



(11) **EP 4 438 753 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.10.2024 Bulletin 2024/40

(51) International Patent Classification (IPC):
C22C 1/051 ^(2023.01) **C22C 29/06** ^(2006.01)
C22C 29/08 ^(2006.01) **B22F 5/00** ^(2006.01)

(21) Application number: **23165500.2**

(52) Cooperative Patent Classification (CPC):
(C-Sets available)
C22C 29/08; C22C 1/051; C22C 29/067;
B22F 2005/001 (Cont.)

(22) Date of filing: **30.03.2023**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **GARCIA, José Luis**
811 81 Sandviken (SE)
• **CHYCHKO, Andrei**
811 81 Sandviken (SE)

(74) Representative: **Sandvik**
Sandvik Intellectual Property AB
811 81 Sandviken (SE)

(71) Applicant: **AB Sandvik Coromant**
811 81 Sandviken (SE)

(54) **CUTTING TOOL**

(57) The present invention relates to a cutting tool comprising a cemented carbide substrate with a Fe-based binder, where the cemented carbide further comprising Ni, Cr and Al so that the weight fraction Ni/(Fe+Ni) is between 0.10 and 0.25, the weight fraction

Cr/(Fe+Ni+Cr+Al) is between 0.005 and 0.05, the weight fraction Al/(Fe+Ni+Cr+Al) is between 0.01 and 0.05; and wherein the amount of Fe in the metal binder is at least 70 wt%. The invention also relates to a method of making such cutting tool.

EP 4 438 753 A1

(52) Cooperative Patent Classification (CPC): (Cont.)

C-Sets

B22F 2998/10, C22C 1/05, B22F 2009/043,
B22F 3/02, B22F 3/15, B22F 3/1028

Description

[0001] The present invention relates to a cutting tool comprising a cemented carbide substrate with a Fe- based binder, where the cemented carbide further comprising Ni, Cr and Al. The invention also relates to a method of making such cutting tool.

Background

[0002] Cemented carbides based on WC with a cobalt binder have been known in the art for almost one hundred years. Other metals that are known as binder metals in cemented carbides are iron and nickel, however cobalt is by far the most used in cutting tool applications.

[0003] It is an ongoing strive to find alternative binders to cobalt due to its environmental and health impact. However, it is difficult to replace or limit the amount of cobalt without impacting material properties in a negative way. For cutting tools the substrate properties are important for the overall performance of the tool and even small changes in composition can have a detrimental impact on performance.

[0004] For cemented carbides with a Co binder there is a relationship between toughness and hardness that is difficult to change. For example, it is difficult to increase the toughness without having a decrease in hardness or vice versa.

[0005] Iron is a known binder element but is usually not preferred since it is considered to have a negative impact on the toughness of cemented carbides. Pure iron binders have a tendency to form brittle phases (i.e. martensite, Fe-carbides etc.). Additionally, it is difficult to control the carbon balance in order to produce a microstructure free from defects such as precipitates of (W,Me)C subcarbides or graphite.

[0006] It is an object of the invention to provide a cemented carbide with an alternative binder phase which has equal or improved properties as compared to a cemented carbide with a Co binder.

Detailed description of the invention

[0007] The present invention relates to a cutting tool comprising a cemented carbide substrate wherein the cemented carbide comprises a hard phase comprising WC and 3 to 20 wt% of a Fe-based metal binder comprising Fe, Ni, Cr and Al, wherein the amount of the elements Fe, Ni, Cr and Al in the cemented carbide is such that:

- the weight fraction Ni/(Fe+Ni) is between 0.10 and 0.25;
- the weight fraction Cr/(Fe+Ni+Cr+Al) is between 0.005 and 0.05
- the weight fraction Al/(Fe+Ni+Cr+Al) is between 0.01 and 0.05; and wherein the amount of Fe in the metal binder is at least 65 wt%.

[0008] The amount of metal binder in the cemented carbide is preferably between 3 and 20 wt% of the cemented carbide, more preferably between 5 and 15 wt%. The amount of metal binder can be determined by image analysis or by chemical analysis of the cemented carbide composition. The metal binder is Fe- based and by that is herein meant that the metal binder comprises more than 65 wt% Fe.

[0009] The cemented carbide comprises Ni in such amount that the weight fraction Ni/(Fe+Ni) is between 0.10 and 0.25 preferably between 0.13 and 0.20 and more preferably between 0.14 and 0.18. If the Ni content is too low, the binder has ferrite (bcc) structure with no or too little residual austenite and if the Ni content is too high, the cemented carbide will have binder with stable austenite (fcc) incapable for stress induced transformation.

[0010] The cemented carbide comprises Cr in such amount that the weight fraction Cr/(Fe+Ni+Cr+Al) is between 0.005 and 0.05, preferably between 0.015 and 0.035. If the Cr content is too low, the residual austenite can decompose too quickly, and if the Cr content is too high, the cemented carbide will have decreased K1c - HV combination due to formation of Cr- carbides.

[0011] The cemented carbide comprises Al in such amount that the weight fraction Al/(Fe+Ni+Cr+Al) is between 0.01 and 0.05 preferably between 0.015 and 0.04, more preferably between 0.02 and 0.035. If the Al content is too low, no austenite stabilization effect is observed and the material properties (K1c - HV) are poor and if the Al content is too high, the stability and amount of austenite (fcc) increase, and the cemented carbide will lose some K1c-HV properties like in case of too high Ni.

[0012] In one embodiment of the present invention, some of the Al is present as Al₂O₃ particles embedded in the microstructure of the cemented carbide. Since Al is highly reactive, it can react with any traces of oxygen that can be present during sintering. Oxygen can e.g. be present as an impurity in the raw material and small amounts of oxygen can also be present in the sintering furnace.

[0013] The main elements in the metal binder are Fe, Cr, Ni and Al. The binder can also comprise other elements present in the cemented carbide, e.g. W or C, which are inevitably dissolved in the binder during sintering.

[0014] In one embodiment of the present invention, the total amount of the elements Fe, Cr, Ni and Al in the metal binder is at least 90 wt% of the binder, preferably at least 95 wt% of the binder.

[0015] The carbon content in the sintered cemented carbide should be selected so that neither eta phase nor free graphite is present in the cemented carbide microstructure after sintering. If the carbon content is too low, eta phase can form. Also, residual austenite transforms quickly into martensite upon cooling and the resulting properties (HV - K1c combination) will be low. If the carbon content is too high, graphite can form in the material and resulting properties (K1c - HV) can decrease as well.

[0016] It is well known by a person skilled in the art how to adjust the carbon content in a cemented carbide during manufacturing, simply by adding W or W_2C to decrease the overall carbon balance or add carbon black to increase the overall carbon balance. How much addition of such additives that are necessary depends on the type of sintering furnace, amount of oxygen in the raw materials etc.

[0017] The cemented carbide is preferably essentially free from Co and by that is herein meant that no Co is added as raw material and that Co is present in the cemented carbide on a level of impurity, preferably below 1 wt%, more preferably below 0.5 wt%. Small amounts of Co are usually detected since some manufacturing equipment, like e.g. milling bodies, contains Co containing cemented carbide and can give a small contribution to the overall composition.

[0018] By cemented carbide is herein meant that at least 50 wt% of the hard phase is WC.

[0019] The average grain size of the WC is suitably between 0.2 and 10 μm , preferably between 0.2 and 5 μm . The average grain size of the WC can e.g. be measured by using a mean linear intercept method on a SEM/LOM image.

[0020] In one embodiment of the present invention, WC is the only hard phase.

[0021] In one embodiment of the present invention, the cemented carbide consists of WC, Fe, Ni, Cr, Al, W and C and unavoidable impurities.

[0022] In one embodiment of the present invention, the metal binder comprises a certain amount of austenite. The remaining phase(s) in the binder are mostly martensite (bct) and/or ferrite (bcc).

[0023] The fraction of fcc (austenite) in the metal binder, I_{fr_fcc} , is herein given as the fraction of the intensity achieved from the fcc peak in a XRD diffractogram, $I(111)_{fcc}$, out of the total intensity of the fcc peak, $I(111)_{fcc}$, and the bct/bcc peak, $I(110)_{bct/bcc}$, i.e.

$$I_{fr_fcc} = I(111)_{fcc} / (I(111)_{fcc} + I(110)_{bct/bcc}).$$

[0024] The fraction of fcc (austenite) given herein is preferably above 25 %, preferably between 25 and 95%, more preferably between 45 and 75%. The fraction of austenite(fcc) can be determined by XRD as described in more detail in Example 1.

[0025] By cutting tool is herein meant a cutting tool insert, end mill or drill.

[0026] In one embodiment of the present invention, the cemented carbide substrate comprises WC and 3 to 20 wt% of a Fe-based metal binder comprising Fe, Ni, Cr and Al, so that the weight fraction $Ni/(Fe+Ni)$ is between 0.13 and 0.2; the weight fraction $Cr/(Fe+Ni+Cr+Al)$ is between 0.015 and 0.035 and the weight fraction $Al/(Fe+Ni+Cr+Al)$ is between 0.015 and 0.04; and wherein the amount of Fe in the metal binder is at least 72.5 wt%.

[0027] In one embodiment of the present invention, the cemented carbide substrate comprises WC and 3 to 20 wt% of a Fe-based metal binder comprising Fe, Ni, Cr and Al, so that the weight fraction $Ni/(Fe+Ni)$ is between 0.13 and 0.2; the weight fraction $Cr/(Fe+Ni+Cr+Al)$ is between 0.015 and 0.035 and the weight fraction $Al/(Fe+Ni+Cr+Al)$ is between 0.02 and 0.035; and wherein the amount of Fe in the metal binder is at least 73 wt%.

[0028] The present invention also relates to a method of making a cutting tool according to the above comprising a cemented carbide substrate as described above. The method comprises the following steps:

- providing a WC powder,
- providing powder(s) comprising the elements Al, Fe, Ni and Cr
- providing a milling liquid,
- milling, drying, pressing and sintering the powders into a cemented carbide.

[0029] The raw materials comprising the elements Al, Fe, Ni and Cr can be added as one or more of pure metals, alloys of two or more metals or as carbides, nitrides or carbonitrides thereof. The raw materials should be added in such amounts so that the binder phase, after sintering will have the composition as has been described above.

[0030] In one embodiment of the present invention, the powders selected from are NiAl, Cr_3C_2 , Fe and Ni.

[0031] The WC powder used with an average grain size of preferably 0.2-10 μm , more preferably 0.2-5 μm (FSSS).

[0032] Any liquid commonly used as a milling liquid in conventional cemented carbide manufacturing can be used. The milling liquid is preferably water, alcohol or an organic solvent, more preferably water or a water and alcohol mixture and most preferably a water and ethanol mixture. The properties of the slurry are dependent on the amount of milling

liquid added. Since the drying of the slurry requires energy, the amount of liquid should be minimized to keep costs down. However, enough liquid needs to be added to achieve a pumpable slurry and avoid clogging of the system. Also, other compounds commonly known in the art can be added to the slurry e.g. dispersion agents, pH-adjusters etc.

[0033] An organic binder is also optionally added to the slurry in order to facilitate the granulation during the following spray drying operation but also to function as a pressing agent for any following pressing and sintering operations. The organic binder can be any binder commonly used in the art. The organic binder can e.g. be paraffin, polyethylene glycol (PEG), long chain fatty acids etc. The amount of organic binder is suitably between 15 and 25 vol% based on the total dry powder volume, the amount of organic binder is not included in the total dry powder volume.

[0034] The slurry comprising powders forming hard constituents and powders forming the binder phase, and possibly an organic binder is suitably mixed by a milling operation, either in a ball mill or attritor mill. The milling is suitably made by first forming a slurry comprising metal binder powder, the first and second powder fraction, and possibly an organic binder. Then the slurry is suitably milled in a ball mill or attritor mill to obtain a homogenous slurry blend. For small scale experiments an agate mortar can be used to homogenize the powder mixture before pressing it into green bodies to be sintered.

[0035] The slurry containing the powdered materials mixed with the organic liquid and possibly the organic binder is atomized through an appropriate nozzle in the drying tower where the small drops are instantaneously dried by a stream of hot gas, for instance in a stream of nitrogen, to form agglomerated granules. For small scale experiments, also other drying methods can be used, e.g. pan drying.

[0036] Green bodies are subsequently formed from the dried powders/granules by a pressing operation such as uniaxial pressing, multiaxial pressing etc.

[0037] The green bodies formed from the powders/granules made according to the present invention, is subsequently sintered according to any conventional sintering methods e.g. vacuum sintering, Sinter HIP, spark plasma sintering, gas pressure sintering (GPS) etc.

[0038] In one embodiment of the present invention, the sintering temperature is between 1350 and 1550°C.

[0039] In one embodiment of the present invention, the sintering process comprises a sinter HIP step performed at a temperature of between 1350 and 1550°C, and a pressure of at least 40 Bar, preferably between 40 and 80 Bar. Usually, an inert argon atmosphere is used during the high pressure (HIP) step, without intentional addition of CO or H₂. However, residual amounts of other gases (H₂O, CO, CO₂) can be formed in-situ during the sintering process.

[0040] The present invention also discloses a cemented carbide cutting tool made according to the method described above.

Description of drawings

[0041]

Figure 1 shows the HV - K1c values compared to cemented carbides having Co as binder (the solid line). The sample numbers 1-5 are the samples according to the invention from Example 1 whereas the sample numbers 1c-4c are the comparative samples from Example 1.

Figure 2 shows the impact of different additions of Al where a positive "delta" value shows improved properties compared to a WC-Co cemented carbide whereas a negative "delta" value shows decreased properties compared to a WC-Co cemented carbide.

Figure 3 shows the impact on HV30 and K1C (calculated as delta) of different Ni/Ni+Fe ratios.

Figure 4a and 4b shows a diffractogram of a cemented carbide according to the present invention.

Example 1

[0042] Cemented carbide samples were prepared from raw material powders WC, Cr₃C₂, NiAl (50/50 by weight), Ni, Fe and carbon black according to Table 1, where the amounts of the different raw materials are given as wt% of the total powder weight. The WC powder had an average particle size of 1.2-1.4 µm (FSSS).

[0043] The raw material powders were milled in a ball mill for 8 h together with an organic binder (2 wt% PEG based on total powder weight) and a milling liquid (water/ethanol) to form a slurry which was dried and milled in agate mortar to obtain a powder blend. The powder was pressed into green bodies.

[0044] The green bodies were sintered in a HIP (hot isostatic pressure) furnace where maximum sintering temperature was 1410°C and sintering time was 1 h at 40 mbar vacuum sintering followed by a 15 min high-pressure sintering step, 50 bar Ar, to reduce porosity of the samples. The average cooling speed was 1.6 °C/min from 1410 to 1100°C and 6.6

°C/min from 1100 to 100°C.

Table 1

Sample No	WC (wt%)	Cr ₃ C ₂ (wt%)	NiAl (wt%)	Ni (wt%)	Fe (wt%)	Carbon black (wt%)
Invention 1	90.24	0.22	0.25	1.37	7.83	0.08
Invention 2	90.18	0.22	0.37	1.31	7.83	0.08
Invention 3	90.12	0.22	0.50	1.24	7.83	0.08
Invention 4	90.06	0.22	0.62	1.18	7.83	0.09
Invention 5	89.99	0.22	0.75	1.12	7.83	0.09
Comparative 1	90.37	0.22	0	1.49	7.83	0.08
Comparative 2	90.59	0	0	1.49	7.83	0.08
Comparative 3	90.46	0	0.25	1.37	7.83	0.08
Comparative 4	90.40	0	0.37	1.31	7.83	0.08

[0045] Chemical analysis was performed on the sintered samples and the results can be seen in Table 2. The elements Al, Co, Cr, Fe and Ni were analyzed using wavelength Dispersive X-Ray Florescence WD-XRF. The instrument was a Axios max-Advanced. Prior to analysis, the samples were prepared by crushing the cemented carbide into a powder, after which the powder was oxidized at 800°C for 2h. Lithium tetraborate is used as a flux to prepare homogenous and uniform pellets by fusion from the oxidized powder.

[0046] Oxygen and carbon were analyzed using LECO. The carbon content was measured using a LECO CS-844. A pre-weighed sample of approximately 0.2 gram is combusted in a stream of purified oxygen using RF induction to heat the sample. Carbon present in the sample is oxidized to carbon dioxide (CO₂) and swept by the oxygen carrier through a heated dust filter, a drying reagent, and then through non-dispersive infrared (NDIR) cells.

[0047] Oxygen was measured using a LECO ON-836. A pre-weighed sample is placed in a graphite crucible which is heated in an impulse furnace to release analyte gases. Oxygen present in the sample reacts with the graphite crucible to form CO and CO₂. An inert gas carrier, typically helium, sweeps the liberated analyte gases out of the furnace, through a Mass Flow Controller, and through a series of detectors. CO and CO₂ are detected using non-dispersive infrared (NDIR) cells.

Table 2

Sample No	Cr (wt%)	Ni (wt%)	Al (wt%)	Fe (wt%)	Co (wt%)	Ctot (wt%)	Otot (wt%)
Invention 2	0.217	1.648	0.14	7.986	0.153	5.58	0.083
Invention 3	0.226	1.574	0.24	7.974	0.161	5.59	0.139
Invention 4	0.213	1.55	0.31	7.941	0.121	5.62	0.135
Comparative 1	0.18	1.48	0	7.72	0.19	5.54	0.009
Comparative 2	0	1.601	0	7.921	0.161	5.53	0.018

[0048] The toughness (K_{1C}) and the hardness (HV₃₀) were measured on the sintered bodies after grinding and polishing. The HV₃₀ has been measured according to ASTM B294. The fracture toughness, K_{1C}, has been measured according to Shetty. The results can be seen in Table 3 together with the fraction of fcc phase (austenite) in the binder determined according to the method described below. The weight fractions for the elements given in Table 3 are calculated from powder composition given in Table 1 and the weight fraction from the chemical analysis is given with parenthesis.

XRD

[0049] XRD measurements were performed on a Bruker Discover D8 diffractometer with Davinci design equipped with a μ S Microfocus Source (CuK α radiation, λ = 1.5418 Å), a Vântec-500 area detector and an ¼ Eulerian cradle. The X-ray source was operated at 50 kV and 1 mA. The sample was mounted with adhesive tape to the sample holder. A collimator size of 1.0 mm diameter was used in all experiments. Measurements were conducted at a polished side of

the investigated sample. Measurements were done on a polished surface away from edges and other areas which could be strongly affected during sample machining.

[0050] Data were collected in the 2θ range 34°-54°. A software, DIFFRAC.EVA, was used to extract 1D data from the 2D detector (Våntec-500).

[0051] To obtain the fraction of the austenite phase in the binder, two peaks from the diffractogram were used. A (111) peak around 43.5° was used to quantify the fraction of austenite phase (fcc), and a (110) peak around 44.5° was used to quantify martensite/ferrite phase (bct/bcc).

[0052] The fraction of fcc (austenite) in the metal binder, I_{fr_fcc} , is herein given as the fraction of the intensity achieved from the fcc peak in a XRD diffractogram, $I(111)_{fcc}$, out of the total intensity of the fcc peak, $I(111)_{fcc}$, and the bct/bcc peak, $I(110)_{bct/bcc}$, i.e. $I_{fr_fcc} = I(111)_{fcc} / (I(111)_{fcc} + I(110)_{bct/bcc})$. The intensity was determined as the height of the peak with the background subtracted. Subtraction of any other overlapping peaks should also be performed if necessary.

[0053] In figure 4a and 4b the diffractogram from one of the samples according to the present invention is shown.

Table 3

Sample No	Ni/ (Ni+Fe)	Cr/ (Fe+Ni+Cr+Al)	Al/ (Fe+Ni+Cr+Al)	HV30	K1C (MPa/m)	fcc phase (%)
Invention 1	0.16	0.020	0.013	1608	9.8	8
Invention 2	0.16 (0.17)	0.020 (0.022)	0.019 (0.014)	1589	10.6	59
Invention 3	0.16 (0.16)	0.020 (0.023)	0.026 (0.0240)	1542	11.9	75
Invention 4	0.16 (0.16)	0.020 (0.021)	0.032 (0.0310)	1479	12.8	94
Invention 5	0.16	0.020	0.038	1461	12.7	95
Comparative 1	0.16 (0.16)	0.020 (0.019)	0	1576	9.1	4
Comparative 2	0.16 (0.17)	0	0	1512	9.2	4
Comparative 3	0.16	0	0.013	1501	9.2	4
Comparative 4	0.16	0	0.020	1535	10.1	10

[0054] The results have been plotted in Figure 1 and 2, where Figure 1 shows the HV - K1c values compared to cemented carbides having Co as binder (the solid line). The solid line is a curve based on a large number of HV - K1c measurements on cemented carbides having Co as binder. The sample numbers 1-5 are the samples according to the invention whereas the sample numbers 1c-4c are the comparative samples.

[0055] As can be seen, all samples according to the invention are above the curve.

[0056] Figure 2 shows the impact of different additions of Al (x-axis) where the value on the y-axis, Delta, is a distance from the reference line for WC-Co to the experimentally measured values of HV and KIC. Delta is:

$$\text{delta} = I \sqrt{\left(\frac{\Delta HV}{HV}\right)^2 + \left(\frac{\Delta KIC}{KIC}\right)^2} \quad (1)$$

[0057] Where ΔHV and ΔKIC are differences between measured (HV, KIC) and calculated (HV_{calc} , KIC_{calc}) values and the coefficient I gets the value -1 when ΔHV and ΔKIC are negative numbers and +1 when ΔHV and ΔKIC are positive values.

$$\Delta HV = HV - HV_{calc}, \quad (2)$$

$$\Delta KIC = KIC - KIC_{calc}, \quad (3)$$

$$HV_{calc} = \frac{a}{KIC^4} + \frac{b}{KIC^2} + c, \quad (4)$$

$$KIC_{calc} = \sqrt{\frac{2a}{\sqrt{b^2 - 4a(c - HV)} - b}}, \quad (5)$$

[0058] Where a, b and c are constants determined by fitting experimentally measured HV and KIC values to the equation 4: a = 2670000, b = 4590, c = 1240.

Example 2

[0059] Cemented carbide samples were prepared from the same raw materials as described in Example 1, but where WC raw material had average grain size (FSSS) of 4.8 μm.

[0060] The different powder compositions are given in Table 4. No Cr was added in these samples.

[0061] Sintered samples are prepared from the powder blends in the same way as in Example 1.

Table 4

Sample No	WC (wt%)	NiAl (wt%)	Ni (wt%)	Fe (wt%)	Carbon black (wt%)	W (wt%)
1	89.76	0.40	0.80	8.98	0.06	0.00
2	89.69	0.52	1.04	8.68	0.07	0.00
3	89.69	0.64	1.28	8.38	0.08	0.00
4	89.69	0.64	1.28	8.38	0.08	0.00
5	89.63	0.72	1.44	8.18	0.08	0.04
6	89.57	0.80	1.60	7.98	0.08	0.08
7	89.50	0.88	1.76	7.78	0.09	0.12

[0062] The toughness (K1C) and the hardness (HV30) were measured on the sintered bodies after grinding and polishing in the same way as in Example 1. The results can be seen in Table 5. The weight fractions given in Table 5 are calculated from powder composition given in Table 4.

Table 5

Sample No	Ni/ (Ni+Fe)	Al/ (Fe+Ni+(Cr)+Al)	HV30	K1C (MPa/m)
1	0.100	0.020	1415	12.0
2	0.130	0.025	1464	11.3
3	0.160	0.031	1398	14.0
4	0.160	0.031	1394	14.6
5	0.180	0.035	1314	17.1
6	0.200	0.038	1284	17.9
7	0.220	0.042	1271	20.0

[0063] In Figure 3, the impact of different Ni/(Ni+Fe) ratios (x-axis) are displayed where the value on the y-axis, delta, is determined as described above.

Claims

1. A cutting tool comprising a cemented carbide substrate wherein the cemented carbide comprises a hard phase comprising WC and 3 to 20 wt% of a Fe-based metal binder comprising Fe, Ni, Cr and Al, wherein the amount of the elements Fe, Ni, Cr and Al in the cemented carbide is such that:

- the weight fraction Ni/(Fe+Ni) is between 0.10 and 0.25;
- the weight fraction Cr/(Fe+Ni+Cr+Al) is between 0.005 and 0.05

- the weight fraction $Al/(Fe+Ni+Cr+Al)$ is between 0.01 and 0.05; and wherein the amount of Fe in the metal binder is at least 65 wt%.

2. A cutting tool according to claim 1 wherein

- the weight fraction $Ni/(Fe+Ni)$ is between 0.13 and 0.20;
- the weight fraction $Cr/(Fe+Ni+Cr+Al)$ is between 0.015 and 0.035
- the weight fraction $Al/(Fe+Ni+Cr+Al)$ is between 0.015 and 0.04.

3. A cutting tool according to any of the preceding claims wherein the total amount of elements Fe, Ni, Cr and Al is at least 90 wt% of the metal binder.

4. A cutting tool according to any of the preceding claims wherein the cemented carbide is essentially free from cobalt.

5. A cutting tool according to any of the preceding claims wherein the fraction of austenite (fcc), I_{fr_fcc} , in the metal binder is above 25% where I_{fr_fcc} is the fraction of the intensity achieved from the fcc peak, $I(111)_{fcc}$, out of the total intensity of the fcc peak, $I(111)_{fcc}$, and the bct/bcc peak, $I(110)_{bct/bcc}$ in a XRD diffractogram according to $I_{fr_fcc} = I(111)_{fcc} / (I(111)_{fcc} + I(110)_{bct/bcc})$.

6. A cutting tool according to any of the preceding claims wherein the cemented carbide consists of WC, Fe, Ni, Cr, Al, W, C and unavoidable impurities.

7. A method of making a cutting tool according to claims 1-6 comprising a cemented carbide substrate wherein the method comprises the following steps:

- providing a WC powder,
- providing powder(s) comprising the elements Al, Fe, Ni and Cr,
- providing a milling liquid,
- milling, drying, pressing and sintering the powders into a cemented carbide substrate.

8. A method according to claim 7 wherein the raw materials comprising the elements Al, Fe, Ni and Cr are added as one or more of pure metals, alloys of two or more metals or as carbides, nitrides or carbonitrides thereof.

9. A method according to claims 7-8 wherein the sintering comprises a sinter HIP step performed at a temperature of between 1350 and 1550°C, and a pressure of at least 40 Bar, preferably between 40 and 80 Bar.

Fig. 1

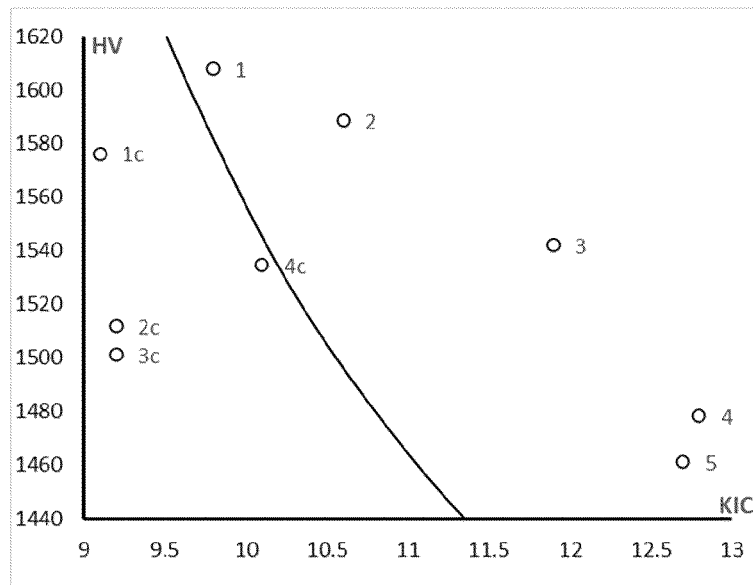


Fig. 2

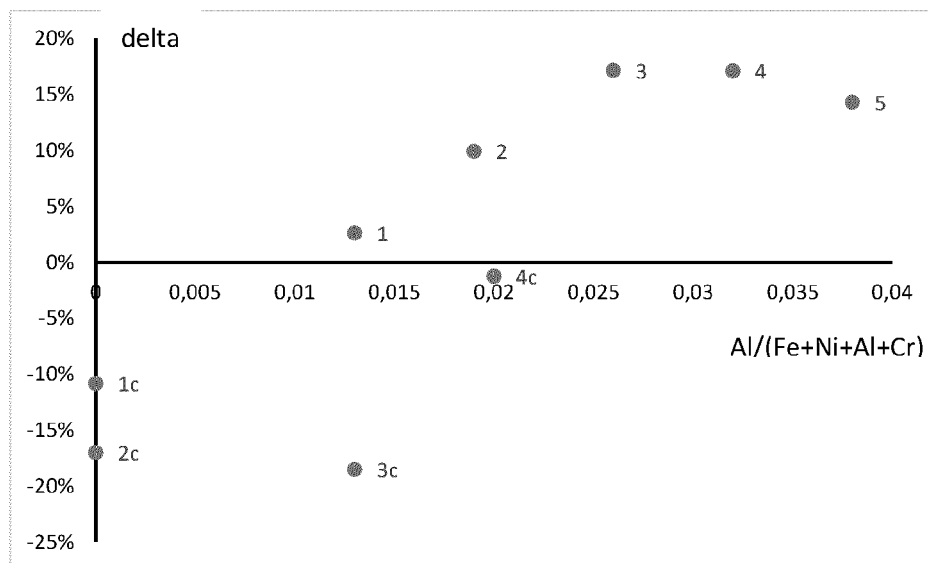


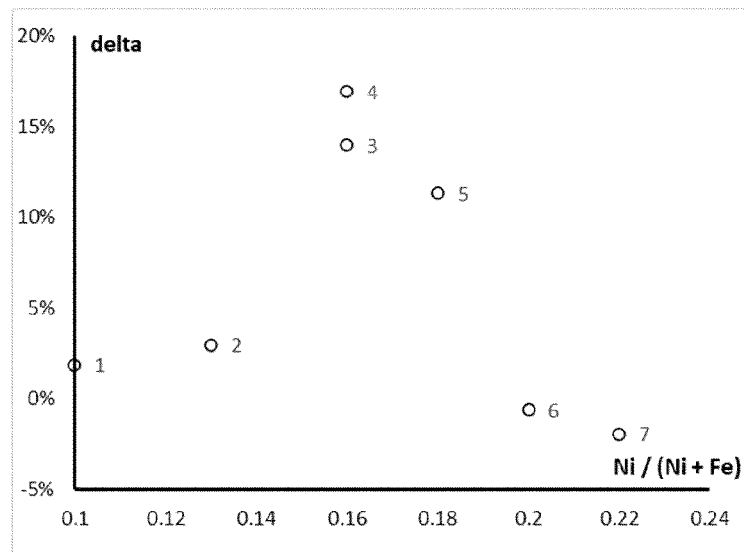
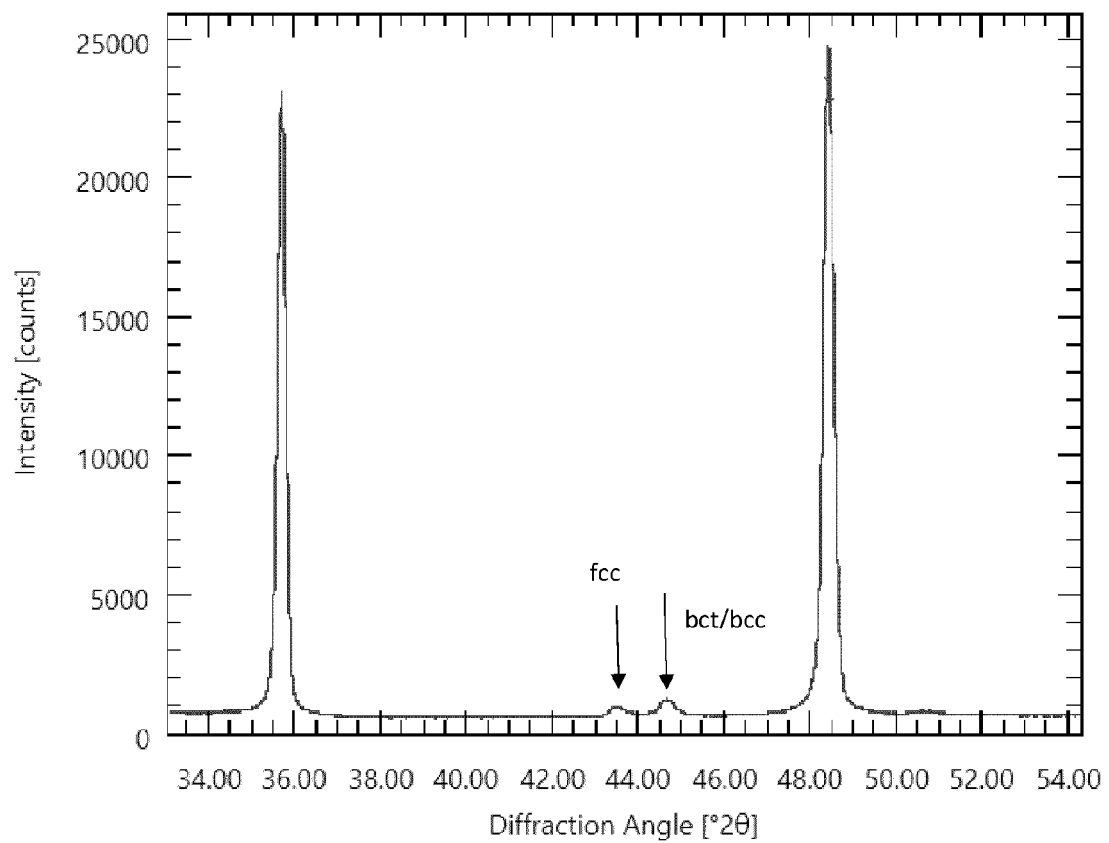
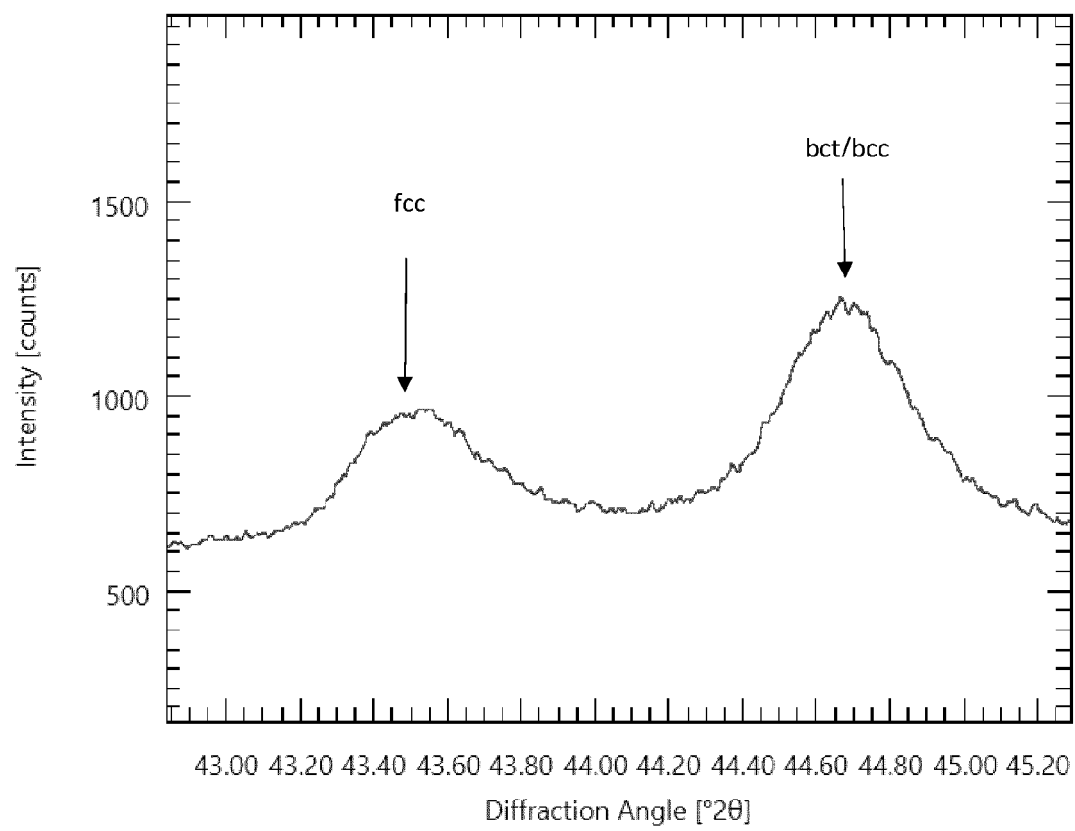
Fig. 3**Fig 4a**

Fig. 4b



EUROPEAN SEARCH REPORT

Application Number

EP 23 16 5500

5

10

15

20

25

30

35

40

45

50

55

2

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CN 113 618 067 A (AVIC SHENGSHI BEIJING DIE CUTTING MACHINERY CO LTD) 9 November 2021 (2021-11-09) * claim 1 * * table 2 *	1-9	INV. C22C1/051 C22C29/06 C22C29/08
A	US 2014/234548 A1 (ZIMMERMANN STEFAN [DE] ET AL) 21 August 2014 (2014-08-21) * Sample No. 7; table 1 *	1-9	ADD. B22F5/00
A	JP 5 502481 B2 (BAYER BETEILIGUNGSVERWALTUNG GOSLAR GMBH & STARCK H C GMBH) 28 May 2014 (2014-05-28) * claim 1 * * table 1 *	1-9	
A	CN 115 772 639 A (NINGXIA YELLOW RIVER HYDROPOWER QINGTONGXIA POWER GENERATION CO LTD ET) 10 March 2023 (2023-03-10) * claims 1, 3 * * examples 1-3 *	1-9	TECHNICAL FIELDS SEARCHED (IPC)
A	KR 100 419 338 B1 (YEONWOO INDUSTRY CO LTD [KR]) 6 March 2004 (2004-03-06) * Sample No. 3; table 1 *	1-9	B22F C22C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 24 August 2023	Examiner Traon, Nicolas
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 P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 5500

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-08-2023

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 113618067 A	09-11-2021	NONE	
US 2014234548 A1	21-08-2014	AU 2012306492 A1	13-03-2014
		CA 2845506 A1	14-03-2013
		CN 103781929 A	07-05-2014
		DE 102011112435 B3	25-10-2012
		EP 2753722 A1	16-07-2014
		JP 6116569 B2	19-04-2017
		JP 2014531509 A	27-11-2014
		KR 20140058673 A	14-05-2014
		MX 359657 B	05-10-2018
		RU 2014113180 A	20-10-2015
		US 2014234548 A1	21-08-2014
		WO 2013034544 A1	14-03-2013
JP 5502481 B2	28-05-2014	AU 2007298940 A1	27-03-2008
		CN 101517109 A	26-08-2009
		CN 104745998 A	01-07-2015
		DE 102006045481 B3	06-03-2008
		DK 2066822 T3	29-10-2018
		EP 2066822 A1	10-06-2009
		ES 2690126 T3	19-11-2018
		JP 5502481 B2	28-05-2014
		JP 2010504426 A	12-02-2010
		KR 20090053941 A	28-05-2009
		PL 2066822 T3	31-01-2019
		RU 2009114860 A	27-10-2010
		US 2010047622 A1	25-02-2010
		WO 2008034902 A1	27-03-2008
		ZA 200901578 B	26-05-2010
CN 115772639 A	10-03-2023	NONE	
KR 100419338 B1	06-03-2004	NONE	