(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 378 925 A1**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **89313419.7**

(51) Int. Cl.[5]: **C22C 33/02, C22C 38/24**

(22) Date of filing: **21.12.89**

(30) Priority: **27.12.88 JP 330078/88**

(43) Date of publication of application: **25.07.90 Bulletin 90/30**

(84) Designated Contracting States: **AT DE FR GB IT SE**

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(54) **Powdered steel for cold processing tool.**

(57) Disclosed is a powdered high speed tool having good wear resistance used for producing cold processing tools such as forging molds and rolling rollers.

The powdered high speed tool steel essentially consists of 1.5 - 5.0 % of C, up to 3.0 % of Si, up to 3.0 % of Mn 10 - 30 % of Cr, 0.5 - 4.0 % of Mo, 0.1 - 10 % of V and the balance substantially of Fe, provided that the followings are met:

$F(C) = Cr + 15.5C \geq 40$, and

$F(H) = 3.8C - 0.62Cr \geq -5$.

The steel may optionally further contain up to 10 % of Mo in the range that W + 2Mo is up to 8.0 %.

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POWDERED STEEL FOR COLD PROCESSING TOOL

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention concerns improvement in powdered steel for producing cold processing tools used under severe conditions. The tools made with this powdered steel have high wear resistance and of good hardenability, and further, of high hardness and high toughness.

State of the Art

As the material for producing tools for cold processing of metals, there has been used, in the field of melted materials, various steels for cold tools represented by SKD 11. SKD 11 is a steel of a good wear resistance and relatively high toughness, and therefore, is a material easy to use.

Because of the recent trend of larger-size and more precision in cold processing tools, such as increased demand for large cold forging molds and desire to minimize clearance of punching dies, vacuum heat treatment has come to be use more and more because it causes less distortion during the heat treatment.

In the vacuum heat treatment, cooling is carried out by gas cooling, and therefore, it is difficult to increase the cooling rate. Further, due to the mass effect imposed by the larger objects to be treated, wear resistant and high toughness materials of good hardenability have been demanded.

The wear resistance of SKD 11 is given mainly by the carbides of M_7C_3 type and $M_{23}C_6$ type, which are eutectic. If the quantities of the carbides are increased for the purpose of hightening the wear resistance, then the toughness decreases to shorten the life of the presision dies.

On the other hand, from the view point of high wear resistance and toughness with good balance therebetween, high speed tool steels such as SKH 51 are better than the usual alloyed tool steels. However, it is difficult to increase the hardenability thereof,because the carbides are mainly of M_6C type and MC type, and the steels may not exhibit the wear resistance which is inherant in the high speed tool steels. Thus, it has been difficult to lengthen the tool life.

SUMMARY OF THE INVENTION

The object of the present invention is to improve the present status of the art and provide a steel for cold processing tools of good wear resistance, high toughness, and having such a high hardenability that the steel is hardenable by conventional heat treatment apparatus and under the usual conditions, thus being suitable as the material of the tools for precise cold processing used under sever conditions, particularly, of various dies.

The conventional heat treatment apparatus and usual conditions mean the apparatus, heating temperature and cooling means which have been used for hardening the conventional materials such as the above mentioned SKD 11. These are chosen because of the economical demand to carry out the treatment with existing facilities and the operational convenience that, at the hardening operation various kinds of mterials are treated together in one furnace, and therefore, it is desired to get the hardening effect at the same heting temperture. Thus, these are important factors for industrial practice.

The powdered steel for cold processing tools according to the presnt invention has the alloy ompositon consisting of 1.5 - 5.0 % of C, up to 3.0 % of Si, 3.0 % of Mn, 10.0 - 30.0 % of Cr, 0.5 - 4.0 % of Mo and 0.1 -10.0 % of V, provided that

$F(C) = Cr + 15.5\,C \geqq 40$ and

$F(H) = 3.8\,C - 0.62\,Cr \geqq -5$,

and the balance substantially of Fe, and has a high wear resistance and high toughness.

The steel may contain, in addition to the above components, up to 10.0 % of W in such a range that W + 2Mo is 8.0 or less.

In both the alloy compositions, with respect to the types of the carbides in the steel, where MC, M_7C_3

and $M_{23}C_6$ are considered, it is preferable that they exist in such a relation that fulfils, in volume ratio, $(M_7C_3 + M_{23}C_6)/MC = 0.5 - 4$.

DRAWING

The attached single drawing is a graph showing the status of the present powdered steel for cold processing tools in the high-C, high-Cr tool steels.

The hatched demain is the range of the alloy composition according to the present invention.

DETAILED EXPLANATION OF THE PREFERRED EMBODIMENTS

For the purpose of realizing the wear resistance of the cold processing tool steel higher than that of SKD 11, it is necessary to increase the amount of the carbides. However, increase in the amount of carbides generally causes decrease of toughness. In order to avoid this, powder metallurgy is chosen in the present invention. This is because the carbides precipitates in the form of fine particles, and formation of the huge carbide particles, which gives undesirable influence on the toughness, is prevented even though the material is heat-treated during the processing.

On the other hand, hardenability increase is realized by the fact that those of M_7C_3 type and $M_{23}C_6$ type, which are easy to dissolve in the matrix and useful for improving the hardenability, share 29 volume % or more of the carbide particles. These types of the carbides are those of Cr, and by satisfying the above noted conditions,

$F(C) = Cr + 15.5\ C \geqq 40$, and

$F(H) = 3.8\ C - 0.62\ C \geqq -5$

the above mentioned carbide profile can be realized.

In the alloy composition of the powdered steel for cold processing tools according to the present invention, as described above, high carbon - high chromium is one of the characteristic features, and this gives the high wear resistance and hardenability. Inclusive of this effect, the significance of the alloy components and the reasons for chosing the alloy composition are explained below:

C : 1.5 - 5.0 %

In order to form a large quantity of the carbides, the carbon content of this steel is so high as at least 1.5 %, which is the typical carbon content in SKD 11. This ensures formation of the M_7C_3 (M is mainly Cr) type carbide, which gives the same wear resistance as that of the high alloy tool steel to the present powdered steel and hightens the hardenability thereof. At or more of the upper limit, 5.0 %, the effect of increasing the hardness saturates and the toughness decrases.

Si: up to 3.0 %, Mn: up to 3.0 %

These elements are added to the steel as the deoxidation agent. Si is further expected to cause secondary hardening during the high temperature tempering. Both the elements, if added in too much quantities, decrease the toughness.

Cr: 10.0 - 30.0 %

Chromium forms carbides with a large amount of carbon and brings about improved wear resistance and hardenability. The lower limit of 10.0 % is necessary for this, and addition exceeding 30.0 % causes formation of too much carbides.

Mo: 0.5 - 4.0 %

Molibdenum cuases precipitaion of fine particles of the carbide, MoC, which contributes to the wear resistance. As the amount of Mo becomes too large, percentage of Mo_2C in the carbides increases, and is not useful for hightening the hardenability, and further, undesirable for the toughness.

W: up to 10.0 % (provided that in + 2Mo: up to 8.0 %)

As noted above, a portion of Molybdenum can be replaced by tungsten. The influence of added W is about twice of Mo, and the carbides thereof, WC and W_2C are not favorable for the heat treatment. Thus, the above limitation is given.

V: 0.1 - 10.0 %

Vanadium forms, like Mo, fine carbide, VC, which hightens the wear resistance. Too much additon lowers the toughness.

The powdered high speed tool steel according to the present invention has a high hardenability, and therefore, even if it is processed to a large sized tool, sufficient hardness of the tool can be obtained even by vacuum heat treatment. Because of precipitation of large amount of the carbides in the form of fine particles the abresion resistance is high and the toughness is at a satisfactory level.

Consequently, the tool steel is suitable as the material for large sized and precise cold processing tools used under severe conditions such as forging molds and rolling rollers. Further, it is useful for various machine parts to which wear resistance is required.

EXAMPLES

Steels of the alloy compositions shown in Table 1 were prepared and the molten steels were atomized by gas spraying. The obtained powderes were subjected to HIP treatment to sinter, and the sintered bodies were annealed, forged and heat treated.

The hardening was carried out by vacuum heating and gas quenching. The temperature of the heating is in the ordinary range for SKD 11 steel, which is lowere than the hardening temperature for high speed tool steels, and the quenching rate is about 0.5°C/sec. On the other hand, the tempering was practiced as high temperature tempering by subjection the sintered bodies to the temperatures to which tools may reach when used.

Test pieces were prepared from the samples, and tested to determine the bend fracture strength, which is a parameter of the toughness, and the wear resistance. The wear resistance was measured by Ohgoshi-type rapid abrasion tester under the following conditions.

Mating material: SCM 415 (annealed)

Circulating distance: 200 m

Circulating speed: 2.93 m/sec

Load: 6.3 kgf

The results of the above tests are shown in Table 2 with the heat treating conditions.

Table 1

Example	Steel	C	Si	Mn	Cr	Mo	W	V	F(C)	F(H)	$\frac{M_7C_3+M_{23}C_6}{MC}$	2Mo+W
Invention	A	2.01	0.33	0.41	15.43	1.03	2.06	1.03	46.58	-1.92	9.3	4.121
	B	2.23	0.61	0.29	11.02	0.72	3.03	6.20	45.58	+1.64	0.3	4.47
	C	3.07	1.02	0.09	19.39	3.11	-	2.51	66.97	-0.35	1.5	6.22
	D	4.05	0.45	0.71	19.98	0.62	-	3.24	82.75	+3.00	1.2	1.24
	E	4.51	0.06	0.56	12.03	2.23	2.61	7.53	81.93	+9.67	0.3	7.07
	F	4.83	0.48	0.38	23.31	3.28	-	6.87	98.17	+3,90	0.7	6.56
Control	G	2.50	0.73	0.39	30.12	2.44	3.01	0.93	68.87	-9.17	14.8	7.89
	H	3.06	0.71	0.71	5.76	3.01	1.23	3.34	53.19	+8.05	3.1	7.25
	I	1.12	0.46	0.23	10.46	0.98	2.01	0.92	27.82	-2.19	6.0	3.97
	J	1.55	0.51	0.46	12.03	1.33	2.27	2.10	36.05	-1.56	3.4	4.93
	K	0.93	0.31	0.42	4.21	4.90	6.03	1.85	17.37	+0.61	0.2	15.83

Table 2

Example	Steel	Hardening	Tempering	Hardness (HRC)	Bend Fracture Strength (Kgf/mm^2)	Abrasion $\times 10^{-8}$ (mm^2/Kgf)
Invention	A	1050°C, 20 min., gas-cooled	520°C, 1 hr, air-cooled, twice	61.2	465	24
	B	1050°C. 20 min., gas-cooled		58.7	440	27
	C	1040°C, 20 min., gas-cooled		61.3	394	11
	D	1030°C, 20 min., gas-cooled		61.5	388	7
	E	1050°C, 20 min., gas-cooled		62.2	370	5
	F	1050°C, 20 min., gas-cooled		62.0	335	2
Control	G	1030°C, 20 min., gas-cooled	520°C, 1 hr, air-cooled, twice	58.1	292	29
	H	1000°C, 20 min., gas-cooled		61.9	288	28
	I	1020°C, 20 min., gas-cooled		59.1	401	59
	J	1040°C, 20 min., gas-cooled		60.2	395	52
	K	1050°C, 20 min., gas-cooled		60.7	272	19

Claims

1. A powdered high speed tool steel having good wear resistance and toughness, characterized in that the steel essentially consists of 1.5 - 5.0 % of C, up to 3.0 % of Si, up to 3.0 % of Mn, 10.0 - 30.0 % of Cr, 0.5 - 4.0 % of Mo, 0.1 - 10.0 % of V and the balance substantially of Fe, provided that the followings are met:

$F(C) = Cr + 15.5C \geqq 40$, and

$F(H) = 3.8C - 0.62Cr \geqq -5$.

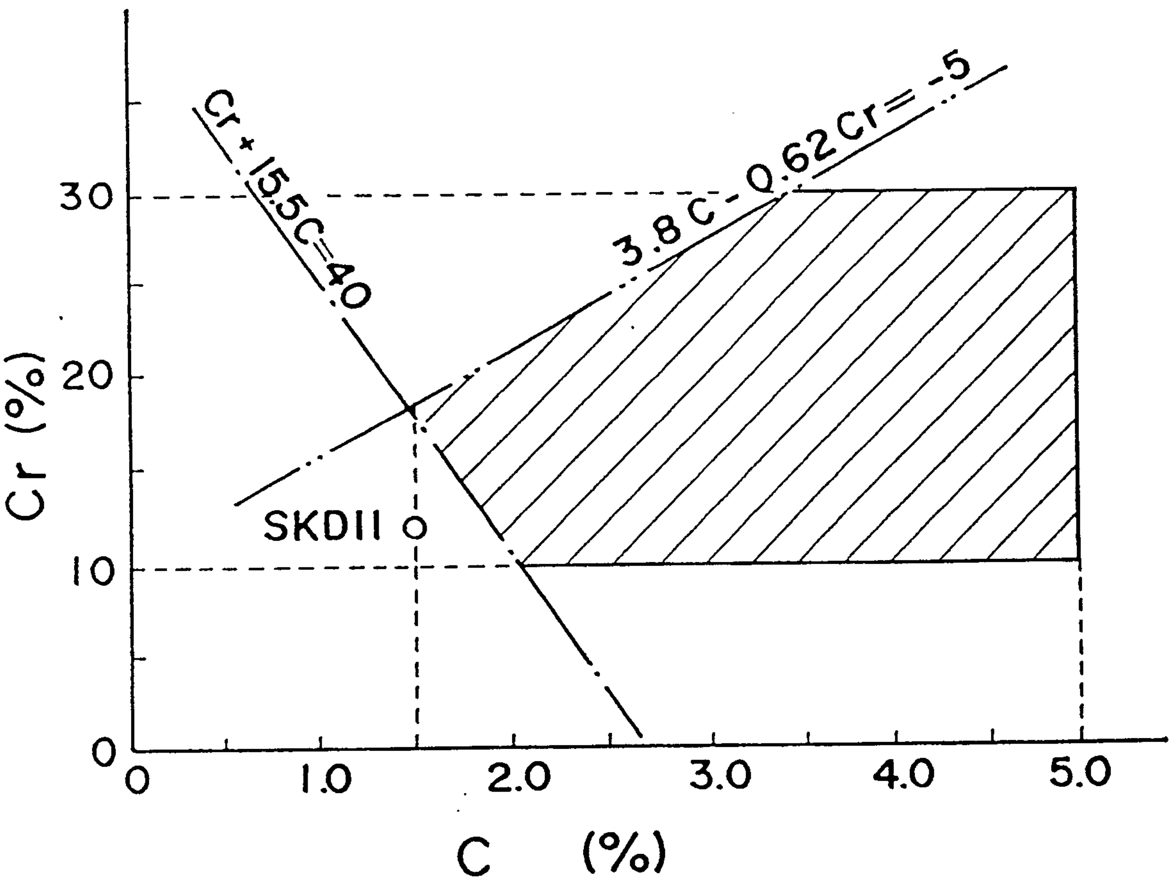
2. A powdered high speed tool steel according to claim 1, characterized in that the steel contains, further to the above alloy components, up to 10.0 % of W in the range that W + 2Mo is up to 8.0 %.

3. A powdered high speed tool steel according to claim 1, characterized in that the metal carbides are contained therein in the range which satisfy the following relation:

$(M_7C_3 + M_{23}C_6)/MC = 0.5 - 4.0$ (volume ratio)

4. A powdered high speed tool steel according to claim 2, characterized in that the metal carbides are contained therein in the range which satisfy the following relation:

$(M_7C_3 + M_{23}C_6)/MC = 0.5 - 4.0$ (volume ratio)


Cr+15.5C=40
3.8C-0.62Cr=-5
SKD11
Cr (%)
C (%)
0
10
20
30
1.0
2.0
3.0
4.0
5.0

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 3419

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.5)
E	EP-A-0 348 380 (BÖHLER) * Claim 1; column 3, line 46 - column 5, line 34 * ---	1-4	C 22 C 33/02 C 22 C 38/24
X	EP-A-0 271 238 (CRUCIBLE) * Claim 2; page 2, lines 45-59 * ---	1-4	
X	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 230 (C-365), 9th August 1986; & JP-A-61 064 854 (NISSAN MOTOR CO.) 03-04-1986 ---		
X	DE-A-3 736 350 (MITSUBISHI KINZOKU) * Claims 1,3; page 6, example 21 *	1-2	
Y	---	3-4	
Y	US-A-4 615 734 (D.R. SPRIGGS) * Claims 1,5-6,9; column 6, line 58 - column 7, line 25 * -----	3-4	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C 22 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12-04-1990	SCHRUERS H.J.

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
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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