

April 30, 1968

F. FREHN

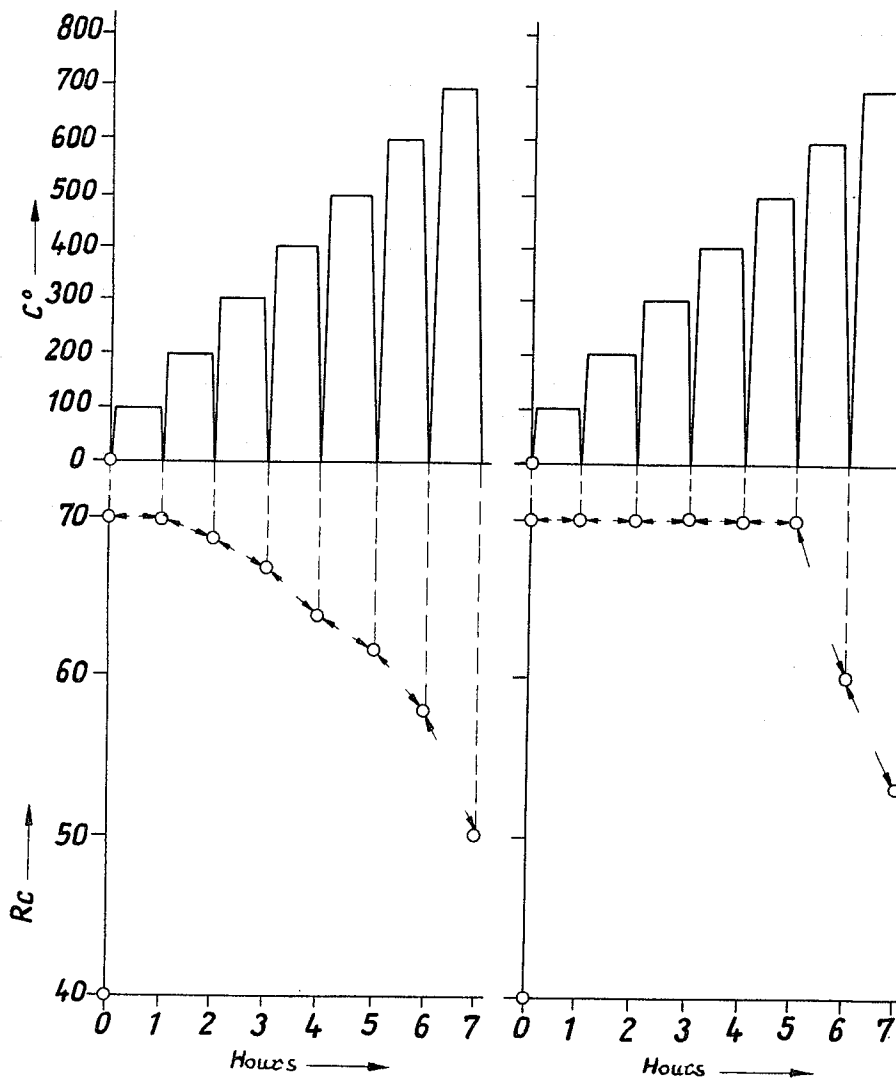
3,380,861

SINTERED STEEL-BONDED CARBIDE HARD ALLOYS

Filed May 5, 1965

I

II



Inventor:

FRITZ FREHN

BY *Cushman, Darby & Cushman*
ATTORNEYS

1

3,380,861

**SINTERED STEEL-BONDED CARBIDE
HARD ALLOYS**

Fritz Frehn, Krefeld, Germany, assignor to Deutsche
Edelstahlwerke Aktiengesellschaft, Krefeld, Germany
Filed May 5, 1965, Ser. No. 453,494
Claims priority, application Germany, May 6, 1964,
D 44,355
5 Claims. (Cl. 148—12.3)

ABSTRACT OF THE DISCLOSURE

In sintered steel-bonded carbide hard alloys of the type comprising a steel matrix of steel hardenable by the transformation of austenite containing TiC (or a mixture of TiC with equivalent carbides), the hardness of the sinter is preserved when tempered if the steel matrix contains from 0.5 to 3% of copper.

The invention relates to sintered steel-bonded carbide hard alloys in which a matrix of steel that is hardenable by the transformation of austenite contains the carbide in quantities between 12.5% and 72% by weight, and the carbide is titanium carbide of which up to 50% may be replaced by one or more carbides of metals of Groups IV to VI of the Periodic Table.

The group of steel-bonded titanium carbide hard alloys has been known for some time, but its technological evaluation did not begin until quite recently. The entire group of these particular hard metals can be divided, according to the nature of the steel matrix, into hardenable and non-hardenable alloys which can be used in diverse fields where their different technological properties are useful.

A matrix of the hardenable type is one that can be hardened either by the transformation of austenite, that is to say by the formation of martensite, or by precipitation. This last named group includes known hard metals based on steels with a high titanium and/or tungsten content, which are first solution treated at 1000° C. and then tempered at between 300 and 500° C. when they precipitate a phase rich in titanium and/or tungsten. The reheat stability of these alloys is roughly equal to that of the steel matrix so that generally speaking hard alloys that are hardenable by martensite formation can be used only for the purpose of cold shaping and for the production of abrasion-proof parts, whereas the more reheat-resistant precipitation hardenable alloys can also be machined and hot shaped.

The general composition of the steel-bonded titanium carbide hard metals can be defined as being 12½ and 75% by weight of titanium carbide, the remaining matrix consisting of transformation-hardenable or precipitation-hardenable steel. Preferably alloys are used containing 27 to 37% by weight of titanium carbide, corresponding to about 40 to 55% by volume of TiC. The steel matrix may be any alloy desired to provide wanted properties. Up to 50% of the titanium carbide itself may be replaced by other known hard carbides, such as tungsten carbide, vanadium carbide, zirconium carbide, niobium carbide, tantalum carbide, chromium carbide and so forth.

These hard metal alloys are always produced by powder

2

metallurgical techniques. To this end the powdered carbide or carbide mixture is mixed with a likewise powdered matrix alloy, ground down to a grain size below 5μ, moulded and then sintered in a vacuum below 10⁻¹ torr at temperatures between 1200 and 1500° C.

The present invention relates to titanium carbide hard metals of the specified kind consisting of a steel matrix which in virtue of its particular composition is hardenable either by martensite formation or by precipitation. The proposed alloys are characterised in that the steel matrix which is hardenable by the transformation of austenite contains between 0.5 and 3.0%, of copper.

This particularly useful property of the novel hard metal alloys permits the sintered alloys, after having been hardened by quenching from 950 to 1000° C. in oil, to be reheated for 0.5 to 2 hours, preferably for one hour, for the removal of internal stress at temperatures between 150 and 500° C., preferably at the temperature at which the hard metal alloy is expected to be further processed. The stresses in the workpiece are thus removed and its impact resistance and bending strength further improved.

The known precipitation hardenable matrix alloys differ from alloys composed as proposed by the present invention in that they contain the elements titanium or tungsten for forming the precipitating phases. Both elements are strong carbide formers and they react with excess carbon or carbon liberated by titanium decomposition. It is therefore extremely difficult in practice to control the degree of hardening.

In the production of sinter steel the use of copper as an age hardening element is as such quite well known. However, in order to produce alloys that can be reheated copper contents exceeding 5% and up to about 30% are provided. In the present context it was ascertained that copper contents in this order of magnitude in steel-bonded carbide hard metals are useless and that it is a matter of importance to provide the copper in the specified concentration range.

The carbide hard metals composed as herein proposed are produced by powder metallurgical techniques in the same way as the known materials. The component powders are mixed, ground down to a grain size between 3 and 5μ, the powder mixture being then moulded and finally sintered at about 1400° C. for 2 hours in a vacuum below 10⁻¹ torr. The sintered mouldings are then cooled to room temperature. After having been annealed at between 700 and 750° C., the hardness of the resultant sintered parts is between 38 and 42 Rc. In this condition they can be machined. When they have been hardened the parts have a hardness between 70 and 73 Rc.

If the parts that have been thus produced are reheated to temperatures from 150° C. to about 500° C. the hardness due to the martensite gradually diminishes but this is compensated by the increased precipitation. In practice this means that a hardness between 70 and 72 Rc is retained up to temperatures of about 500° C.

The appended diagrams illustrate the relationship between high-temperature hardness and working temperature. For comparison purposes the measurements were performed, on the one hand, on a sample consisting of normal steel-bonded titanium carbide hard metal and, on the other hand, on an alloy according to the invention containing 2% Cu. The composition of the examined hard metals is given in Table I.

TABLE I

	TiC	Cr	Mo	C	Cu	Fe	Treatment
Normal steel bonded titanium carbide hard metal.	33.0	2.0	2.0	0.5	-----	Remainder....	Hardened from 980° in brine bath.
Hard metal according to the invention.	33.6	2.0	2.0	0.5	2.0	-----do-----	In oil—hardness 70 Rc.

As shown in the curve in Diagram 1 the tested samples were heated to temperatures rising in 100° C. steps and held at these temperature levels for 1 to 7 hours when they were recoiled to room temperature from each of these temperatures. The hardnesses that were then measured are plotted in Diagram 1. Curve I in this diagram illustrates the change in hardness of a normal steel-bonded carbide hard metal, whereas curve II is that of a hard metal according to the invention containing 2% Cu. As will be understood from these curves the initial hardnesses of the normal steel-bonded titanium hard metal and of the hard metal according to the invention are alike. The hardness of the hard metal according to the invention remains substantially the same up to 500° C., whereas the hardness of the normal steel-bonded titanium carbide hard metal has already diminished considerably at 150° C. Above 500° C. the hardness of the hard metal according to the invention also begins to decline, but it nevertheless still remains above that of the normal steel-bonded titanium carbide hard metal.

The effect of the copper upon the hardness of a tempered or untempered steel-bonded titanium carbide hard metal of the composition

	Percent by wt.
TiC -----	33
Cr -----	2
Mo -----	2
C -----	0.5
Fe -----	Remainder

is illustrated in Table II. The titanium carbide hard metal was sintered at 1400° C. for two hours, quenched from 980° C. in oil and then reheated at 100° C. for one hour. Other tested samples were reheated at 500° C. The hardnesses were then measured at room temperature.

TABLE II

Cu, percent	Hardness in Rc annealed at 100° C.	Hardness in Rc annealed at 500° C.
0	71-73	61-63
1.0	71-73	62-64
1.7	71-73	68-70
2.0	71-72	70-72
5.0	46-50	48-55
6.0	42-45	44-45

The table clearly shows that the hardness declines considerably when the copper content rises to over 3% and that there is then no hardening or age hardening effect. The reason for this may be that although the high copper content reduces the sinter temperature of the alloy and would therefore permit the alloy to be sintered at lower temperatures, the steel matrix nevertheless requires high temperatures for forming the alloy. When the copper content exceeds 5% the sintering temperature would therefore have to be 30 to 50° C. lower to prevent the copper from running out or from evaporating at too high a rate. However, the steel matrix would then not be thoroughly sintered and the formation of the alloy would be incomplete so that no hardening by the transformation of austenite (for instance by martensite formation) nor by copper precipitation when reheating is possible.

Up to 50% of the titanium carbide may be replaced, as previously stated, by one or more other hard carbides,

What I claim is:

1. A sintered steel-bonded carbide hard metal alloy of the type having a matrix consisting of a steel hardenable by the transformation of austenite and a carbide content present in quantities of from 12.5% to 72% by weight consisting of titanium carbide, of which up to 50% may be replaced by one or more carbides of metals of Group IV or VI of the Periodic Table, wherein the improvement consists in that the said steel matrix contains 0.5 to 3.0% of copper.

2. A sintered steel-bonded carbide hard metal according to claim 1 in which at least one said hard carbide other than titanium carbide is present in the alloy in a content of up to 36% by weight of the alloy.

3. A method of heat treating a steel-bonded carbide hard metal alloy according to claim 1, in which the alloy is hardened by heating to 950 to 1000° C. and quenching in oil and is reheated one or more times for 0.5 to 2.0 hours, at temperatures between 150 and 500° C.

4. The method according to claim 3, in which said reheating is carried on for about one hour.

5. A method for forming treated, steel-bonded hard carbide alloy molding comprising:

mixing in powdered form

(a) a steel matrix alloy of the type which is hardenable by the transformation of austenite to martensite, said steel matrix alloy essentially including between 0.5 percent and 3.0 percent copper; and

(b) 12.5 percent to 72 percent, by weight, of at least one metal carbide chosen from the group consisting of titanium carbide and a mixture of metal carbides consisting of titanium carbide and up to 50 percent by weight of at least one other carbide of metals of Group IV to Group VI of the Periodic Table

grinding the component powders to a grain size between 3 and 5μ;

molding and sintering the powder mixture at about 1400° C. for about 2 hours in a vacuum below about 10⁻¹ torr;

cooling the sintered molding to room temperature; annealing the sintered molding at between about 700 and 750° C.;

machining the annealed, sintered molding;

reheating the machined, annealed sintered molding to between 150° C. and about 500° C. for about 0.5 to 2.0 hours.

References Cited

UNITED STATES PATENTS

2,683,677	7/1954	Walters et al. -----	75-125 X
2,694,626	11/1954	Tanczyn -----	75-125 X
2,828,202	3/1958	Goetzel et al. -----	75-123
2,868,638	1/1959	Mott -----	75-125
2,891,858	6/1959	Kegerise et al. -----	75-125
3,053,706	9/1962	Gregory et al. -----	148-31
3,183,127	5/1965	Gregory et al. -----	148-31

CHARLES N. LOVELL, *Primary Examiner*.