintered ore produced with a mixing ratio $[(C/F) \times 100]$ not satisfying the conditions of the present invention yielded poor results in terms of JPU, which was determined to be about 19 to 21, i.e., not more than 21, as shown in Table 1.

[0036] In addition, when lines capable of classification and milling of iron ore are available, the mixing ratio C/F as specified in the method of the present invention may be obtained by adjusting the milling conditions for not only coke breeze, but also for coarse particles in iron ore.

INDUSTRIAL APPLICABILITY

[0037] According to the present invention, a precursor powder for sintered ore that offers excellent sintered ore production efficiency may be obtained. The present invention may also improve productivity and maintain air permeability in a blast furnace, and consequently increase sintered ore yield and sintered ore strength, thereby allowing for stable and highly efficient operation of the blast furnace.

Claims

1. A method for adjusting a precursor powder for sintered ore, comprising:

mixing and granulating an iron ore raw material, coke breeze, and an auxiliary raw material in a drum mixer to obtain a precursor powder for sintered ore; and
charging the precursor powder to a sintering machine where the precursor powder is sintered to produce sintered ore to be used in a blast furnace,

wherein the mixing and the granulating are performed with a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material being adjusted in the range of 2 % to 3 %.

2. The method for adjusting a precursor powder for sintered ore according to claim 1, wherein the mixing ratio $[(C/F) \times 100]$ is set in the range of 2.2 % to 2.8 %.

3. A precursor powder for sintered ore to be used in a blast furnace, the precursor powder comprising:

an iron ore raw material;
coke breeze; and
an auxiliary raw material,

wherein a mixing ratio $[(C/F) \times 100]$ of a mass (C) of particles having a particle size of 3 mm or more in the coke breeze to a mass (F) of particles having a particle size of 3 mm or more in the iron ore raw material is set in the range of 2 % to 3 %.

4. The precursor powder for sintered ore according to claim 3, wherein the mixing ratio $[(C/F) \times 100]$ is set in the range of 2.2 % to 2.8 %.

Patentansprüche

1. Verfahren zum Einstellen eines Precursor-Pulvers für gesintertes Erz, mit:

Mischen und Granulieren eines Eisenerz-Rohmaterials, Koks klein und eines Hilfsrohmaterials in einem Trommelmischer, um ein Precursor-Pulver für gesintertes Erz zu erhalten; und
Zuführen des Precursor-Pulvers in eine Sintermaschine in der das Precursor-Pulver gesintert wird, um ein gesintertes Erz herzustellen, das in einem Hochofen genutzt werden soll,

wobei das Mischen und Granulieren mit einem Mischverhältnis $[(C/F) \times 100]$ einer Masse (C) von Partikeln, die eine

Partikelgröße von 3 mm oder mehr in dem Kokslein aufweisen zu einer Masse (F) von Partikeln, die eine Partikelgröße von 3 mm oder mehr in dem Eisenerz-Rohmaterial aufweisen, in dem Bereich von 2 % bis 3 % eingestellt wird.

2. Verfahren zum Einstellen eines Precursor-Pulvers für gesintertes Erz nach Anspruch 1, wobei das Mischverhältnis $[(C/F) \times 100]$ in dem Bereich von 2,2 % bis 2,8 % eingestellt wird.
3. Precursor-Pulver für gesintertes Erz, das in einem Hochofen verwendet werden soll, wobei das Precursor-Pulver aufweist:

ein Eisenerz-Rohmaterial,
Kokslein; und
ein Hilfsrohmaterial, wobei ein Mischverhältnis $[(C/F) \times 100]$ einer Masse (C) von Partikeln, die eine Partikelgröße von 3 mm oder mehr in dem Kokslein aufweisen zu einer Masse (F) von Partikeln, die eine Partikelgröße von 3 mm oder mehr in dem Eisenerzmaterial aufweisen, in dem Bereich von 2 % bis 3 % eingestellt ist.

4. Precursor-Pulver für gesintertes Erz nach Anspruch 3, wobei das Mischverhältnis $[(C/F) \times 100]$ in dem Bereich von 2,2 % bis 2,8 % eingestellt ist.

Revendications

1. Procédé d'ajustement d'une poudre de précurseur pour minerai fritté, comprenant :

mélanger et granuler une matière première de minerai de fer, du poussier de coke, et une matière première auxiliaire dans un mélangeur à tambour pour obtenir une poudre de précurseur pour minerai fritté ; et charger la poudre de précurseur dans une machine de frittage où la poudre de précurseur est frittée pour produire du minerai fritté devant être utilisé dans un haut fourneau,

dans lequel le mélange et la granulation sont effectués avec un rapport de mélange $[(C/F) \times 100]$ d'une masse (C) de particules ayant une taille de particule de 3 mm ou plus dans le poussier de coke sur une masse (F) de particules ayant une taille de particule de 3 mm ou plus dans la matière première de minerai de fer étant ajusté dans la plage de 2 % à 3 %.

2. Procédé d'ajustement d'une poudre de précurseur pour minerai fritté selon la revendication 1, dans lequel le rapport de mélange $[(C/F) \times 100]$ est défini dans la plage de 2,2 % à 2,8 %.

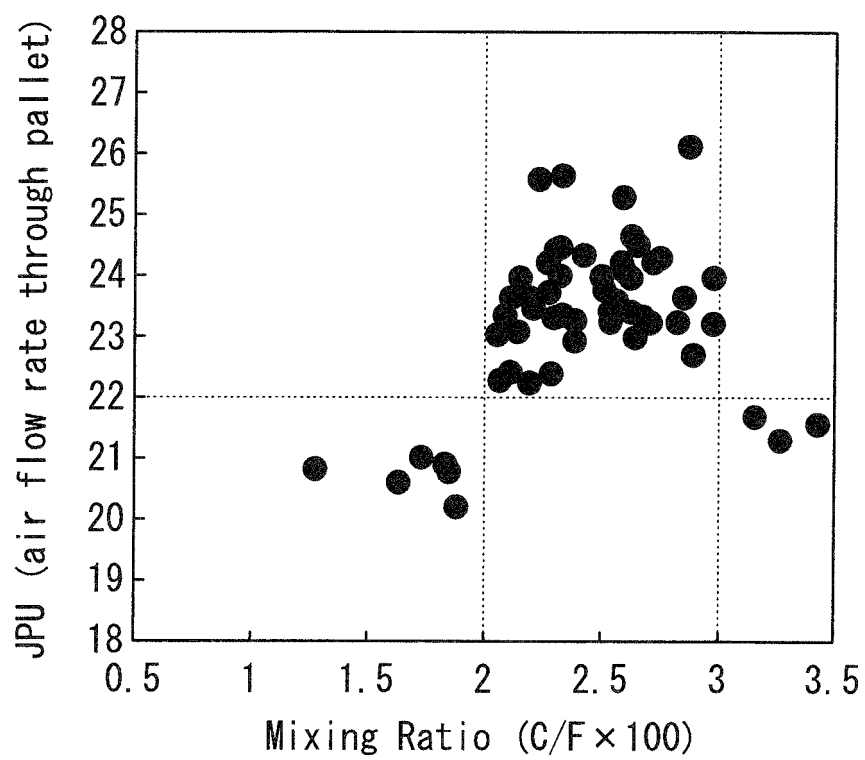
3. Poudre de précurseur pour minerai fritté devant être utilisé dans un haut fourneau, la poudre de précurseur comprenant :

une matière première de minerai de fer;
du poussier de coke ; et
une matière première auxiliaire,

dans laquelle un rapport de mélange $[(C/F) \times 100]$ d'une masse (C) de particules ayant une taille de particule de 3 mm ou plus dans le poussier de coke sur une masse (F) de particules ayant une taille de particule de 3 mm ou plus dans la matière première de minerai de fer est défini dans la plage de 2 % à 3 %.

4. Poudre de précurseur pour minerai fritté selon la revendication 3, dans laquelle le rapport de mélange $[(C/F) \times 100]$ est défini dans la plage de 2,2 % à 2,8 %.

FIG. 1



REFERENCES CITED IN THE DESCRIPTION

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