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㉚ **Ferrous alloy for the working layer of rolling mill rolls.**

㉛ Ferrous alloy for cladding rolling mill rolls by means of casting techniques, endowed with high mechanical strength, wear resistance and thermal fatigue resistance, having a dual phase structure with a martensitic matrix characterized in that it contains carbides only for the globular type, uniformly distributed and with a volume fraction of between 5 and 45%.

The alloy preferably includes:

C	0.6 - 3.0 % by wt
Cr	4.0 - 8.0 % by wt

and at least one element selected from:

Nb	0 - 15.0 % by wt
V	3.0 - 15.0 % by wt
Ti	0 - 15.0 % by wt

the remainder being iron and other elements normally present in alloys of this type, said elements being intercorrelated as per the following mathematical relationships: % Nb + % V + % Ti $\geq$ 1.5
% C - 0.13 % Nb - 0.24 % (Ti + V) = 0.4 - 0.7

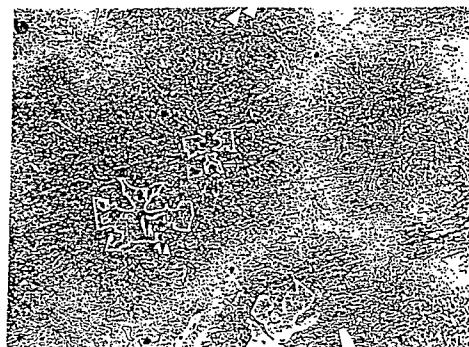


FIG. 1

Description

FERROUS ALLOY FOR THE WORKING LAYER OF ROLLING MILL ROLLS

The object of this invention is the production of a ferrous alloy that can be advantageously used especially for forming the working layer on rolling mill rolls and more generally for making products subject to wear and thermal fatigue.

It is a well known fact that hot and cold rolling mill rolls for flat products are very heavily stressed in the contact zones (working body of roll) with the material to be rolled.

At these points the rolls are subject to wear and thermal fatigue, with consequent crack formation. They are also subject to encrustations of hard oxides coming from the strip or plate (banding), the nature of which must be properly controlled.

A technology has thus been developed for the production of rolls by compound casting methods, preferably centrifugal casting, so as to obtain rolls with a central part consisting of conventional high toughness material (e.g. spheroidal cast iron) clad with a different material, whose thickness depends on the type of use, and in the case of flat rolling is around 70 mm for instance possessing the following characteristics:

- resistance to wear, both localized (comet's tail) and generalized over the whole of the working body of the roll;
- resistance to thermal fatigue under normal rolling conditions and burning in the event of rolling accidents;
- high mechanical strength, especially as regards maintenance of the roll profile;
- ability to form lubricating surface oxides that adhere well to the roll body to counter banding.

Materials presently on the market and adopted for this purpose, namely high-chromium cast irons, are dual-or triple-phase materials containing around 3% C and 10-20% Cr by weight, characterized by a high hardness matrix and by reticular carbides. Said materials have good wear resistance owing to the high volume fraction of said reticular carbides, however, they have low thermal fatigue resistance and little burning resistance. Reticular carbides, are, in fact, considered to be the site of preferential thermal-crack initiation and propagation.

These cracks have a very marked effect on roll life firstly because to eliminate them the whole of the roll surface must be removed to the entire depth of the cracks, thus resulting in reduction in diameter, and secondly because they are held to be the site from which subsequent localized wear starts.

In an attempt to improve thermal fatigue resistance, efforts have been made to reduce the quantity of reticular carbides by lowering the chromium and carbon levels, as described in US Patent 4507366. However, the ensuing material has little wear resistance, not least because of the difficulty of forming lubricating oxide layers during service; this factor has led to very unsatisfactory results, especially when the material is used on finishing rolls where such qualities are most needed.

The necessity was thus felt to develop a material that was not plagued with such drawbacks.

The solution to the problem has been found by developing a material with a martensitic matrix and characterized by the presence of carbides only of the globular type, uniformly distributed throughout the matrix.

Said globular carbides have been obtained through a specific association which links the carbon with elements like Nb, V and Ti that form primary carbides.

The object of this invention is thus the production of a ferrous alloy that can be used to clad rolls by casting techniques, endowed with high mechanical strength and very good wear and thermal fatigue resistance, having a dual phase structure with a martensitic matrix characterized by the fact that it contains only globular carbides uniformly distributed and having a volume fraction between 5 and 45%, preferably 5 and 35%.

The composition of the alloy for achieving these ends preferably includes:

C	0.6 - 3.0 % by wt
Cr	4.0 - 8.0 % by wt

and at least one element selected from:

Nb	0 - 15.0 % by wt
V	3.0 - 15.0 % by wt
Ti	0 - 15.0 % by wt

the remainder being iron and other elements normally present in alloys of this type, said elements being intercorrelated as per the following mathematical relationships: $\% \text{Nb} + \% \text{V} + \% \text{Ti} \geq 1.5$
 $\% \text{C} - 0.13 \% \text{Nb} - 0.24 \% (\text{Ti} + \text{V}) = 0.4 - 0.7$

This ferrous alloy can advantageously include between 0.5 and 5.0 % Mo by wt. Other elements such as Mn and/or Si and/or Ni can be present in the alloy to control hardenability. The preferred quantities of these elements are 0.5-1.5 % Mn by wt, 0.5-1.5 % Si by wt and up to 2 % Ni by wt.

The martensitic structure with globular carbides as per the invention is obtained by casting techniques, e.g.

centrifugal casting known to experts in this field, whereby it is possible to optimize carbide dimensions to suit the end use by appropriately adapting process parameters. For instance, it is preferable to have mostly small carbides when thermal fatigue resistance is to be favoured, while a greater quantity of larger carbides is preferred when the aim is better wear resistance.

Moreover, conventional quenching and tempering treatments on the as-cast alloy as per the invention enable a structure with primary, secondary and tertiary globular carbides to be obtained in a tempered martensitic matrix, thus further increasing mechanical strength. As stated, the formation of globular carbides is held to be closely tied in with the quantities of carbon and of elements like Nb, V and Ti which readily form carbides, while the low levels of chromium are such that with a similar combination of elements, non-reticular primary carbides are produced. These carbides are held to be responsible not only for the high wear resistance, but particularly for the high thermal fatigue resistance of the alloy as per the invention.

Then, too, such a low quantity of chromium, together with the other alloy elements, ensures that at roll operating temperatures (typically between 400 and 700 °C) surface oxides are formed which are adherent due to the presence of chromium and Nb and/or V and/or Ti. Said oxides, which exert lubricating action and prevent the plate or strip from sticking to the rolls, lengthen the life of the latter.

A major advantage of the alloy as per the invention stems from the fact that the above characteristics are attained without subjecting the ensuing products to mechanical working after production of the alloy by melting and casting. Hence the alloy is particularly suitable for use in all those products requiring a dual phase structure like the one described, without having to be subjected to mechanical working processes.

A further advantage of the alloy which makes it particularly suitable in the hot rolling field stems from the fact that by varying the concentrations of the specific elements within the ranges defined, it is possible to achieve the optimum combination of wear resistance and thermal fatigue resistance to suit the desired use (roughing stands, first finishers or final finishers).

To further clarify the invention but without in any way restricting its scope, two alloys have been prepared whose compositions (in wgt %) are given below (the remainder to 100 being essentially Fe).

ELEMENT	C	Mn	Si	Cr	Mo	Ti	Nb
SAMPLE							
6.1	1.24	1.07	1.17	5.52	0.58	0.06	6.29
7.3	1.26	0.99	1.16	5.80	0.50	0.42	4.43

The as-cast samples were subjected to heat treatment at 1000 °C, then cooled in still air and tempered at 500 °C.

As illustrated by Figs 1 and 2, the microstructures obtained (5% Nital etching) consist of primary globular carbides dispersed in a martensitic matrix containing no reticulate carbides. Hardnesses exceeded 600 HV.

Claims

1) Ferrous alloy for cladding rolling mill rolls by casting techniques, endowed with high mechanical strength, wear resistance and thermal fatigue resistance, having a dual phase structure with a martensitic matrix characterized in that it contains carbides only of the globular type, uniformly distributed and with a volume fraction of between 5 and 45%.

2) Ferrous alloy as per Claim 1 in which the volume fraction is between 5 and 35%.

3) Ferrous alloy as per Claim 1, including:

C 0.6 - 3.0 % by wt

Cr 4.0 - 8.0 % by wt

and at least one element selected from:

Nb 0 - 15.0 % by wt

V 3.0 - 15.0 % by wt

Ti 0 - 15.0 % by wt

the remainder being iron and other elements normally present in alloys of this type, said elements being intercorrelated as per the following mathematical relationships: % Nb + % V + % Ti $\geq$ 1.5

% C - 0.13 % Nb - 0.24 % (Ti + V) = 0.4 - 0.7

4) Alloy as per Claim 3 including between 0.5 and 5.0 % Mo by wt.

5) Alloy as per Claim 3 including at least one element selected from Mn in a quantity variable between

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0.5 and 5.0 % by wt, Si in a quantity variable between 0.5 and 1.5 by wt and Ni up to 2 % by wt.

6) Products made with Claim 1 alloy that are not subjected to mechanical working.

7) Rolling stands with rolls clad with the alloy as per Claim 1.

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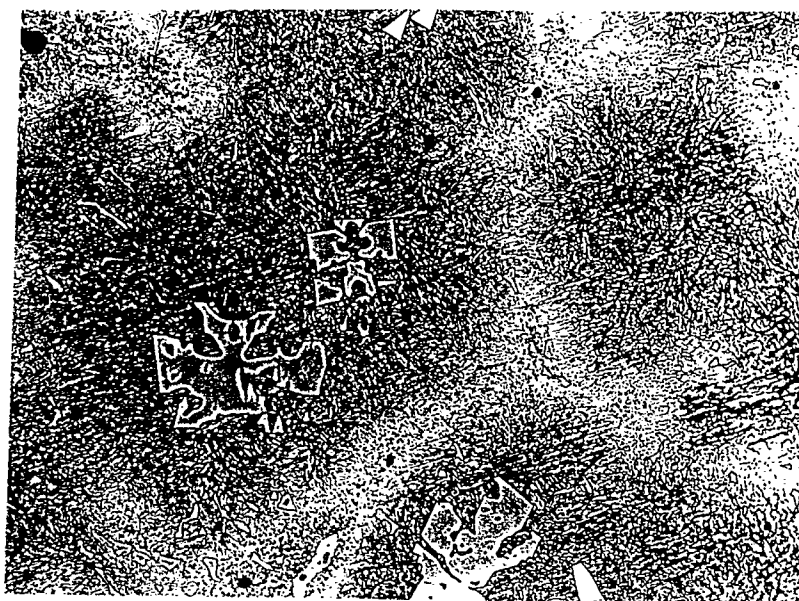
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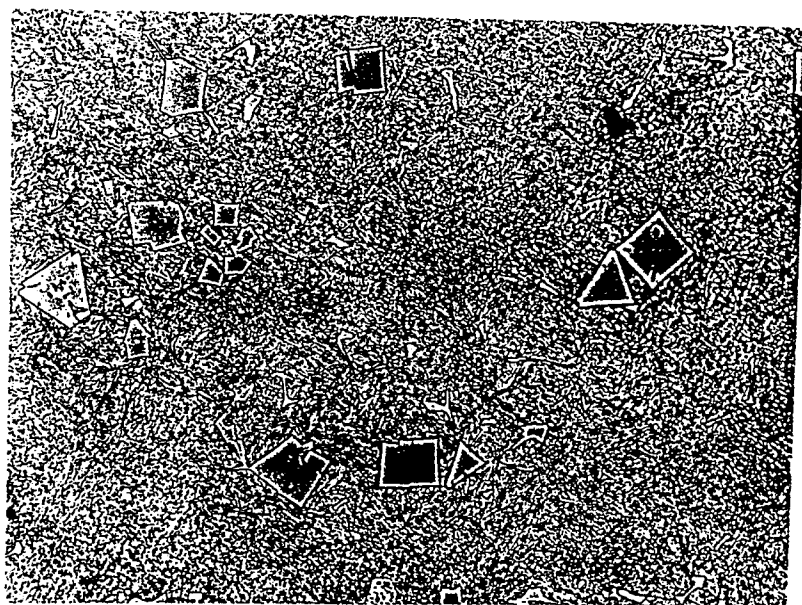
65



X 500

Nital 5%

FIG.1



X 500

Nital 5%

FIG.2



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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-3 901 690 (PHILIP et al.) * Claim 9; columns 3,4; table I; examples 1-8 * ---	1,3	C 22 C 38/24 C 22 C 38/26 C 22 C 38/28 C 22 C 38/36 B 21 B 27/00
X	DE-B-1 225 871 (GEBR. BÖHLER & CIE AG) * Whole document * ---	1,3	
Y	GB-A-1 140 070 (NATIONAL TWIST DRILL & TOOL CO.) * Claims 1,3,4; page 3, examples 1-3 * ---	3	
Y	GB-A- 669 396 (GEBR. BÖHLER & CO. AG) * Whole document * ---	3	
A	US-A-3 367 770 (FLETCHER et al.) * Claims 1-4; table I * ---	3	
A	SU-A- 339 593 (MOISEEV et al.) * Whole document * -----	3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			C 22 C 38 B 21 B 27/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13-09-1989	Examiner LIPPENS M.H.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	