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(54) Skid member using Fe/Cr dispersion strengthened alloys

Gleitschienenteil benutzend dispersionsverstärkte Eisen-Chrom-Basis-Legierungen

Partie de rail de glissement en usant des alliages à base de fer et de chrome renforcés par dispersion

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Description

The present invention concerns skid rails having a component which is exposed to furnace atmospheres made of a heat-resistant alloy having good strength, and corrosion and oxidation properties at high temperature.

Steel plates and steel wires are produced by rolling steel pieces called slabs or billets after uniformly heating them in a heating furnace such as a walking beam furnace or pusher furnace. If the temperature of the steel piece is lower at the position where the steel piece contacts the furnace bed than at the remaining positions, then uneven thickness of the rolled steel plate or even cracking may occur. In order to avoid these troubles, it is necessary to raise the temperature of the furnace bed at the position of contact with the heated piece to a temperature near the average heating temperature. Thus, at the highest temperatures of use the furnace bed metal attains a high temperature such as 1300°C or higher.

As a typical material for the furnace bed withstanding a high temperature of 1150°C or higher, there has been used a solid solution strengthened type heat-resistant casting alloy, which contains, in addition to Fe, 20-35% Cr, 15-35% Ni and 5-50% Co as the main components, and 0.5-5% Mo, 0.5-5% W and 0.2-4.0% Ta as the solid solution strengthening elements. However, skid rails in the soaking zone of a furnace are subjected to such a high temperature as 1200-1350°C, and suffer from heavy strain and abrasion. The above mentioned conventional heat-resistant casting alloy, of the solid solution strengthened type, is not satisfactory as a material for the skid rails at these high temperatures.

It has been proposed to use ceramics having high heat-resistance and anti-abrasion properties as the material of the furnace bed metal (for example, Japanese Utility Model Publication No. 35326/1989). So-called fine ceramics materials such as SiC and Si_3N_4, preferable from the viewpoint of high shock-resistance, which is one of the properties needed in the skid rails, are easily damaged by oxidation when used in a strongly oxidative atmosphere.

On the other hand, it has been disclosed that super alloys of the oxide-dispersion strengthened type, i.e., Ni-based super alloys in which fine particles of an oxide having a high melting point such as Y_2O_3 are dispersed, are useful as components in gas-turbines and jet-engines (for example, Japanese Patent Publication No. 38665/1981). As to high temperature furnaces, it has been proposed to use an oxide-dispersion strengthened type super alloy of the composition consisting of 12.5-20% Cr, up to 1% Al, up to 0.1% C and up to 0.5% (volume) Y_2O_3, the balance being Ni, as the material for mesh belts (Japanese Patent Publication No. 9610/1984).

In furnaces using heavy oil as the fuel, however, Ni-based super alloys are easily corroded owing to high temperature sulfidation attack by the sulfur in the heavy oil. Furthermore, Ni-based alloys are expensive, and therefore, it is desirable to construct the skid rails with a less expensive alloy. If an Fe-based alloy having equal performance in skid rail service to that of a Ni-based alloy were available, the above desire would be satisfied. Prior art alloys also include those described in JP-A-63157827 and US-A-4427447. The former discloses a heat-resistant Co-based alloy useful for the manufacture of furnace parts such as skid rails, the alloy containing ≤ 0.1% C, ≤ 0.8% Si ≤ 0.8% Mn, 25-30% Cr, 20-30% Ni, 0.5-2% Mo, only 10-20% Fe and ≤ 0.04% P and S. Ceramic particles are dispersed in the alloy.

The latter document (US-A-4427447) relates to metal powder mixtures containing 0-30 wt % Cr, 0-3 wt % Ti, 0.3-10 wt % Al and 0.3-10 wt % of particles of a specified aluminayttria mixed oxide. The mixtures can be mechanically processed into high temperature alloys. In the examples of the document, Cr contents of no higher than 20 wt % are present.

The general object of the present invention is to provide metal components for furnace construction, particularly, skid rails, of higher performance by using a heat-resistant oxide-dispersion strengthened iron-based alloy (or steel).

The furnace component according to the present invention comprises a furnace atmosphere contacting surface made of an oxide-dispersion strengthened type heat resistant alloy consisting, apart from impurities, of 25-40 wt % Cr, up to 5 wt % Al, up to 5 wt % Ti, and the balance of Fe, and containing 0.1-2% of fine particles of a high melting point metal oxide dispersed in the ferrite matrix.

A preferable range of Cr content is 25-35%. Percentages are by weight.

The high melting point metal oxide may be one or more selected from Y_2O_3, ZrO_2 and Al_2O_3. Y_2O_3 gives the best results.

Skid members or rails embodying the invention have been found to exhibit, when used in various furnaces such as heating furnaces for hot processing of steel, excellent properties against heat deformation, oxidation resistance, abrasion resistance, sulfidation resistance and thermal shock resistance, and therefore, can be used for long periods of time. This will decrease maintenance labor of the heating furnaces and facilitates continuous operation thereof. Decreased costs for energy and maintenance result in lower production costs in the hot processing of steel.

In order to produce the above mentioned oxide-dispersion strengthened type alloy, so-called mechanical alloying technology developed by INCO (The International Nickel Co., Inc.) is useful. The technology comprises subjecting powders of metal components and fine crystals of a high melting point metal oxide in a ball mill, for example, a high kinetic energy type ball mill, so as to produce by repeated welding and fracturing a granular product comprising an intimate and uniform mixture of very fine particles of the components. The product prepared by mechanical alloying is then compacted and sintered by hot extrusion or hot isostatic pressing and, if necessary, machined to provide the component of the skid rail.

A typical embodiment of the skid rail of the present invention is, as shown in Figure 1 to Figure 3, a skid rail 1A made by welding metal saddles 3A on a water-cooled skid pipe 2, attaching skid members 4A made of the oxidedispersion strengthened heat-resistant alloy to the saddles and covering all the members except for the skid members 4A with refractory insulator 5.

The skid rails may be of other configurations. For example, a skid structure may use cylindrical saddles to attach button shaped skid members.

In general, nickel-basedoxide-dispersion strengthened type super alloys are stable even at a high temperature, and the above mentioned known nickel-base alloys have alloy compositions suitable for uses such as turbine blades (Japanese Patent Publication No. 56-38665) or mesh belts (Japanese Patent Publication No. 59-9610) and contain suitable amounts of oxide particles. However, these known nickel-base alloys do not have sufficient corrosion-resistance against high temperature sulfidation attack occurring in furnaces having atmosphere resulting from combustion of heavy oil.

By using a skid member made of the above described iron-base oxide-dispersion strengthened alloy it is possible to achieve a high compresssion creep strength, as shown in the working example described later, in addition to the heat-resistance and oxidation-resistance. Thus, less expensive, but more durable skid members are provided.

Criteria associated with the selected alloy compositions employed in the skid members of the present invention are as follows:

In the heat-resistant alloy of the basic composition,

Cr: 25-40%

If the content of Cr is less than the lower limit, the desired heat-resistance is not obtained. On the other hand, if it exceeds the upper limit, an intermetallic compound called "sigma phase" is formed and the material becomes brittle. Preferable range of Cr content is 25-35%.

In the heat-resistant alloy containing optionally added elements,

Al: Up to 5%

In case where a better anti-oxidation property is desired, for example, in the material for the skid rails to be used in heating furnaces with atmosphere containing a relatively large quantity of oxygen (up to several %), up to 5% Al is advantageous for oxidation resistance. Further additions of Al up to 10% also give improved results. Addition of higher amounts will cause occurrence of harmful large inclusions.

Ti: Up to 5%

Ti also contributes to the strength of the alloy and, therefore, is optionally added preferably in amounts up to 5%. Additions in amounts over 10% also causes formation of large inclusions.

High Melting Point Metal Oxide: 0.1-2%

The most preferred metal oxide is, as noted above, Y_2O_3. In skid rails used in heating furnaces of relatively low temperature (up to about 1200°C), the whole or a portion of the Y_2O_3 may be replaced with ZrO_2 or Al_2O_3. Of course, combined use of two or three of Y_2O_3, ZrO_2 and Al_2O_3 is possible. Contents of the high melting point metal oxide should be 0.1% or more. Otherwise, the effect of stabilizing the alloy at a high temperature will not be satisfactory. As the content increases, the effect slows down at about 1% and saturates at 2%, and therefore, a suitable content in this range should be chosen. It should be noted that during processing originally added Y_2O_3 may convert to various yttria-alumina compounds (e.g., YAG) if alumina is copresent.

Figure 1 to Figure 3 illustrate a typical embodiment of the skid rail using an alloy embodying the invention:

Figure 1 being a plan view;
Figure 2 a side elevation view; and
Figure 3 a cross-sectional view.

Oxide-dispersion strengthened type alloys INCOLOY MA956 and improved MA956 groups and having the composition as shown in Table 1 (weight %, the balance being Fe) were prepared by the above noted mechanical alloying process, and the alloys were hot extruded and machined to give testing materials.

The above obtained materials and a conventional skid rail material "TH101" (0.1C-32Cr-21Ni-23Co-2.5W-Zr) were subjected to compression creep test at a very high temperature for determining their durability as a material for the skid rail. The compression creep test is carried out by cramping a columnar test piece of 3mm in diameter and 6.5mm high between a fitting plate and a receiving plate, and applying compressing load at a high temperature. After a certain period of time, the height of the test piece is measured, and the deformation is calculated as the percentage of decrease in height.

Deformation (%) of the materials at various testing conditions are as shown in Table 2.

From reference to the case of a temperature of 1300°C, a stress of 0.4 kgf/cm^2 and a testing period of 30 hours, it is seen that deformation of the conventional material reached 6.14%. In contrast, deformation of the material used in skid rails or skid rail members of the present invention was as small as 0.24%.
Thus, the good results were ascertained.

In practical use in soaking zones of steel heating furnaces, the life of a skid rail embodying the present invention was more than 10 times that of the conventional products.

In the case of alloys No. 3 and No. 4 where a portion of Y_2O_3 was replaced with ZrO_2 or Al_2O_3, when compared to the case of Y_2O_3 used alone the extent of deformation is smaller even at longer testing periods, and the performance is much higher than that of the conventional material. Further, it is expected that, even if whole of Y_2O_3 is replaced with ZrO_2, Al_2O_3 or a combination thereof, the resulting oxide-dispersion reinforced super alloy can be used at a relatively low heating furnace temperature up to around 1200°C.

Table 1

No.	C	Cr	Al	Ti	Metal Oxide	
* 1	0.05	20	4.5	0.5	Y_2O_3	0.5
* 2	0.05	15	5.0	3.0	Y_2O_3	0.8
3	0.05	25	4.0	1.5	Y_2O_3	0.7
					ZrO_2	0.3
4	0.05	33	4.0	0.4	Y_2O_3	0.7
					Al_2O_3	0.3
* 5	0.05	25	5.5	0.5	Y_2O_3	0.5

* (Comparative)

Table 2

Alloy	Testing Conditions	Period (Hrs)			
		20	40	60	80
TH101		3.63	6.94	9.95	13.2
No. 1 (Comparative)		0.07	0.14	0.21	0.28
No. 2 (Comparative)	1200°C	0.06	0.13	0.20	0.27
No. 3	0.9 kgf/mm^2	0.07	0.15	0.20	0.28
No. 4		0.06	0.14	0.20	0.28
No. 5 (Comparative)		0.07	0.14	0.20	0.28
TH101		4.72	7.21	9.83	
No. 1 (Comparative)		0.12	0.24	0.36	
No. 2 (Comparative)	1250°C	0.10	0.22	0.34	
No. 3	0.6 kgf/mm^2	0.11	0.23	0.35	
No. 4		0.10	0.23	0.35	
No. 5 (Comparative)		0.12	0.24	0.37	
		Period (Hrs)			
		10	20	30	
TH101		2.31	4.43	6.14	
No. 1 (Comparative)		0.10	0.20	0.30	
No. 2 (Comparative)	1300°C	0.09	0.17	0.25	

Table 2 (continued)

		Period (Hrs)			
		10	20	30	
No. 3	0.4 kgf/mm^2	0.08	0.16	0.24	
No. 4		0.10	0.19	0.28	
No. 5 (Comparative)		0.11	0.20	0.31	

Claims

1. A Skid member for use in a furnace operating at high temperatures having at least one surface exposed to high temperature furnace atmosphere, characterized in that the skid member is made of an oxide-dispersion strengthened type heat-resistant alloy, which consists, apart from impurities, of 25-40 wt % Cr, up to 5 wt % Al, up to 5 wt % Ti and the balance of Fe, and containing 0.1-2% of fine particles of high melting point metal oxide dispersed in the ferrite matrix.

2. A skid member according to claim 1, wherein the high melting point metal oxide in said heat resistant alloy comprises Y_2O_3.

3. A furnace skid rail comprising skid members (4A) in accordance with claim 1 or claim 2 attached along a skid pipe (2) by saddles (3A).

4. Use of an oxide-dispersion strengthened type heat-resistant alloy as defined in claim 1 or claim 2, as a member subject to heat and abrasion in a high-temperature furnace.

5. Use according to claim 4 in which the metal oxide is Y_2O_3, ZrO_2, Al_2O_3.

Patentansprüche

1. Gleitschienenelement zur Verwendung in einem bei hohen Temperaturen betriebenen Ofen, umfassend zumindest eine der Hochtemperaturatmosphäre des Ofens ausgesetzte Oberfläche, dadurch gekennzeichnet, daß das Gleitschienenelement aus einer mit Oxiddispersion verstärkten, hitzebeständigen Legierung besteht, die abgesehen von Verunreinigungen aus 25-40 Gew.-% Cr, bis zu 5 Gew.-% Al, bis zu 5 Gew.-% Ti und ansonsten aus Fe besteht sowie 0,1-2% Feinteilchen eines hochschmelzenden Metalloxids enthält, die in der Ferritmatrix dispergiert sind.

2. Gleitschienenelement nach Anspruch 1, worin das hochschmelzende Metalloxid in der hitzebeständigen Legierung Y_2O_3 umfaßt.

3. Ofengleitschiene mit Gleitschienenelementen (4A) nach Anspruch 1 oder 2, die über Sättel (3A) entlang eines Gleitschienenrohrs (2) befestigt sind.

4. Verwendung einer in Anspruch 1 oder 2 definierten, mit Oxiddispersion verstärkten, hitzebeständigen Legierung als Element, das in einem Hochtemperaturofen Hitze und Abrieb ausgesetzt ist.

5. Verwendung nach Anspruch 4, worin das Metalloxid Y_2O_3, ZrO_2, Al_2O_3 ist.

Revendications

1. Partie de rail de glissement à utiliser dans un four fonctionnant à de hautes températures ayant au moins une surface exposée à l'atmosphère du four à haute température, caractérisée en ce que la partie de rail de glissement est faite d'un alliage thermorésistant du type renforcé par une dispersion d'oxyde qui consiste, outre les impuretés, en 25-40 % en poids de Cr, jusqu'à 5 % en poids de Al, jusqu'à 5 % en poids de Ti, le reste étant Fe et contenant 0,1-2 % de particules fines d'un oxyde d'un métal à point de fusion élevé, dispersé dans la matrice de ferrite.

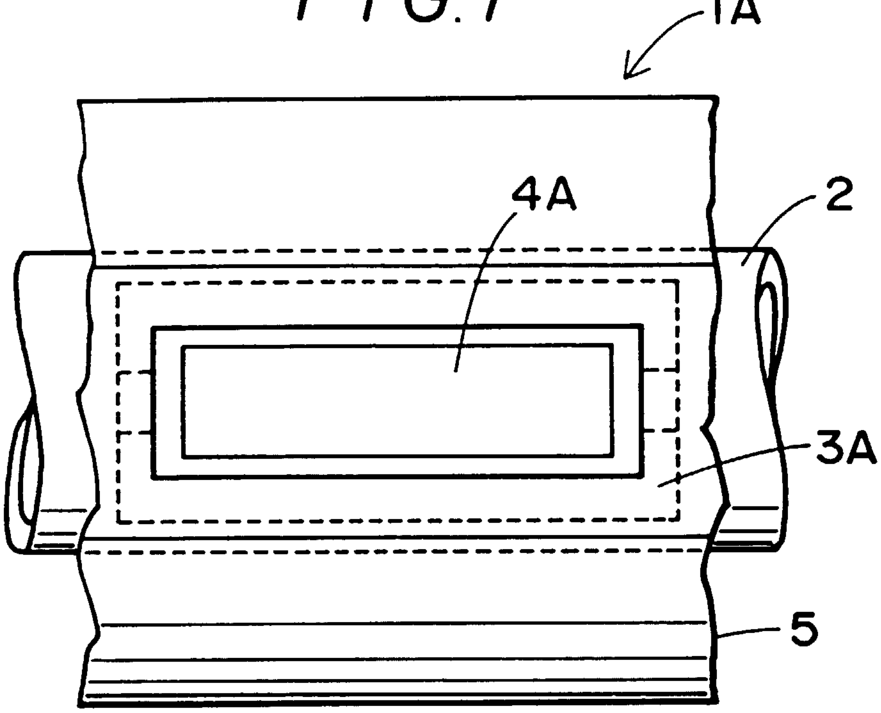
2. Partie de rail de glissement selon la revendication 1, où l'oxyde de métal à point de fusion élevé dans ledit alliage thermorésistant comprend Y_2O_3.

3. Rail de glissement de four comprenant des parties de rail de glissement (4A) selon la revendication 1 ou la revendication 2 attachés le long d'un tube de glissement (2) par des pattes d'attache (3A).

4. Utilisation d'un alliage thermorésistant du type renforcé par une dispersion d'oxyde selon la revendication 1 ou la revendication 2, comme partie soumise à l'usure et à l'abrasion dans un four à haute température.

5. Utilisation selon la revendication où l'oxyde de métal est Y_2O_3, ZrO_2, Al_2O_3.

F I G. 1



F I G. 2

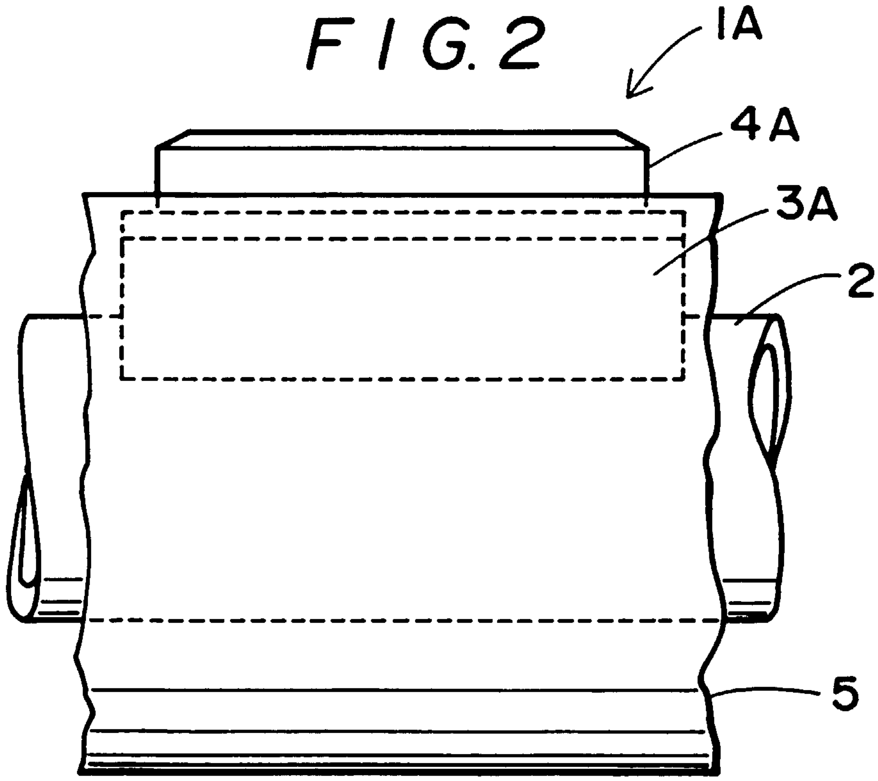


FIG. 3