

European Patent No. 90890280.2-

The invention relates to a cold work steel according to the preamble of Claim 1 and the use of this steel for components and tools.

Cold work steels are used for the working of materials at temperatures below 250° C, particularly at room temperatures. Working of this kind may or may not be chipping, and the components or tools are subject to different stresses at the same time. Account is taken of the predominant stress(es) and/or required property (properties) of the part such as compression strength, hardness, toughness, wear resistance, cutting edge retention, and optionally, erodibility and the like usually by choosing an appropriate cold work steel composition.

To fulfil requirements for e.g. high wear resistance it is known to use Cr steels with contents of 1.5 to 2.5 % C and 10 to 17 % Cr like, for example, in steels corresponding to DIN material No. 1,2379 or AISI-Type D 7.

Although steels of this kind usually have high wear resistance the toughness thereof is low due to their high and coarse carbide levels usually arranged in lines so that bending or shear stresses may cause the part to crack or chip.

Wear resistant cold work steel, produced according to a powder metallurgy process and having very high impact strength, is known from EP-A1 0275475 and has a composition from substantially 1.0 to 2.5 % by weight of C, 6.5 to 11.0 % by weight of Cr and 3.0 to 7.0 % by weight of V, the remainder being iron.

To produce cold work tools with good toughness it is known to use alloys with about 5% or about 8 % Cr and a carbon content of about 1.0 % or about 0.5 % with additions of Mo, W and V like, for example, steels according to DIN material No. 1,2363 or material No. 1,2362 and also material No. 1,2345 or AISI type A2. These steels can have good toughness properties and adequate eroding and abrasive performance when they have a favourable crystalline structure and/or carbide structure, but their wear resistance and the compression strength are not suitable for some fields of application. A die steel with improved impact strength contains in % by weight Nb 0.05 to 0.1, Al 0.03 to 0.08 and Ca 0.003 to 0.005 in a steel base with substantially C 0.75 to 0.85, Cr 4.2 to 4.7, Mo 0.7 to 1.0, W 1.7 to 2 and V 0.8 to 1 according to SU 1,073,321 (Chemical Abstracts 100:178630j). A super high-speed steel based on Mo is also known from CH-A5 585 799

with a large cutting capacity with substantially in % by weight 1.05 to 1.50 C, 4.0 to 5.0 Cr, 5.0 to 6.0 W and which has 6.05 to 6.95 Mo, 2.16 to 4.5 V, 0.1 to 4.0 Nb and 0.11 to 0.25 N in addition to iron. The alloy variants, those with Cr contents of 10 to 17 % and those with 5 to 8 % Cr also have the disadvantage that they do not usually retain hardness adequately and that the hardness of the basic material obtained using the preceding hardening and tempering process is reduced when there is an additional surface hardening by nitriding and/or carbonitriding or a CVD or PVD process at temperatures between 350 and 600 ° C.

It is the object of the invention to use the action of the alloy elements synergetically in a particular field of concentration and to produce a cold work steel with high compression strength which has a high degree of hardness, toughness, wear resistance and erodibility, and which produces dies and punches with good grindability and with cutting edge resistance, optionally, when processes for hardening and/or coating surfaces are used which can be carried out at elevated temperature, the mechanical properties of the basic material obtained using the preceding hardening and tempering process are not critically adversely affected.

This object is attained according to the category by the invention as characterised in the claims.

In the case of the cold work steel according to the invention it is important for the carbon content and the nitrogen content and also the elements producing the preferred carbides and/or nitrides and corresponding to the carbon and nitrogen affinity and tendency to produce carbides and/or nitrides, to be aligned with each other.

Excessively high carbon contents of above 1.5 % cause proportionally large, even coarse carbide grains causing the material to have bad toughness properties, and at contents of below 0.6% the required mechanical properties, particularly the degree of hardness, are not obtained. Chromium, molybdenum, tungsten and vanadium are added to the alloy to form carbides and, according to the invention, the respective concentration of these elements takes account of the interaction and/or the mutual effect. It is therefore important that during heat treatment those carbides, which are separated submicroscopically during tempering at temperatures of above 500° C, dissolve, bring about a high degree of hardness or an increase in secondary hardness to a certain extent and cause the steel to retain hardness to a large extent. Aluminium and silicon which particularly constrict the γ field of alloying, are required for several reasons. It is surprisingly found that the hardening and tempering behaviour of the steel and the hardening resistance thereof are substantially

improved by these ferrite-producing elements in the required fields of concentration. At the appropriate nitrogen content of alloying, nitrides are also produced which prevent grain growth during hardening and/or austenitizing at high temperatures. Aluminium and silicon have a advantageous effect for surface hardening by nitriding or carbonitriding and/or surface coating using a CVD or PVD process or a similar process. Niobium is a very strong carbide-producing element, and even finely separated niobium carbides are dissolved only with difficulty during hardening, and also at high temperatures of austenitizing.

However high niobium contents in the carbon concentrations of cold work steels lead to coarse niobium-carbide grains so that the maximum concentration of niobium which is added by alloying is 0.5%.

In comparative studies it was found that the steels according to DIN material No. 1.2363 and material No. 1.2379 have a admissible specific pressure load of 2785 N/mm or 3026 N/mm² and also a tempering hardness at 550 °C of 56 HRC or 60 HRC. The cold work steel according to the invention has at least one admissible specific pressure loadability of 3022N/mm², a tempering hardness of 63.5 HRC and a toughness improved by 28% in relation to material No. 1.2379.

The invention is explained in greater detail below with reference to the examples of the embodiment.

Example 1:

From a steel A according to the invention with a composition of % by weight

C = 0.89

Si = 0.98

Mn = 0.43

Cr = 8.96

Mo = 1.82

V = 0.38

Al = 1.33

Nb = 0.04

N = 0.028

and from an alloy D according to material No. 1.2379 with

C = 1.53

Si = 0.32

Mn = 0.31

Cr = 11.15

Mo = 0.64

V = 0.92

similar punching tools are produced for producing valve discs from 17 % Cr steel with a strength of 624 N/mm² and a thickness of 1 mm. The stamp and the die of steel A had a degree of hardness of 63 HRC and 64,629 punchings could be carried out. In spite of the fact that the degree of hardness of steel D is only insignificantly lower at 62 HRC only 20,751 punchings were possible which corresponds to the tool according to the invention increasing output by about 300 %.

Example 2

For extrusion tools for pressing video heads from aluminium, a steel B was used with the composition of % by weight

C = 1.09

Si = 0.94

Mn = 0.36

Cr = 8.24

Mo = 2.14

W = 0.23

V = 0.54

Al = 1.06

Nb = 0.08

N = 0.043

and an alloy D as mentioned in the preceding example. The surface of the tool made of steel B was enriched in a bath nitriding process at about 570° C with nitrogen according to which the degree of hardness of the basic material was 63.5 HRC. This tool was used to produce 407,320 pressings without excessive wear occurring whereas the tool made from steel D was eliminated after 239,865 pressings.

Example 3

Cold stamping tools for Pilger milling seamless tubes made of Cr-Ni steel were produced from steel D, from steel C with a composition of % by weight

C = 1.22

Si = 0.81

Mn = 0.38

Cr = 7.63

Mo = 2.57

V = 1.08

Al = 0.47

Nb = 0.15

N = 0.021

and from a steel G with a composition of % by weight

C = 0.96

Si = 0.34

Mn = 0.56

Cr = 5.06

Mo = 0.93

V = 0.18

(material No 1,2363)

6,120 metres of ready-to-use tubing could be produced and/or put through a Pilger mill using steel D, 12,764 metres using steel C according to the invention and 5,087 metres using steel G.

Claims

1. A cold work steel with high compression strength and the following composition in % by weight

C	0.6 to	1.5
Si	0.2 to	1.6
Mn	0.2 to	1.2
Cr	5.0 to	10.0
Mo	to	3.0
W	to	6.0
(Mo+2W)	1.0 to	3.0
V	0.3 to	1.5
Al	0.2 to	1.6
Nb	to	0.5
N	to	0.1

the remainder being iron and impurities caused by production.

2. A cold work steel according to Claim 1, characterised in that it has

Nb	0.02 to	0.35
N	0.01 to	0.06

in % by weight.

3. A cold work steel according to Claim 1 or 2, characterised in that it has

C	0.8 to	1.3
Si	0.7 to	1.4
Mn	0.3 to	1.2
Cr	6.0 to	9.0
Mo	to	3.0
W	to	3.0
(Mo+2W)	1.0 to	3.0
V	0.5 to	1.3
Al	0.4 to	1.4
Nb	0.04 to	0.3
N	0.015 to	0.04

in % by weight.

4. A cold work steel according to one of Claims 1 to 3, characterised in that it has

C	0.9 to	1.2
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Si	0.8 to 1.2
Mn	0.3 to 1.0
Cr	7.0 to 9.0
Mo	to 2.5
W	to 5.0
(Mo+2W)	1.5 to 2.5
V	0.6 to 1.2
Al	0.5 to 1.3
Nb	0.06 to 0.2
N	0.02 to 0.35

in % by weight.

5. A use of a cold work steel according to one of the previous Claims 1 to 4, for components and tools with a wearing course produced at elevated temperature.
6. A use of a cold work steel according to Claim 5, characterised in that the layer near to the surface has a higher nitrogen and/or carbon content and, by way of example, is applied by nitriding, carbonitriding or carburizing at temperatures below 600° C, in particular between 350°C and 570°C.
7. A use of a cold work steel according to Claim 5 characterised in that a hard material layer is applied using a CVD or PVD process or a similar process at temperatures below 600°C, in particular below 570°C.
8. A use of cold work steel according to one of Claims 1 to 7, for punching tools.

