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**EP 0 264 528 A1**

(54) **Non-ledeburitic high speed steels.**

(57) This invention relates to non-ledeburitic high-speed steels containing tungsten and/or molybdenum as main alloying components, especially containing by weight 6.0 to 7.0 % of tungsten, or 5.0 to 6.0 % of molybdenum, or totally 1.0 to 6.0 % of tungsten and molybdenum and, moreover, 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of chromium, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, up to 4.0 % of nickel, 0.2 up to 0.5 % of zirconium, 0.4 up to 1.5 % of silicon, up to 0.03 % of sulphur, up to 0.03 per cent of phosphorus and having a total content of titanium and niobium from 1.5 up to 6.0 % and properly a balanced carbon content according to the following formula:
$0.5 + 0.2 [\%\ Ti + \%\ Nb + \%\ Zr + (\%\ V - 1)] < \%\ C < 0.65 + 0.26 [\%\ Ti + \%\ Nb + \%\ Zr + (\%\ V - 1)]$.

## Non-ledeburitic high-speed steels

This invention relates to non-ledeburitic high-speed steels containing as the main alloying component tungsten and /or molybdenum.

Those skilled in the art know from FRG Patent Specification No. 2,846,889 high-speed tungsten steel containing 6.0 to 7.0 per cent of tungsten by weight, and from FRG Patent Specification No. 2,937,724 high-speed molybdenum steel containing 5.0 to 6.0 per cent of molybdenum by weight and , finally, from the USSR Patent Specification No. 3,322,988 high-speed tungsten-molybdenum steel containing totally 1.0 to 6.0 per cent of tungsten and molybdenum. It is also well known that the above mentioned steels can contain the following amounts of other constituents by weight: 1.2 up to 2.3 per cent of carbon, 3.0 up to 7.0 per cent of chromium, 1.0 up to 1.3 per cent of vanadium, up to 1.5 per cent of manganese, 0.2 up to 0.5 per cent of zorconium, 0.4 up to 1.5 per cent of silicon,up to 0.4 per cent of nickel, up to 0.03 per cent of sulphur, up to 0.03 per cent of phosphorus, up to 1.5 per cent of titanium and/or niobium and other elements in the form of unavoidable impurities.

These steel after having been cast exhibit ledeburitic structure and after plastic working a considerable microsegregation of carbides which leads to deformation and cracking of tools during heat treatment and strongly varying usefulness.

These undesirable phenomena encountered in the above mentioned steels are caused by improperly chosen contents of alloying elements.Thus, if the content of tungsten, molybdenum and vanadium is insufficient and does not correspond to the limiting solubility of these elements in martensite,no secondary hardness is observed during tempering process and the required hardness greater than 62 HRC cannot be obtained. On the other hand, the required chromium content is essential for ensuring the desired considerable hardening capacity.An improper amount of niobium and titanium in the afore mentioned steels leads in effect to the appearance of a pseudo-binary eutectic in the structure. If carbon content is not good then the required hardening capacity cannot be obtained.

The nature of the invention comprises to introduce in steel another steel containing by weight 6.0 to 7.0 per cent of tungsten, or 5.0 to 6.0 per cent of molybdenum, or 1.0 to 6.0 per cent of tungsten and molybdenum totally, and moreover, 1.2 up to 1.3 per cent of vanadium, up to 1.5 per cent of manganese, 0.2 up to 0.5 per cent of zirconium, 0.4 up to 1.5 per cent of silicon, up to 0.4 per cent of nickel, up to 0.03 per cent of sulphur, up to 0.03 per cent of phosphorus and some other elements in the form of unavoidable impurities, as well as 1.5 up to 6.0 per cent of titanium and niobium totally with the properly balanced carbon content acc. to the following formula:

$$0.5 + 0.2\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)] < \%\,C < 0.65 + 0.26\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)].$$

Steels acc. to the invention contained in the casting form no carbon eutectics. Moreover, these steels does not exhibit, both after having been cast or plastic worked, any macro-or microsegregation of carbides. After final heat treatment, the structure of these steels exhibits a uniform distribution of primary carbides of titanium, niobium and zirconium, as well as secondary carbides containing mainly tungsten, molybdenum and vanadium in tempered martensite matrix and a small amount of retained austenite.

If an alloy with a carbon content smaller than that given on the left hand side of the presented inequality is produced, then the matrix of that alloy will contain a stable ferrite. Such an alloy cannot attain high enough hardness exceeding 62 HRC and cannot be treated as high-speed steel.

If an alloy with a carbon content greater than that on the right-hand side of the presented inequality has been produced, then its structure will contain a considerable amount of carbon eutectics with molybdenum and tungsten carbides. It will exhibit both macro-as well as microsegregation of carbides.

Examples of chemical compositions of steels

| | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| C | 1.5 | 1.9 | 1.7 | 2.3 | 1.2 | 2.3 |
| W | 6.4 | 6.2 | 2.0 | 2.0 | - | - |
| Mo | - | - | 3.0 | 2.8 | 5.2 | 5.0 |
| Cr | 4.5 | 4.4 | 4.5 | 4.3 | 4.0 | 4.0 |
| V | 1.3 | 1.2 | 1.3 | 1.3 | 1.3 | 1.0 |
| Mn | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Zr | 0.4 | 0.4 | 0.2 | 0.4 | 0.4 | 0.4 |
| Si | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Ni | 0.3 | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 |
| P | 0.028 | 0.03 | 0.026 | 0.012 | 0.023 | 0.026 |
| S | 0.03 | 0.03 | 0.022 | 0.024 | 0.026 | 0.022 |
| Ti | 3.0 | 3.0 | 2.7 | 6.0 | 1.5 | 3.0 |
| Nb | - | 3.0 | 1.8 | - | - | 3.0 |

## Claims

1. Non-ledeburitic high-speed tungsten steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of chromium, 6.0 to 7.0 % of tungsten, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 to 0.5 % of zirconium, 0.4 to 1.5 % of silicon, up to 0.4 % of nickel, up to 0.03 % of sulphur, up to 0.03 % of phosphorus, characterized in that it contains totally 1.5 to 6.0 % of titanium and niobium.

2. Non-ledeburitic high-speed steel according to claim 1, characterized in that is has a properly balanced carbon content according to the inequality:
$0.5 + 0.2\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)] < \%\,C < 0.65 + 0.26\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)]$.

3. Non-ledeburitic molybdenum high-speed steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of molybdenum, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 to 0.5 % of zirconium, 0.4 to 1.5 % of silicon, up to 0.4 % of nickeL, up to 0.03 % of sulphur, up to 0.03 % of phosphorus, characterized in that it contains totally 1.5 to 6.0 % of titanium and niobium.

4. Non-ledeburitic high-speed steel according to claim 3, characterized in that it has a properly balanced carbon content according to the following inequality:
$0.5 + 0.2\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)] < \%\,C < 0.65 + 0.26\,[\%\,Ti + \%\,Nb + \%\,Zr + (\%\,V - 1)]$.

5. Non-ledeburitic tungsten-molybdenum high-speed steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of chromium, 1.0 to 6.0 % of tungsten and molybdenum, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 up to 0.5 % of zirconium, 0.4 up to 1.5 % of silicon, up to 0.4 % of nickel, up to 0.03 % of phosphorus, characterized in that it contains totally by weight 1.5 to 6.0 % of titanium and niobium.

6. Non-ledeburitic high-speed steel according to claim 5, characterized in that it has a properly balanced carbon content according to the following inequality:
0.5 + 0.2 [% Ti + % Nb + % Zr + (% V - 1)] <% C <0.65 + 0.26 [% Ti + % Nb + % Zr + (% V - 1)].

7. The use of the steel according to claims 1 to 6 for the manufacturing of tools.

Claims for the following contracting state: AT

1. A process for producing non-ledeburitic high-speed tungsten steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of chromium, 6.0 to 7.0 % of tungsten, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 to 0.5 % of zirconium, 0.4 to 1.5 % of silicon, up to 0.4 % of nickel, up to 0.03 % of sulphur, up to 0.03 % of phosphorus, characterized in that totally 1.5 to 6.0 % of titanium and niobium are added.

2. The process according to claim 1, characterized in that the non-ledeburitic high-speed tungsten steel has a properly ballanced carbon content according to the inequality:
0.5 + 0.2 [% Ti + % Nb + % Zr + (% V - 1)] <% C <0.65 + 0.26 [% Ti + % Nb + % Zr + (% V - 1)].

3. A process for the production of a non-ledeburitic molybdenym high-speed steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of molybdenum, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 to 0.5 % of zirconium, 0.4 to 1.5 % of silicon, up to 0.4 % of nickeL, up to 0.03 % of sulphur, up to 0.03 % of phosphorus, characterized in that totally 1.5 to 6.0 % of titanium and niobium are added.

4. The process according to claim 3, characterized in that the non-ledeburitic high-speed steel has a properly ballanced carbon content according to the following inequality:
0.5 + 0.2 [% Ti + % Nb + % Zr + (% V - 1)] <% C <0.65 + 0.26 [% Ti + % Nb + % Zr + (% V - 1)].

5. A process for the production of non-ledeburitic tungsten-molybdenum high-speed steel containing by weight 1.2 to 2.3 % of carbon, 4.0 to 7.0 % of chromium, 1.0 to 6.0 % of tungsten and molybdenum, 1.0 to 1.3 % of vanadium, up to 1.5 % of manganese, 0.2 up to 0.5 % of zirconium, 0.4 up to 1.5 % of silicon, up to 0.4 % of nickel, up to 0.03 % of phosphorus, characterized in that totally by weight 1.5 to 6.0 % of titanium and niobium are added.

6. A process according to claim 5, characterized in that the non-ledeburitic high-speed steel has a properly ballanced carbon content according to the following inequality:
0.5 + 0.2 [% Ti + % Nb + % Zr + (% V - 1)] <% C <0.65 + 0.26 [% Ti + % Nb + % Zr + (% V - 1)].

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# EUROPEAN SEARCH REPORT

Application Number

EP 87 10 5124

## 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) |
|---|---|---|---|
| A | DE-B-1 271 409 (FUJIKOSHI KOZAI KOGYO K.K.)<br>* Whole document * | 1,3,5 | C 22 C 38/22<br>C 22 C 38/24<br>C 22 C 38/26<br>C 22 C 38/28<br>C 22 C 38/36 |
| A | EP-A-0 105 861 (VEREINIGTE EDELSTAHLWERKE AG)<br>* Claim * | 1,3,5 | |
| A | US-A-4 116 684 (UCHIDA et al.)<br>* Claims 1-5 * | 1,3,5 | |
| A | US-A-3 692 515 (FLETCHER et al.)<br>* Claims 1-7 * | 1,3,5 | |
| A | US-A-3 367 770 (FLETCHER et al.)<br>* Claims 1-4 * | 1,3,5 | |

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

C 22 C 38

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 29-12-1987 | LIPPENS M.H. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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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

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