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(54) **CEMENTED CARBIDES COMPRISING AN FE-CR BINDER BASED METALLIC BINDER**

(57) The present disclosure relates to a cemented carbide with a Fe-Cr based metallic binder, a method for manufacturing the cemented carbide and a use of the cemented carbide as a cutting tool, a wear part, a seal ring, a bushing, a die or a tool for handling radioactive parts.

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Description**Technical Field**

5 [0001] The present disclosure relates to a cemented carbide comprising an Fe-Cr based metallic binder, a method for manufacturing the cemented carbide and the use of the cemented carbide as a cutting tool, a wear part, a seal ring, a bushing, a die or a tool for handling radioactive parts.

Background

10 [0002] Cemented carbides typically have a cobalt or a nickel based metallic binder. However, there is a need to find alternative metallic binders for cemented carbides that do not contain any cobalt or nickel but which are able to replicate, as close as possible, the physical and mechanical properties and performance of cobalt and nickel based metallic binders when used in a given application.

15 [0003] The aim of the present disclosure is to provide a solution to the problem mentioned above.

Summary

20 [0004] Thus, the present disclosure therefore provides a cemented carbide comprising a hard phase and an iron-chromium (FeCr) based metallic binder phase, characterized in that the chromium content of the iron-chromium based metallic binder phase is of from 1 to 10 weight% (wt%) of the total amount of the iron-chromium based metallic binder phase.

[0005] Furthermore, the present disclosure also relates to a method of producing a cemented carbide comprising the steps of:

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- a. providing a hard phase powder and at least one powder consisting of FeCr and optionally a powder consisting of Cr_3C_2 ;
 - b. milling the powders with an organic binder to obtain a powder mixture;
 - c. pressing the milled powder mixture; and
 - 30 d. sintering the pressed powder mixture to obtain a sintered cemented carbide;

characterized in that the Cr content is of from 1 to 10 wt% of the total amount of added FeCr powder and Cr_3C_2 powder.

35 [0006] Additionally, the present disclosure also relates to the use of the cemented carbide as described hereinbefore or hereinafter for manufacturing a cutting tool, a wear part, a seal ring, a bushing or a die. The present disclosure further relates to the use of the cemented carbide as described hereinbefore or hereinafter for manufacturing a tool for handling radioactive parts.

Detailed description

40 [0007] According to one aspect, the present disclosure relates to a cemented carbide comprising a hard phase and an iron-chromium (FeCr) based metallic binder phase, characterized in that the chromium content of the iron-chromium based metallic binder phase is of from 1 to 10 wt% of the total amount of the iron-chromium based metallic binder phase.

[0008] The inventors have found that if the Cr content of the Fe-Cr based metallic binder phase is of from 1 to 10 wt%, such as of from 2 to 8 wt%, of the total amount of the metallic binder phase, the obtained cemented carbide will have surprisingly high wear resistance, transverse rupture strength and thermal conductivity compared to a cemented carbide with a cobalt or nickel based binder with equivalent grain size and metallic binder content.

45 [0009] In the present disclosure, the term "iron-chromium based metallic binder" means that the metallic binder phase contains more than 50 wt% (weight %) iron-chromium based on the total amount of metallic binder phase.

[0010] If the chromium (Cr) content is less than 1 wt%, then the beneficial effect of adding Cr to increase corrosion and flame resistance is not achieved. It is also hypothesized that Cr within the metallic binder phase will act as a hardener. If the Cr content is >10 wt%, the stability of the cemented carbide at higher temperatures is reduced, which is of particular importance in metal cutting applications. Furthermore, if the Cr content is not within the range of the present disclosure, a two phase composition will not be achieved. The term 'two-phase composition' is used to describe a composition containing minimal amounts of graphite precipitation, i.e. less than 2 vol% and no significant ternary phases, i.e. less than 2 vol% M_6C or M_5C_2 , where M is the metal of the hard phase. The problem with the presence of ternary phases is that as they are more brittle, the presence of such phases may reduce the transverse rupture strength of the material and therefore, for example when used as a cutting tool, there is a higher probability of catastrophic failure of the tool occurring.

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[0011] In one embodiment, the wt% of the Fe-Cr based metallic binder phase is of from 3 to 35 wt% of the total cemented carbide composition, such as of from 3 to 25 wt%. If the binder phase is below 3 wt% of the total cemented carbide composition, then the cemented carbide may not be fully cemented and the cemented carbide may have a porous microstructure. This would have a detrimental effect on the material properties, such as a reduction in the hardness and the toughness of the cemented carbide. If the binder phase content is greater than 35 wt%, the contiguity of the hard phase may be reduced, which would have a detrimental effect on the material properties, such as a reduction in hardness and toughness.

[0012] In one embodiment of the cemented carbide, the hard phase particles is selected from one or more of WC, TiC, TaC, ZrC, Mo₂C or HfC or a mixture thereof.

[0013] In one embodiment of the cemented carbide the hard phase essentially consists of WC. In the present disclosure the terms 'essentially consists of' means the hard phase contains more than 90 wt% particles of the given carbide based on the total amount of hard phase.

[0014] Small amounts of other elements, such as V, Mo or Mn, could also be added to the cemented carbide composition, such as in an amount of less than or equal to 3 wt%. These elements are added to further improve the properties of the cemented carbide, for example these elements may assist with grain refinement, or stabilisation of the M₆C phase.

[0015] Another aspect of the present disclosure relates to a method of producing a cemented carbide comprising the steps of:

- a. providing a hard phase powder, at least one powder consisting of FeCr and optionally a powder consisting of Cr₃C₂;
- b. milling the powders with an organic binder to obtain a powder mixture;
- c. pressing the milled powder mixture; and
- d. sintering the pressed powder mixture to obtain a sintered cemented carbide;

characterized in that the Cr content is of from 1 to 10 wt% of the total amount of added FeCr powder and Cr₃C₂ powder.

[0016] In the method of the present disclosure, the term "weight percent" (wt%), refers to the relative weights of the powders weighed in comparison to the total amount of powder added.

[0017] The hard phase powder, the Fe-Cr based metallic binder powder and any additional powders are milled together typically using a ball mill, and then sintered, for example using a Sinter HIP furnace. However, other milling and sintering methods could also be employed. Fe is normally added in the pre-alloyed form as handling of elemental Fe is not practical due to the oxidation hazard it poses. The required ratio of Fe:Cr is achieved through either providing: a pre-alloyed Fe-Cr powder with the required Cr content; a pre-alloyed Fe-Cr metallic binder with a lower than required Cr content with the addition of an appropriate amount of Cr₃C₂; or two pre-alloyed Fe-Cr powders with higher and lower Cr contents in a suitable ratio to achieve the required Cr content.

[0018] In one embodiment of the method, the chromium content is of from 2 to 8 wt% of the total amount of the iron-chromium based metallic binder phase.

[0019] In one embodiment of the method, the cemented carbide comprises of from 3 to 35 wt% iron-chromium based metallic binder phase of total cemented carbide composition.

[0020] In one embodiment of the method, the hard phase particles is selected from one or more of WC, TiC, TaC, ZrC, Mo₂C or HfC or a mixture therefore.

[0021] In one embodiment of the method, the hard phase essentially consists of WC.

[0022] Another aspect of the present disclosure is the use of a cemented carbide as described hereinbefore or hereinafter a cutting tool, a wear part, a seal ring, a bushing or a die.

[0023] Another aspect of the present disclosure is a cutting tool, a wear part, a seal ring, a bushing, a die or a tool manufactured from the cemented carbide as described hereinbefore or hereinafter.

[0024] Another aspect of the present disclosure is the use of a cemented carbide as described hereinbefore or hereinafter for manufacturing a tool for handling radioactive parts. It should however be appreciated that the cemented carbide described hereinbefore or hereinabove is not limited to these uses and may be useful in other applications.

[0025] The following examples are illustrative, non-limiting examples.

Examples

[0026] Cemented carbides with a Fe-Cr based metallic binder were prepared by providing a powder of WC, a powder of FeCr and a powder of C to adjust the carbon content to form a material with a two phase composition. The required Cr content was achieved by providing pre-alloyed FeCr powder with the required wt% of Cr. The variants were then milled in a 250 ml ball mill for 8 hours with 1200 g of milling media (WC based cypbebs) in 50ml ethanol milling liquid.

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The obtained powder was then dried at 75°C, sieved using a 500 micron mesh sieve and pressed using the TOX press to a target pressing pressure of 80 MPa to sample pieces with dimensions of approximately 5.5 x 6.5 x 20 mm. The obtained pieces were then vacuum sintered at a temperature of 1450°C with 50 bar Ar pressure for 1 hour. After sintering, the samples were mounted in Bakerlite and the hardness and toughness were determined according to ISO 28079 using an indentation of 50kg.

[0027] Table 1 shows a summary of the example compositions tested and Table 2 shows a summary of their physical and mechanical properties as measured. The WC types of WC008, WC0095, WC020 and WC060 mean the WC powder has an average grain size of 0.8 µm, 0.95 µm, 0.2 µm and 6 µm respectively, as measured using the Fischer method.

Table 1

Sample	WC type	WC content (wt%) compared to total composition	FeCr Binder content (wt%) compared to total composition	Cr content (wt%) compared to total composition	Cr content as a wt% of binder content	C addition (wt%)
A	WC008	93	7	0.07	1	0.39
B	WC0095	93	7	0.59	7	0.52
C (comparative)	WC020	93	7	1.16	16	0.58
C	WC008	90	10	0.8	8	0
D	WC060	92	8	0.64	8	0.3
E	WC060	94	6	0.48	8	0.3

[0028] The properties in Table 2 have been measured according to standards used in the cemented carbide field, i.e ISO 3369:1975 for the density; ISO 3878:1983 for the hardness and ISO 28079:2009 for the toughness. The examples show that it is possible to produce full density sintered cemented carbides with hardness, toughness and thermal conductivities which compare favourably to current WC-Co cemented carbides using the Fe-Cr based binder.

[0029] Wear tests were carried out according to the B611 standard method. Samples of powders A, B and C were pressed to a geometry of 40 x 20 x 5 mm at 42 tonnes and sintered at 1450°C and 50 bar argon pressure to plates with a density of approximately 14.5 g/cm³ and the wear test was completed on both sides of the plate. The Fargo plates were then secured perpendicular to the abrasive wheel, submerged in an alumina slurry whilst impinging an abrasive wheel which was rotated at 100 rpm for 1000 revolutions with an applied contact force of 196 N. The mass loss was then measured and then the wear number for volume loss calculated using the formula density/mass loss. The results are shown in Table 2. The same test was performed on comparative samples with Ni or Co based binders. When comparing against samples with equivalent grain size and binder content the wear resistance of the Fe-Cr variants is higher. It can also be noted that wear resistance is higher if the Cr content of the binder is not greater than 10 wt%.

[0030] Transverse rupture strength (TRS) was determined according to standardised method ISO 3327:2009. The test was completed on samples A, B and C. The results show that the highest TRS values were achieved when the Cr content of the binder was not greater than 10 wt%.

Table 2

Sample	Density (g cm ⁻³)	HV (kgf mm ⁻²)	K _{1C}	Wear no. (mm ³)	Transverse Rupture Strength (N/mm ²)
A	14.56	1824	7.6	88.51	2547
B	14.51	1704	7.2	95.77	2386
C (comparative)	14.48	1743	7.3	67.50	1876
C	14.15	1770	8.3	-	-
D	14.31	1247	13	-	-
E	14.65	1103	17.8	-	-

[0031] Thermal conductivity measurements of cemented carbides have shown that for an equivalent WC grain size, the thermal conductivity of the cemented carbides with a Fe-Cr based binder phase have a higher thermal conductivity than cemented carbides with a Co based binder phase.

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Claims

1. A cemented carbide comprising a hard phase and an iron-chromium based metallic binder phase, **characterized in that** the chromium content of the binder phase is of from 1 to 10 wt% of the total amount of the iron-chromium based metallic binder phase.
2. The cemented carbide according to claim 1, wherein the chromium content is of from 2 to 8 wt% of the total amount of the iron-chromium based metallic binder phase.
3. The cemented carbide according to claim 1 or claim 2, wherein the cemented carbide comprises of from 3 to 35 wt% iron-chromium based metallic binder phase of total cemented carbide composition.
4. The cemented carbide according to any of the previous claims, wherein the hard particle of the hard phase is any one of WC, TiC, TaC, ZrC, Mo₂C or HfC or a mixture thereof.
5. The cemented carbide according to any of the previous claims, wherein the hard phase essentially consists of WC.
6. A method of producing a cemented carbide comprising the steps of:
 - a. providing a hard phase powder at least one powder consisting of FeCr and optionally a powder consisting of Cr₃C₂;
 - b. milling the powders together with an organic binder to obtain a powder mixture;
 - c. pressing the milled powder mixture; and
 - d. sintering the pressed powder mixture to obtain a sintered cemented carbide;**characterized in that** the Cr content is of from 1 to 10 wt% of the total amount of added FeCr powder and Cr₃C₂ powder.
7. The method according to claim 6, wherein the Cr content is of from 2 to 10 wt% of the total amount of added FeCr powder and Cr₃C₂ powder.
8. The method according to claim 6 or claim 7, wherein the total amount of added powders of FeCr and Cr₃C₂ provided is between 3-35 wt% of the total cemented carbide composition.
9. The method according to any of claims 6-8, wherein the hard phase powder provided is selected from being one or more of WC, TiC, ZrC, Mo₂C or HfC or a mixture thereof.
10. The method according to any of claims 6-9, wherein the hard phase essentially consists of WC.
11. A use of a cemented carbide according the any of the preceding claims, for manufacturing a cutting tool, a wear part, a seal ring, a bushing or a die.
12. A cutting tool, a wear part, a seal ring, a bushing, a die or a tool according to any of claims 1 to 10.
13. Use of a cemented carbide according to any of claims 1 to 10, for manufacturing a tool for handling radioactive parts.

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EUROPEAN SEARCH REPORT

Application Number
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