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[54] **SUPER-HIGH-SPEED STEELS OF HIGH CUTTING CAPACITY**

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[58] **Field of Search** ..... 75/126 C

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[57] **ABSTRACT**

Mo-based super-high-speed steel of high cutting capacity, containing, in addition to the iron and the usual alloying and contaminating elements, also 1.05 to 1.50 weight percent of C, 4.0 to 5.0 weight percent of Cr, 5 to 6 weight percent of W, 0.05 to 2.0 weight percent of S, 0.05 to 0.50 weight percent of Pb and optionally being alloyed with Co, improved in that it contains 6.05 to 6.95 weight per cent of Mo, 2.16 to 4.50 weight percent of V, 0.10 to 4.0 weight percent of Nb and 0.11 to 0.25 weight percent of N_2.

6 Claims, No Drawings

SUPER-HIGH-SPEED STEELS OF HIGH CUTTING CAPACITY

The cutting capacity of high-speed steels is determined to a decisive extent — the other factors being identical — by the physico-chemical properties, dimensions, dispersity, distribution in the structure of the carbides of the steel.

The various known cutting-tool steels called "super-high-speed steels" of great hardness (for instance the American steels of type M30 – M40) have been developed by taking into consideration the effect of these factors.

A common characteristic of the super-high-speed steels consists in that they contain considerably more carbon than required for stoichiometrical achievement of their carbide-forming alloying content.

These super-high-speed steels — in addition to their lower alloying content — have greater strain and hot hardness, being thus more resistant to the abrasive effect of the chippings, and rendering possible the achievement of the higher cutting capacity with economic edge life.

Such known super-high-speed steel is the series marked M40 according to the (AISI) standard of USA, which contains 1.10 to 1.25 percent of C, 3.75 to 4.25 percent of Cr, 1.15 to 2.25 percent of V, 1.5 to 8.75 percent of W, 3.75 to 9.5 percent of Mo and 5 and 12 percent of Co. The hardness of these super-high-speed steels is 65 to 68 HRc, and the bending strength amounts to 200 to 300 kp per sq.mm.

Similarly known super-high-speed steels can be found in the West-German steel standard (Stahl-Eisen Werkstoffblatt 320 - 63) the hardness of which is 63 to 66 HRc and the bending strength 250 to 350 kp per sq.mm., or there is the type S12-1-4-5, having a hardness of 64 to 67 HRc abd a bending strength of 200 to 300 kp per sq.mm. The super-high-speed steel of type S6-5-3 contains 1.15 to 1.25 percent of C, 3.8 to 4.5 percent of Cr, 4.7 to 5.2 percent of Mo, 3.0 to 3.5 percent of V and 6.0 to 6.7 percent of W, whereas the steel of type S-12-1-4-5 contains 1.25 to 1.4 percent of C, 4.5 to 5 percent of Co, 3.8 to 4.5 percent of Cr, 0.7 to 1.0 percent of Mo, 3.5 to 4.0 percent of V and 11.5 to 12.5 percent of W.

Although the above super-high-speed steels have more advantageous cutting properties than the conventional high-speed steels, for the further development of the cutting technology — economic stock removal, with large chip cross-section — high-speed steels of even more advantageous properties (as for the hardness and especially the bending strength) are required.

The object of the present invention is the production of a highly wear-resistant super-high-speed steel having greater hardness, higher bending strength and cutting capacity than those known to date, being suitable for up-to-date stock removal with economic cutting parameters.

Said object can be achieved by the invention so that the steel contains 6.05 to 6.95 percent of Mo, 2.16 to 4.50 percent of V, 0.10 to 4.0 percent of Nb and 0.11 to 0.25 percent of N_2.

The excellent cutting properties of the high-speed steels according to the invention are ensured by the expedient ratios of the above alloying element, applying at the same time a suitable heat-treatment. As a result

of these alloying ratios the development of complex alloyed carbides is achieved, by which the tool can completely utilize the alloying content of the steel for increasing the cutting capacity.

Thus, for instance, the grain refining effect or a part of the stable NbC forming from the C and Nb alloyed in the steel increases the bending strength and the other part, being precipitation hardened, results in the increase of the hardness, whereas the NbCN formed with the alloyed N- has a strengthening and dislocation effect, that is similarly a hardness increasing effect, due to its substitution solution. Therefore, the hardness and bending strength of the super-high-speed steel according to the invention result together in highly advantageous complex properties, with respect to economic stock removal.

The super-high-speed steels according to the invention contain in addition to the usual alloying elements also special additive agents S, P*b* which in spite of the increased hardness — considerably improve the machinability of steel and the grindability of the tools made of it as compared to the conventional high-speed steels. The additive agents, increasing to a great extent the grindability index, also reduce the crater-wear of the tools, since they act as solid lubricants during cutting, thus reducing the value of the component of frictional force of the cutting.

The invention will be now described in more detail by the examples, and by means of the table.

Example 1

The super-high-speed steel having a composition shown in row 1 of the table, — after being hardened at 1,230°C and four times tempered at 580°C — has a hardness of 68 HRc, a bending strength of 560 kp per sq.mm. — measured on a test piece of $70 \times 10 \times 6$ mm. — and a deflection of 0.76 mm. in case of 55 mm. support. The cutting speed value pertaining to the critical 12 min. edge life, characteristic of the cutting property of the single-point cutting tool made of super-high-speed steel, is $V_{12} = 43$ to 45 m. per min. (in case of 0.42 mm. feed and 2.5 mm. depth of cut, when cutting unalloyed steel of 80 kp per sq.mm. tensile strength). When examining the cutting capacity, the cutting being carried out at a speed of 27 m. per min., an edge life of 60 min. has been found for super-high-speed steel of type S6-5-3 and that of 180 min. for the steel according to the invention, with identical edge geometrical and cutting parameters.

Example 2

According to the same tests carried out with super-high-speed steel of the composition shown in row 2 of the table, after a hardening at 1,230°C and four temperings at 550°C, the hardness was 69 HRc, the bending strength 619 kp per sq.mm., the deflection 0.81 mm. and $V_{12} = 45$ to 46 m. per min. During the test of the cutting capacity carried out at a cutting speed of 29 m. per min., the edge life of the super-high-speed steel of type S6-5-3 was found to be 20 min., whereas that of the steel according to the invention was 64 min.

Example 3

According to the same tests carried out with the super-high-speed steel of the composition shown in row 3 of the table, after a hardening at 1,230°C and four temperings at 550°C, the hardness was 70 Hrc, the

Examples	COMPOSITION							weight percent		
	C	Mo	W	V	Co	Cr	Nb	S	N_2	Pb
1	1.14	6.45	5.5	2.56	0.15	4.26	0.12	0.195	0.16	0.07
2	1.18	6.49	5.16	3.48	0.08	4.33	0.18	0.215	0.18	0.10
3	1.20	6.78	5.07	3.55	6.84	4.56	0.14	0.103	0.22	0.12
4	1.38	6.2	5.08	4.19	7.25	5.0	2.74	0.112	0.15	0.10

bending strength 427 kp per sq.mm., the deflection 0.76 mm. and $V_{12}=45$ to 49 m. per min. With a cutting carried out with 1 mm. depth of cut and a feed of 0.14 mm. per revolution, the value of V_{12} was 83 to 85 m. per min.

Example 4

According to the same tests carried out with the super-high-speed steel of the composition according to row 4 of the table, after a hardening at 1,230°C and four temperings at 550°C, the hardness was 70 HRc, the bending strength 474 kp per sq. mm., the deflection 0.69 mm. and $V_{12}=48$ to 51 m. per min. When cutting with a 1 mm. depth of cut and a feed of 0.14 mm. per revolution, the value of V_{12} was found to be 93 to 105 min.

The complex carbide composition, distribution, advantageous grain size of the super-high-speed steels according to the invention, constituting an optimum with respect to the cutting, provide in a wide range of the heat-treating parameters for the suitable tool hardness required for the stock removal. Consequently, these steels can meet the most varied requirements concerning the mechanical properties of the tools. The metallurgical structure of the new super-high-speed steels satisfies the demands on the improvement not only of the machinability of the high-speed steel but also of the grindability of the finished tool.

The cutting tools made of the super-high-speed steels according to the invention thus render possible the application of up-to-date, economic cutting methods and parameters, the reduction of tool consumption and of tool costs, as well as an increase of the cutting capacity.

What we claim is:

1. A Mo-based super-high-speed steel of high cutting capacity consisting essentially of the following elements in weight percent:

C	1.05 to 1.50
Cr	4.0 to 5.0
W	5.0 to 6.0
S	0.05 to 2.0
Pb	0.05 to 0.50
Mo	6.05 to 6.95
V	2.16 to 4.50
Nb	0.10 to 4.0
N_2	0.11 to 0.25
Fe	and impurities — balance.

2. A Mo-based super-high-speed steel of high cutting capacity consisting essentially of the following elements in weight percent:

C	1.14	to	1.38
Cr	4.26	to	5.0
W	5.07	to	5.5
S	0.103	to	2.15
Pb	0.07	to	0.12
Co	0.08	to	7.25
Mo	6.2	to	6.78
V	2.56	to	4.19
Nb	0.12	to	2.74
N_2	0.15	to	0.22
Fe	and impurities — balance.		

3. A steel according to claim **1** wherein the V content is 2.16 to 3.0 weight percent and the Nb content is 0.10 to 2.0 weight percent.

4. A steel according to claim **1** wherein the V content is 3.05 to 3.50 weight percent and the Nb content is 0.10 to 2.0 weight percent.

5. A steel according to claim **1** wherein the V content is 3.55 to 4.00 weight percent and the Nb content is 0.10 to 2.0 weight percent.

6. A steel according to claim **1** wherein the V content is 4.00 to 4.50 weight percent and the Nb content is 2.05 to 4.00 weight percent.

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