



US 20240295012A1

(19) **United States**

(12) **Patent Application Publication**
MARTENSSON et al.

(10) **Pub. No.: US 2024/0295012 A1**

(43) **Pub. Date: Sep. 5, 2024**

(54) **CEMENTED CARBIDE INSERT FOR
MINING OR CUTTING APPLICATIONS
COMPRISING GAMMA PHASE CARBIDE**

B22F 3/24 (2006.01)

B22F 5/00 (2006.01)

B22F 9/02 (2006.01)

B22F 9/04 (2006.01)

(71) Applicant: **SANDVIK MINING AND
CONSTRUCTION TOOLS AB,**
Sandviken (SE)

C22C 1/051 (2006.01)

C22C 29/06 (2006.01)

E21B 10/56 (2006.01)

(72) Inventors: **Malin MARTENSSON,** Vastberga
(SE); **Carl-Johan MADERUD,**
Vastberga (SE); **Anders NORDGREN,**
Enskededalen (SE); **Jose Luis**
GARCIA, Vastberga (SE)

(52) **U.S. Cl.**

CPC *C22C 29/08* (2013.01); *B22F 3/15*

(2013.01); *B22F 3/24* (2013.01); *B22F 5/00*

(2013.01); *B22F 9/026* (2013.01); *B22F 9/04*

(2013.01); *C22C 1/051* (2013.01); *C22C*

29/067 (2013.01); *E21B 10/56* (2013.01);

B22F 2005/001 (2013.01); *B22F 2009/043*

(2013.01); *B22F 2301/15* (2013.01); *B22F*

2302/10 (2013.01); *B22F 2998/10* (2013.01);

B22F 2999/00 (2013.01)

(21) Appl. No.: **18/578,454**

(22) PCT Filed: **Jul. 8, 2022**

(86) PCT No.: **PCT/EP2022/069146**

§ 371 (c)(1),

(2) Date: **Jan. 11, 2024**

(57)

ABSTRACT

A sintered cemented carbide insert for mining or cutting applications includes a mean WC grain size of between 0.8-18 μm , a binder phase in a weight between 4-18 wt %, a gamma phase with the cubic gamma phase precursors in a weight of between 0.8-10 wt %, and any unavoidable impurities and a balance of WC. A difference between the hardness at any point 0.3 mm from the surface of the insert and the hardness of the bulk is at least 25 HV3, wherein hardness is measured according to ISO EN6507. A method of producing the cemented carbide is also provided.

(30) **Foreign Application Priority Data**

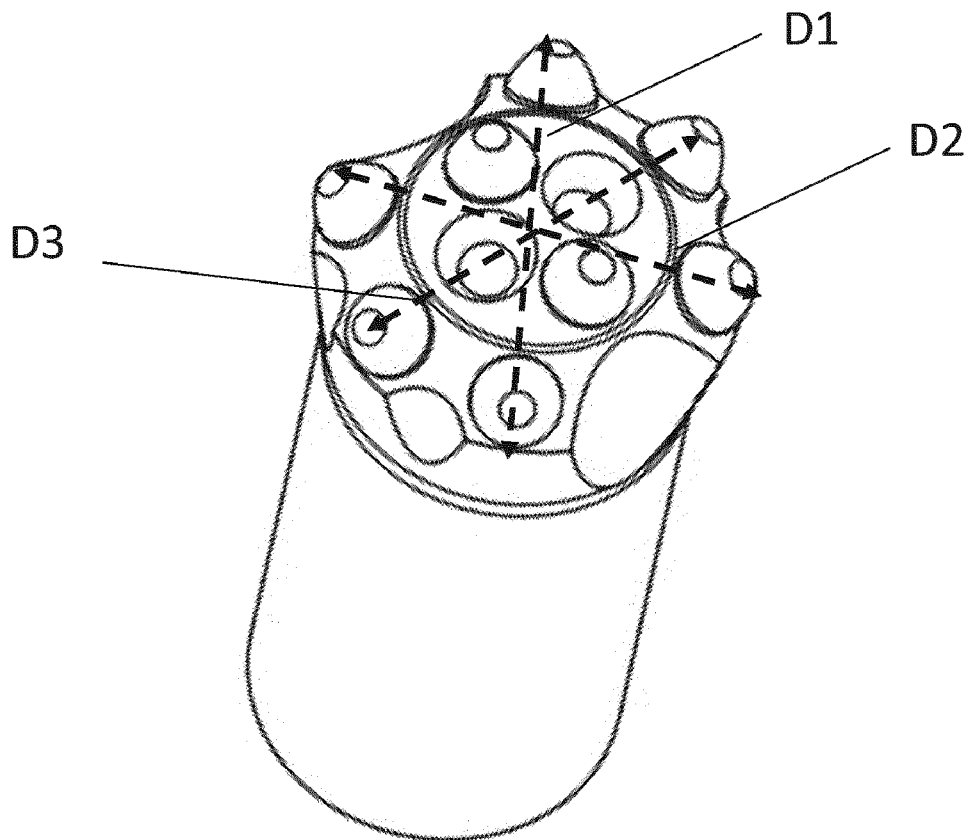
Jul. 14, 2021 (EP) 21185471.6

Publication Classification

(51) **Int. Cl.**

C22C 29/08 (2006.01)

B22F 3/15 (2006.01)



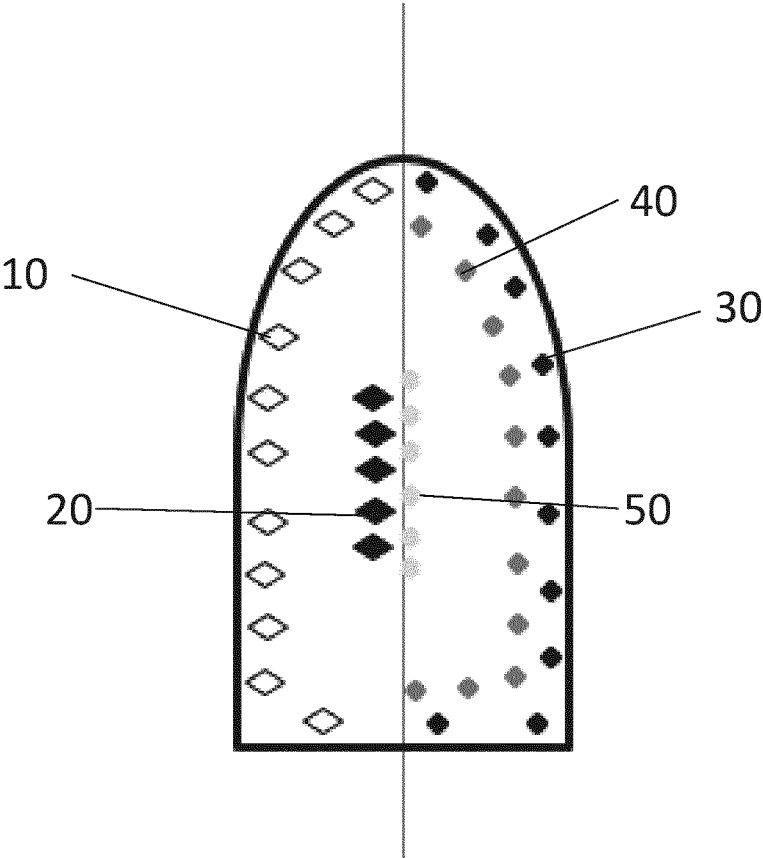


Fig 1

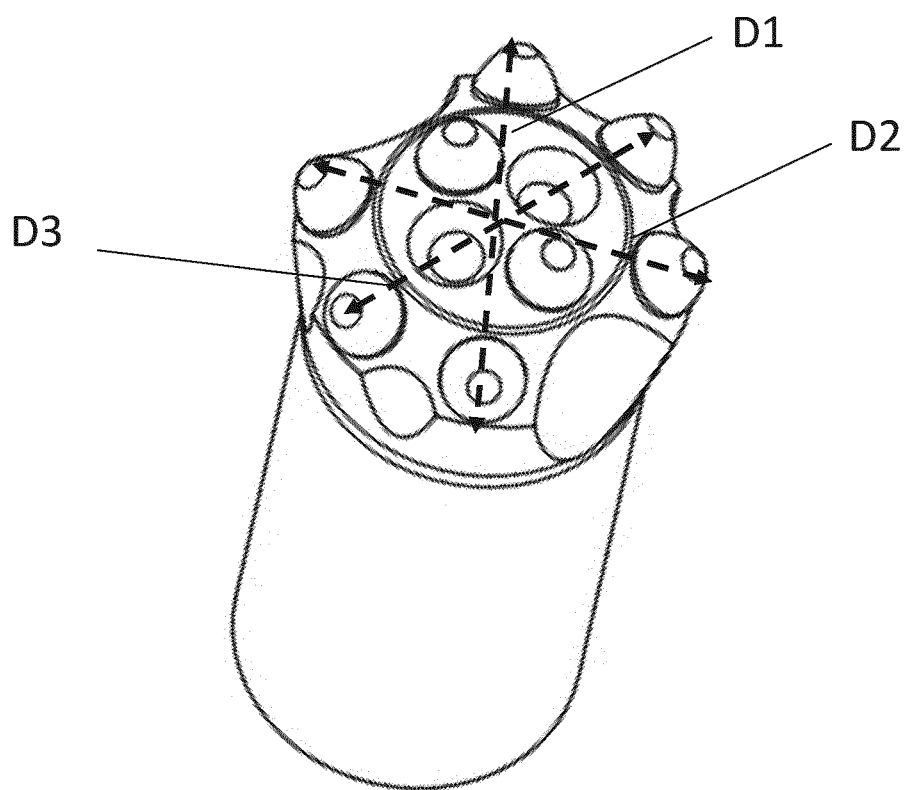


Fig 2

CEMENTED CARBIDE INSERT FOR MINING OR CUTTING APPLICATIONS COMPRISING GAMMA PHASE CARBIDE

TECHNICAL FIELD

[0001] The present invention relates to a cemented carbide insert for mining or cutting applications containing gamma phase carbide and a method of making said mining insert.

BACKGROUND

[0002] Cemented carbide has a unique combination of high elastic modulus, high hardness, high compressive strength, high wear and abrasion resistance with a good level of toughness. Therefore, cemented carbide is commonly used in products such as mining tools. Cemented carbide comprises a hard metal phase and a binder phase. Typically, the cemented carbide used for mining inserts using tungsten carbide hard metal phase, with only very minor quantities of other carbides that are present as impurities rather than purposely added.

[0003] The use of gamma phase hard metals which includes cubic carbides and nitrides and carbonitrides of titanium, tantalum and niobium carbide that together with hexagonal tungsten carbide form a mixed cubic carbide (Me1, Me2, Me3)(C) or mixed cubic carbonitride (Me1, Me2, Me3)(C,N), so called gamma phases, are commonly used in cemented carbides used in the metal cutting industry as they provide the benefit of improved wear resistance and improved resistance towards plastic deformation. However, gamma phase hard metals are not currently used in cemented carbide for mining inserts as it embrittles the carbide, which when subjected to mining operations, such as a percussive drilling action, will result in the inserts prematurely cracking, therefore reducing the lifetime of the inserts.

Definitions

[0004] By “cemented carbide” is herein meant a material that comprises at least 50 wt % WC, possibly other hard constituents common in the art of making cemented carbides and a metallic binder phase preferably selected from one or more of Fe, Co and Ni.

[0005] The term “bulk” is herein meant the cemented carbide of the innermost part (centre) of the rock drill insert and for this disclosure is the zone having the lowest hardness.

[0006] The term “green” refers to a cemented carbide mining insert produced by milling the hard phase component (s) and the binder together and then pressing the milled powder to form a compact cemented carbide mining insert, which has not yet been sintered.

[0007] The term “cubic carbides” refers to the cubic carbides such as TaC, NbC, TiC that together with hexagonal WC will form a cubic “gamma phase” during sintering.

[0008] The term “cubic nitrides” refers to cubic nitride such as TiN that together with hexagonal WC will form a cubic “gamma phase” during sintering.

[0009] The term “cubic carbonitrides” refers to the cubic carbonitride such as Ti(C,N) that together with hexagonal WC will form a cubic “gamma phase” during sintering.

[0010] The term “gamma phase” refers to the mixed cubic carbides and carbonitrides formed and precipitated during sintering when cubic carbide and/or nitride formers/precursors are added prior to the green forming step in higher

amounts than can be dissolved in the binder in the sintered cemented carbide body. Typical cubic gamma phase formers/precursors are for example Ta, Nb and Ti that together with W from the hexagonal WC form the cubic gamma phase for example, but not limited to, (Ta,Nb,W)(C), (Ta, Nb, Ti, W)(C,N). It is assumed that substantially all added cubic carbides/nitrides/carbonitrides form “gamma phase” and the amount of these cubic gamma phase precursors in the sintered body is either calculated from the sum of the added cubic carbide/nitrides/carbonitrides or can be calculated backwards by analysing the element concentration of Me1, Me2 including nitrogen in the sintered body and assume that all Me1 was added as Me1C, where Me1 is a metal that form cubic carbides as Ta or Nb. If nitrogen is present some of the Me2 was added as Me2N or Me2(C,N) and Me2C, where Me2 is a metal that forms both cubic carbides, nitrides and mixtures thereof as Ti. The elemental analyses are preferably performed using an XRF-instrument equipped with a wavelength dispersive spectrometer on an oxidised and dissolved sintered material that for example is included into a light element (as boron) glass. The analysis and evaluation are performed using quantitative XRF-methods that are carefully calibrated within the range of the claims.

SUMMARY OF INVENTION

[0011] A cemented carbide mining insert having improved wear resistance without increased brittleness has now been developed. Different aspects of the invention include a cemented carbide mining insert, a rock drill bit body comprising one or more mounted cemented carbide inserts, and a method of producing a cemented carbide insert, which are characterized by what is stated in the independent claims. Various embodiments of the invention are disclosed in the dependent claims.

[0012] According to a first aspect of the present invention there is a sintered cemented carbide insert for mining or cutting applications comprising: a mean WC grain size of between 0.8-18 μm ; a binder phase in a weight between 4-18 wt %; gamma phase with the cubic gamma phase precursors in a weight of between 0.8-10 wt %; any unavoidable impurities and a balance of WC; and wherein the difference between the hardness at 0.3 mm at any point from the surface of the insert and the hardness of the bulk is at least 25 HV3, wherein hardness is measured according to ISO EN6507 3:2005.

[0013] Advantageously, a cemented carbide mining insert having improved wear resistance without increased brittleness is provided. Therefore, the lifetime of the insert is increased. Further, it makes it easier to be able to use recycled carbide, that typically has higher gamma phase content that would be acceptable for cemented carbide grades that are commonly used for used mining or cutting applications. A cemented carbide insert should be considered to include any insert used for interaction with rock, for example inserts for percussive drilling, top hammer drilling, down-the-hole (DTH) drilling, protection inserts or cutting tools.

[0014] According to second aspect of the present invention there is a method of producing a cemented carbide insert, comprising the steps of:

[0015] a) providing a green cemented carbide insert comprising between 0.8-10 wt % cubic carbides and or

carbonitrides and or nitrides, between 4-18 wt % binder, any unavoidable impurities and a balance of WC hard phase;

[0016] b) sintering the green carbide mining insert to form a sintered cemented carbide insert;

[0017] c) subjecting the sintered cemented carbide insert to a high energy post-treatment.

[0018] Advantageously, this method produces cemented carbide inserts having improved wear resistance without increased brittleness and therefore the inserts produced by this method have an increased lifetime.

[0019] According to a third aspect, there is provided a rock drill bit body comprising one or more mounted cemented carbide inserts.

BRIEF DESCRIPTION OF DRAWINGS

[0020] FIG. 1: Schematic drawing showing the positions on the insert where the hardness and toughness measurements were taken.

[0021] FIG. 2: Schematic drawing of a top hammer bit with ballistic inserts with the diameter measuring points indicated.

DETAILED DESCRIPTION

[0022] The present invention relates to a sintered cemented carbide insert for mining or cutting applications comprising: a mean WC grain size of between 0.8-18 μm ; a binder phase in a weight between 4-18 wt %; gamma phase with the cubic gamma phase precursors in a weight of between 0.8-10 wt %; any unavoidable impurities and a balance of WC; and wherein the difference between the hardness at 0.3 mm from any point of the surface of the insert and the hardness of the bulk is at least 25 HV3, when the hardness is measured according to ISO EN6507.

[0023] Preferably the sintered WC grain size is between 0.8-16 μm , more preferably between 0.8-8 μm or 0.8-5 μm or 0.9-8 μm or 1.0-5 μm or 1.0-4.0 μm .

[0024] The mean WC grain size was evaluated using the Jeffries method described below, from at least two different micrographs for each material. An average value was then calculated from the mean grain size values obtained from the individual micrographs (for each material respectively).

[0025] The procedure for the mean grain size evaluation using a modified Jeffries method was the following: A rectangular frame of suitable size was selected within the SEM micrograph so as to contain a minimum of 300 WC grains. The grains inside the frame and those intersected by the frame are manually counted, and the mean grain size is obtained from equations (1-3):

$$M = \frac{L_{\text{scale mm}} \times 10^{-3}}{L_{\text{scale micro}} \times 10^{-6}} \quad (1)$$

$$\text{vol \% WC} = 100 \times \left(-1.308823529 \times \frac{\left(\frac{\text{wt \% Co}}{100} - 1 \right)}{\left(\frac{\text{wt \% Co}}{100} + 1.308823529 \right)} \right) \quad (2)$$

$$d = \frac{1500}{M} \times \sqrt{\frac{L_1 \times L_2 \times \text{vol \% WC}}{\left(n_1 + \frac{n_2}{2} \right) \times 100}} \quad (3)$$

[0026] Where:

[0027] d=mean WC grain size (μm)

[0028] L_1, L_2 =length of sides of the frame (mm)

[0029] M=magnification $L_{\text{scale mm}}$ =measured length of scale bar on micrograph in mm

[0030] $L_{\text{scale micro}}$ =actual length of scale bar with respect to magnification (μm)

[0031] n_1 =no. grains fully within the frame

[0032] n_2 =no. grains intersected by frame boundary

[0033] wt % Co=known cobalt content in weight %.

[0034] Equation (2) is used to estimate the WC fraction based on the known Co content in the material. Equation (3) then yields the mean WC grain size from the ratio of the total WC area in the frame to the number of grains contained in it. Equation (3) also contains a correction factor compensating for the fact that in a random 2D section, not all grains will be sectioned through their maximum diameter.

[0035] Preferably, the binder phase is between 4-18 wt % or 5-15 wt % or 5-12 wt % or 6-12 wt % or 5-8 wt % and 10-15 wt %.

[0036] For percussive applications as Top hammer (TH) and Down the Hole (DTH) the grain sizes are preferable between 0.8-5 microns and the binder phase concentration is preferable between 4-8 wt % and the room temperature hardness is preferable between 1250-1650 HV20.

[0037] For Rotary applications the grain size is preferable between 2-8 microns and the binder phase content is preferable between 8-15 wt % and the room temperature hardness is between 1000-1400 HV20.

[0038] For mechanical cutting applications the grain sizes are preferable between 6-18 microns and the binder phase content are between 6-18 wt % and the room temperature hardness is preferable between 800-1200 HV20.

[0039] Preferably, the weight percent of gamma phase is less than 10 wt %, more preferably less than 8 wt % even more preferable less than 6 wt % or less than 4 wt % or less than 2 wt %.

[0040] Preferably, the weight percent of gamma phase is >0.8 wt %, more preferably >0.9 wt %, more preferable >1.0 wt %, even more preferable >1.1 wt %, even more preferably >1.2 wt %.

[0041] The gamma phase forming carbides or nitrides or carbonitrides added could be any of Ta, Nb, Ti, Zr, Hf.

[0042] Preferably, the volume of gamma phase is evenly distributed throughout the insert.

[0043] Preferably, the gamma phase grains are smaller than 10 microns, more preferable smaller than 5 microns, preferable smaller than 4 microns most preferable smaller than 3 microns.

[0044] The hardness of the cemented carbide inserts is measured using Vickers hardness measurement. The cemented carbide bodies are sectioned along the longitudinal axis and polished using standard procedures. The sectioning is done with a diamond disc cutter under flowing water.

[0045] In one embodiment the difference between the hardness at 0.3 mm depth at any point of the surface of the dome of the rock drill insert and the minimum hardness of the bulk of the rock drill insert is at least 25 HV3 or at least 30 HV3 or at least 35 HV3, or at least 40 HV3. The average hardness at a certain depth is defined as the average of at least 10 measured, more preferable 20 hardness values at the certain depth evenly distributed around the insert. The large difference in hardness between the surface of the rock drill

insert and its interior is present over the whole surface and will therefore also reduce the risk of other types of failures during handling.

[0046] Preferably, the cemented carbide insert has a bulk hardness of not higher than 1700 HV3 or not higher than 1650 HV3, or not higher than 1600 HV3.

[0047] In one embodiment the top of the insert has a higher surface hardness than the cylindrical part and the bottom, but the bulk hardness is the same in the interior of the insert.

[0048] Preferably, the binder phase comprises at least 80 wt % of one or more of cobalt, nickel, iron or a combination thereof.

[0049] Preferably the binder phase is Co and/or Ni, most preferably Co, even more preferably between 3 to 20 wt % Co. Optionally, the binder is a nickel chromium or nickel aluminium alloy.

[0050] The carbide mining insert may optionally also comprise a grain refiner compound in an amount of 20 wt % of the binder content. The grain refiner compound is suitably selected from the group of carbides, mixed carbides, carbonitrides or nitrides of vanadium, chromium, tantalum and niobium. With the remainder of the carbide mining insert being made up of the one or more hard-phase components.

[0051] The binder content may be constant throughout the insert or have a gradient from the surface to the bulk of the insert.

[0052] Preferably, the cubic precursors for gamma phase is tantalum carbide or niobium carbide or a mixture thereof. This is beneficial for the plastic deformation resistance at elevated temperature.

[0053] Preferable the amount of TaC+NbC=0.8-10 wt % or 1-8 wt % or 1-5 wt % or 1.2-5 wt % or 1.2 to 3 wt % or 1.5-6 wt %.

[0054] Preferably, the ratio of Ta/Nb in weight is 0.1-100, more preferable 0.5-50, even more preferable 1-10, most preferable 2-6.

[0055] Optionally, the cemented carbide also comprises Cr in such an amount that the mass ratio Cr/Co in the bulk is 0.04-0.19. Preferably, the mass ratio Cr/Co in the cemented carbide is 0.06-0.16, more preferably the mass ratio Cr/Co in the cemented carbide is 0.07-0.15, most preferable the mass ratio Cr/Co in the cemented carbide is 0.075-0.12. Advantageously, the presence of the chromium improves the plastic deformation of the cemented carbide, this enables higher compressive stresses to be introduced into the carbide when it is treated with a surface high energy post-treatment, such as tumbling or intensive shaking. This increase in compressive stress provides an apparent hardness increase which improves the wear resistance of the cemented carbide, without reducing the toughness.

[0056] The mass ratio of the Cr/binder is calculated by dividing the weight percentage (wt %) of the Cr added to powder blend by the wt % of the binder in the powder blend, wherein the weight percentages are based on the weight of that component compared to the total weight of the powder blend. To a great extent the Cr is dissolved into the binder phase, however there could be some amount, e.g. up to 3 mass %, of undissolved chromium carbide in the cemented carbide body. It may however be preferable to only add Cr up to the mass ratio of Cr/binder so that all the Cr dissolved into the binder so that the sintered cemented carbide body is free of undissolved chromium carbides.

[0057] The Cr is normally added to the powder blend in the form of Cr_3C_2 as this provides the highest proportion of Cr per gram of powder, although it should be understood that the Cr could be added to the powder blend using an alternative chromium carbide such as Cr_{26}C_2 or Cr_7C_3 or a chromium nitride or even an oxide. The addition of the Cr also has the effect of improving the corrosion resistance of the cemented carbide body. The presence of the Cr also makes the binder prone to transform from fcc to hcp during drilling, this is beneficial for absorbing some of the energy generated in the drilling operation. The transformation will thereby harden the binder phase and reduce the wear of the button during use thereof. The presence of the Cr will increase the wear resistance of the cemented carbide and increase its ability for deformation hardening. The combination of the Cr in the cemented carbide powder and the application of the powder comprising a grain refiner compound and optionally a carbon-based grain growth promoter, to at least one portion of the surface of the compact produces a cemented carbide body having a chemical and hardness gradient which produce a cemented carbide mining insert with high wear resistance.

[0058] In one embodiment of the present invention, the cemented carbide comprises M_7C_3 carbides and/or M_{23}C_6 carbide, and possibly also M_3C_2 carbides, where M is Cr and possibly one or more of W, Co and any other elements added to the cemented carbide. By that is herein meant that the M_7C_3 and/or M_{23}C_6 carbide carbides should be clearly visible in a SEM (scanning electron microscope) image using backscattering at a magnification enough to detect particles of a size of 100 nm. In one embodiment of the present invention, the cemented carbide comprises M_7C_3 carbides and/or M_{23}C_6 carbides in an amount given by the ratio vol % (M_7C_3 carbides and/or M_{23}C_6 carbide)/vol % Co. Suitably the ratio vol % (M_7C_3 carbides and/or M_{23}C_6 carbide)/vol % Co is between 0.01 to 0.5 preferably between 0.03 to 0.25. The vol % of M_7C_3 carbides and/or M_{23}C_6 carbide and the Co binder can be measured by EBSD or image analysis using a suitable software.

[0059] In one embodiment the cemented carbide is free from eta phase and graphite. If the binder phase consists of cobalt, the cemented carbide will be free from eta phase and graphite when the Com/Co ratio is $0.75 \leq \text{Com/Co} \leq 0.98$. The metals used as binder phase in cemented carbides, like Co, Ni, and Fe are ferromagnetic. The saturation magnetization is the maximum possible magnetization of ferromagnetic material, characterized by parallel orientation of all magnetic moments inside the material. A Foerster KOERZIMAT 1.096 is used to determine the magnetic saturation (Com) dipole moment jS and the derived weight specific saturation magnetization oS ($4\pi\sigma$) of the inserts. The Co content is then measured with XRF (X-ray fluorescence) using a Malvern Panalytical Axios Max Advanced instrument. The Com/% Co range that is between eta phase and graphite formation is affected by changing the binder composition, such as by adding Cr, Fe, Ni etc.

[0060] The solubility of W in the binder phase is directly related to the carbon content. The amount of W in the binder increases with decreasing carbon content until the limit for eta phase formation is reached. If the carbon content would decrease even lower, the solubility of W in the binder will not increase further. In some cemented carbide grades where it is beneficial to obtain a high amount of W dissolved in the

binder, the carbon content has been kept low but above the limit for eta phase formation.

[0061] In one embodiment, the fracture toughness difference (Delta K1C) between 0.5 mm below the surface and the bulk is at least 1.5, more preferably at least 1.8, even preferable at least 2.0, most preferable at least 2.2 MPa*m^{0.5}. The fracture toughness K1C is measured using 5-10 Vickers indentations, 30 kg load and calculated using Shetty's formula.

[0062] FIG. 1 shows the positions where the indentations were placed for delta K1C and delta HV3 measurements. On the left side of the sectioned and polished sample HV30 indentations were placed 0.5 mm from the surface **10** (unfilled diamonds) and in the bulk **20** (black diamonds). On the right side of the sample HV3 was measured 0.3 mm from the surface **30** (black filled diamonds), 1 mm from the surface **40** (grey diamonds) and in the bulk **50** (light grey diamonds).

[0063] In one embodiment, there is a rock drill bit body comprising one or more mounted cemented carbide inserts as described hereinabove or hereinbelow.

[0064] According to one embodiment, the cemented carbide inserts are mounted in a rock drill bit body of a top-hammer (TH) device or a down-the-hole (DTH) drilling device or a rotary drilling device or a cutting disc device. The rotary drilling device may be an oil and gas rotary cutter device. The invention also relates to a rock drill or cutting device, in particular a top-hammer device, or a down-the-hole drilling device, or a rotary drilling device, or a cutting disc device as well as the use of a cemented carbide insert according to the invention in such a device.

[0065] Another aspect of the present disclosure relates to the use of the cemented carbide mining insert as described hereinbefore or hereinafter for rock drilling or oil and gas drilling.

[0066] Another aspect of the present invention is a method of producing a cemented carbide insert according to any of claims 1-7, comprising the steps of:

[0067] a) providing a green cemented carbide insert comprising between 0.8-10 wt % cubic carbides and or carbonitrides and or nitrides, between 4-18 wt % binder, any unavoidable impurities and a balance of WC hard phase;

[0068] b) sintering the green carbide mining insert to form a sintered cemented carbide insert;

[0069] c) subjecting the sintered cemented carbide insert to a high energy post-treatment.

[0070] High energy post-treatment (HET) is considered to be a process wherein a post-treatment a homogenous cemented carbide mining insert has been deformation hardened such that $\Delta HV3\% \geq 9.72 - 0.00543 * HV3_{bulk}$, wherein the $\Delta HV3\%$ is the percentage difference between the HV3 measurement at 0.3 mm from the surface compared the HV3 measurement in the bulk. HET could also be understood to mean a post-treatment process that induces a hardness difference between 0.3 mm from the surface and the bulk of at least 20 HV3. HET could also be understood to mean that there is both a hardness and toughness increase induced

from the surface to the bulk without changing the chemical composition or the WC grain size near the surface (0.3 mm below) or in the bulk.

[0071] To introduce higher levels of compressive stresses into the cemented carbide mining insert, a high energy shaking or tumbling process may be used. There are many different possible process set ups that could be used to introduce HET, including the type of equipment, the volume of media added (if any), the treatment time and the process set up, e.g. RPM for a centrifugal tumbler or shaking equipment etc. Therefore, the most appropriate way to define HET is in terms of "any process set up that introduces a specific degree of deformation hardening in a homogenous cemented carbide mining insert consisting of WC—Co, having a mass of about 20 g". In the present disclosure, HET is defined as a post-treatment process that would introduce a hardness change, measured using HV3, after post-treatment ($\Delta HV3\%$) of at least:

$$\Delta HV3 \% = 9.72 - 0.00543 * HV3_{bulk} \quad (\text{equation 1})$$

$$\text{Wherein: } \Delta HV3 \% = 100 * (HV3_{0.3 \text{ mm}} - HV3_{bulk}) / HV3_{bulk} \quad (\text{equation 2})$$

[0072] $HV3_{bulk}$ is an average of at least 10 indentation points measured in the innermost (centre) of the cemented carbide mining insert and $HV3_{0.3 \text{ mm}}$ is an average of at least 10 indentation points at 0.3 mm below the tumbled surface of the cemented carbide mining insert. This is based on the measurements being made on a cemented carbide mining insert having homogenous properties. By "homogeneous properties" we mean that post sintering the hardness difference is no more than 1% from the surface zone to the bulk zone. The HET-parameters used to achieve the deformation hardening described in equations (1) and (2) on a homogenous cemented carbide mining insert would be applied to cemented carbide bodies having a gradient property.

[0073] HET may typically be performed using centrifugal tumbling in an ERBA 120, having a disc size of about 600 mm, run at about 200 RPM if the tumbling operation is either performed without media or with media that is larger in size than the inserts being tumbled, or at about 300 RPM if the media used is smaller in size than the inserts being tumbled; using a Rösler tumbler, having a disc size of about 350 mm, at about 280 RPM if the tumbling operation is either performed without media or with media that is larger in size than the inserts being tumbled, or at about 320 RPM if the media used is smaller in size than the inserts being tumbled. Typically, the parts are tumbled for at least 40-80 minutes. Using a commercially available paint shaker of trademark Corob™ Evoshake500 with a maximum load of 40 kg and a maximum shaking frequency of 65 Hz corresponding to 600 rpm. One insert up to the maximum load of the machine of inserts are placed in a plastic sealed containers being cylindrical or square in shape optional together with almost spherical cemented carbide media of a hardness around 1200-1600 Vickers of sizes ranges from 3-20 mm in

diameter with a small amount of cooling liquid (water with an antioxidizing agent) added, such that not all of the inserts are covered in cooling liquid. The filling degree in the plastic containers is preferable between 20-80% of the volume, most preferable between 30-50% of the container volume. The container is shaken for 5-30 min using the 100% of the shaking capacity of the machine (600 rpm), preferable between 5-15 min which corresponds to or above the compressive stress levels that can be obtained in the ERBA 120 using the parameters above. Softer ramping steps can be applied by lower the rpm; this is beneficial if the inserts is prone to breaking. During the shaking process the inserts and the cooling liquid are heated up to about 70-90 degrees C.

[0074] In one embodiment, the high energy post treatment is conducted at an elevated temperature of or above 100° C., preferably at a temperature of or above 200° C., more preferably at a temperature of between 200° C. and 450° C. The advantage the elevated process temperature is that an increased toughness of the carbide and hence the collisions do not result in defects such as micro cracks, large cracks or edge chipping. The higher level of compressive stress in combination with decreased collision defects will improve the fatigue resistance and fracture toughness of the mining insert and consequently increase the lifetime of the insert. Further advantages of this method are that insert geometries, such as those with a sharp bottom radius, which were previously prone to excessive damage to the corners and therefore low yields, can now be tumbled without causing edge damage. This opens the possibility to develop mining insert products with different geometries, which were previously not suitable for HET. The method also makes it possible to use cemented carbide compositions that would have previously been too brittle for mining applications. The ability to introduce higher levels of compressive stress means that the toughness of the mining inserts is increased to an acceptable level and thus mining inserts having a higher hardness can be used which is beneficial for increasing the wear resistance of the mining inserts.

[0075] In one embodiment of the present invention the mining insert is subjected to a surface hardening treatment at a temperature of between 150-250° C., preferably at a temperature of between 175-225° C.

[0076] In one embodiment of the present invention the mining insert is subjected to a surface hardening treatment at a temperature of between 300-600° C., preferably at a temperature of between 350-550° C., more preferably of between 450-550° C.

[0077] The temperature is measured on the mining insert using any suitable method for measuring temperature. Preferably, an infrared temperature measurement device is used.

[0078] The effect of the surface hardening treatment at elevated temperatures is enhanced if the process is done in dry conditions. By “dry” conditions it is meant that no liquid is added to the process. Without being bound by this theory, it is thought that, if liquid is introduced to the process, it will keep the parts at room temperature. Further, the inclusion of the liquid will reduce the degree of the impact between the

parts being HET-treated. Liquid prevents the internal friction and collision heat to increase the temperature in the collision points. If no liquid is used, then the temperature at the collision points gets high resulting in a higher toughness of the material subjected to the collision points.

[0079] Alternatively, the tumbler could be pressurized to a pressure that prevents water from boiling so that it would be possible to conduct the high temperature HET-treated in wet conditions.

[0080] The HET process could be conducted in the presence or absence of media depending on the geometry and material composition of the mining inserts being tumbled. If it is decided to add media, the type and ratio of media to inserts is selected to suit the geometry and material composition of the mining inserts being HET-processed.

[0081] Optionally, all or part of the heat is generated by friction between the inserts and any media added in the HET process.

[0082] In one embodiment the inserts can be heated in a separate step prior to the surface hardening process step. Several methods can be used to create the elevated temperature of the mining insert, such as induction heating, resistance heating, hot air heating, flame heating, pre-heating on a hot surface, in an oven or furnace or using laser heating.

[0083] In one embodiment, the mining inserts are kept heated during the surface hardening process. For example, using an induction coil.

[0084] In one embodiment, all or part of the heat is generated by the friction between the inserts and any media added in the HET-process. Advantageously, this removes debris and oxides, for example iron oxide, that are deposited on the insert surfaces from the inside of the process container. The second surface hardening process performed at room temperature could be performed in wet conditions, which will aid in removing dirt and dust from the mining inserts being treated which reduces health hazards.

[0085] In one embodiment, after the mining inserts have been subjected to the surface hardening process at an elevated temperature, the mining inserts are subjected to a second surface hardening process at room temperature.

[0086] In one embodiment, second surface hardening process is high energy tumbling.

[0087] In one embodiment, the high energy post-treatment is conducted by a bi-directional shaking process.

[0088] In one embodiment the main movement of the bi-directional shaking process is in the vertical direction and the minor movement is in the horizontal direction.

[0089] In one embodiment the bi-directional shaking process is conducted at 400-700 rpm for between 5-30 minutes. Preferably at between 500-600 rpm. Preferably for between 5-15 minutes.

EXAMPLES

Example 1—Samples

[0090] Table 1 shows the summary of the samples tested, including their compositions and surface hardening treatment. WC content is the balance in the example below.

TABLE 1

Summary of samples									
Sample	Co Wt %	Cr Wt %	TiC Wt %	TiN Wt %	TaC Wt %	NbC Wt %	Sintered WC grain size (μm)	Bulk hardness HV20	Post sintering treatment
A (comparative)	6.0	—	—	—	—	—	1.91	1470	None
B (comparative)	6.0	—	—	—	—	—	1.91	1470	5 min HET
C (comparative)	6.0	—	—	—	—	—	1.91	1470	10 min HET
D (comparative)	7.6	—	—	—	1.20	0.32	1.08	1490	none
E (invention)	7.6	—	—	—	1.20	0.32	1.08	1490	5 min HET
F (invention)	7.6	—	—	—	1.20	0.32	1.08	1490	10 min HET
G (invention)	7.6	—	—	—	1.20	0.32	1.08	1490	HOT HET 20 min
H (comparative)	7.2	—	1.90	0.40	2.90	0.49	1.53	1530	none
I (invention)	7.2	—	1.90	0.40	2.90	0.49	1.53	1530	5 min HET
J (invention)	7.2	—	1.90	0.40	2.90	0.49	1.53	1530	10 min HET
K (comparative)	7.0	0.7	—	—	—	—	1.36	1480	none
L (comparative)	7.0	0.7	—	—	—	—	1.36	1480	5 min HET
M (comparative)	7.0	0.7	—	—	—	—	1.36	1480	10 min HET
N (comparative)	7.0	0.7	—	—	1.10	0.30	1.41	1541 HV3	none
O (invention)	7.0	0.7	—	—	1.10	0.30	1.41	1541 HV3	5 min HET
P (comparative)	6.3	0.63	—	—	1.00	0.20	—	1556 HV3	none
Q (invention)	6.3	0.63	—	—	1.00	0.20	—	1556 HV3	5 min HET
R (comparative)	9.0	0.9	—	—	—	—	0.5	1740	10 min HET
S (comparative)	7	1.05	—	—	—	—	1.40	1535	5 min HET

[0091] All cemented carbide inserts were produced using a WC powder grain size measured as FSSS was before milling between 2 and 18 m. The WC and Co powders were milled in a ball mill in wet conditions, using ethanol, with an addition of 2 wt % polyethylene glycol (PEG 3400) as organic binder (pressing agent) and cemented carbide milling bodies. After milling, the mixture was spray-dried in N₂-atmosphere and then uniaxially pressed into GT7S100A mining inserts having a size of about 10 mm in outer diameter (OD) and about 16-20 mm in height with a weight of approximately 17 g each with a spherical dome (“cutting edge”) on the top. The samples were then sintered using Sinter-HIP in 55 bar Ar-pressure at 1410° C. for 1 hour and then ground on the cylindrical part.

[0092] The samples that were HET were treated using a commercially available paint shaker of trademark Corobi™ Evoshake500 with a maximum load of 40 kg and a maximum shaking frequency of 65 Hz (600 rpm). 20 inserts were placed in a plastic bucket height=12 cm OD=10 cm together with 3 kg 7 mm almost spherical cemented carbide media of a hardness around 1600 Vickers and 1 dl of water with an antioxidizing agent was added. The filling degree was about 40%. The bucket was shaken for 5 min using the 100% of the shaking capacity of the machine. Three softer ramping steps were also applied 30 s at 25%, 30 s at 50% and 30 s at 75% of the maximum shaking capacity. After 5 min at max frequency 10 inserts were removed (“5 min HET”) and

then the same program was restarted for an additional 5 min at max frequency (“10 min HET”).

[0093] Some inserts were treated at 300° C. in a so called “HOT HET” treatment using the paint shaker of trademark Corobi™ Simple Shake 90 with a maximum load of 40 kg and a maximum shaking frequency of 65 Hz (600 rpm). The hot shaking method was conducted at a frequency of 5 Hz. About 800 grams or 50 pieces of inserts and 3.75 kg carbide media (7 mm balls) were placed in a cylindrical steel container with inner diameter of 10.4 cm and inner height of 12.4 cm filling it up to 1/3 to 2/3 of the height, preferable around 1/2. The steel cylinder with the mining insert were heated with media in a furnace to an elevated temperature of 300° C., the mining inserts were held at the target temperature for 120 minutes. After heating, the steel cylinder was transferred straight into the paint shaker and immediately shook for 2 times 5 minutes using a program without ramping. The transfer time between the furnace until the shaker started was less than 20 seconds. The media (7 mm balls) was made of a cemented carbide grade having a sintered HV20 of about 1600. The shaking was performed in dry conditions, i.e. no water was added to the shaking and the samples were heated to 300° C. For all runs the inserts were left to cool down to room temperature before they were subjected to a final wet shaking operation for 2x5 min using plastic buckets as in previous description. None of the inventive samples had any edge damage after the post treatment process.

Example 2—Insert Compression Test

[0094] The insert compression test method involves compressing a drill bit insert between two plane-parallel hard counter surfaces, at a constant displacement rate, until the failure of the insert. A test fixture based on the ISO 4506:2017 (E) standard “Hard metals—Compression test” was used, with cemented carbide anvils grade H6F from Hyperion having a hardness exceeding 2000 HV, while the test method itself was adapted to toughness testing of rock drill inserts. The fixture was fitted onto an Instron 5989 test frame.

[0095] The loading axis was identical with the axis of rotational symmetry of the inserts. The counter surfaces of the fixture fulfilled the degree of parallelism required in the ISO 4506:2017 (E) standard, i.e. a maximum deviation of 0.5 µm/mm. The tested inserts were loaded at a constant rate of crosshead displacement equal to 0.6 mm/min until failure, while recording the load-displacement curve. The compliance of the test rig and test fixture was subtracted from the measured load-displacement curve before test evaluation. Three inserts were tested per run. The counter surfaces were inspected for damage before each test. Insert failure was defined to take place when the measured load suddenly dropped by at least 1000 N. Subsequent inspection of tested inserts confirmed that this in all cases this coincided with the occurrence of a macroscopically visible crack. The material strength was characterized by means of the total absorbed deformation energy until fracture. The summary fracture energy (Ec), in Joules (J), required to crush the samples is shown in table 2 below:

TABLE 2	
Fracture energy (J) required to crush the samples	
Sample	Fracture energy Ec (J)
A (comparative)	3.0
B (comparative)	8.0
C (comparative)	8.6
D (comparative)	5.0
E (invention)	8.0
F (invention)	14.5
H (comparative)	8.2
I (invention)	16.5
J (invention)	18.3
K (comparative)	5.3
L (comparative)	14.3
M (comparative)	16.2
N (comparative)	7.2
O (invention)	15.2
S (comparative)	12.0

Example 3—Hardness Measurements

[0096] The hardness of the cemented carbide inserts is measured using Vickers hardness 3 kg at both 0.3 mm and 1.0 mm from the surface of the inserts and also in the bulk of the inserts. The hardness measurements are an average of 30 indentations. Table 3 shows a summary of the hardness measurements and table 4 shows a summary of the delta HV3 hardness values.

TABLE 3

Hardness measurements			
Run	HV3 at the surface of the 0.3 mm from the surface of the insert	HV3 at a depth of 1 mm from the surface of the insert	HV3 bulk hardness measurement
E (invention)	1553.2	1526.4	1508.4
G (invention)	1559.4	1529.7	1512.9
I (invention)	1574.5	1564.3	1548.8
O (invention)	1592.5	1571.0	1551.2
Q (invention)	1637.9	1614.4	1608.6

TABLE 4

Delta HV3 hardness values			
Run	ΔHV3 (HV3 0.3 mm from the surface of the insert-HV3 bulk)	ΔHV3 (HV3 1 mm from the surface of the insert-HV3 in the bulk)	ΔHV3 (HV3 0.3 mm from the surface- HV3 1 mm from the surface)
E (invention)	44.8	18.0	26.8
G (invention)	46.5	16.8	29.7
I (invention)	25.7	15.5	10.2
O (invention)	41.3	19.8	21.5
Q (invention)	29.3	5.8	23.5

Example 4—Wear Test

[0097] The samples tested in an abrasion wear test, wherein the sample tips are worn against a rotating granite log counter surface in a turning operation. The test parameters used were as follows: 100 N load applied to each insert, granite log rpm~190, log diameter ranging from 130 to 150 mm, and a horizontal feed rate of 0.339 mm/rev. As much of the length of the log (max 300 mm) was used in each test to remove that difference in composition in the rock have a significant impact on the results. If large piece broke out from the log this area was avoided and therefore the length in some tests were shorter than 300 mm. The sliding distance varied due to the difference in diameter and length of the part of the rock that could be used but were around 330-460 m and the mass loss versus sliding distance was approximately linear between the three samples of each grade that was tested. The sample was cooled by a continuous flow of water. Each sample was carefully cleaned and weighed prior to and after the test. Mass loss of three samples per material was evaluated, the sample volume loss for each of the tested materials was calculated from the measured mass loss and sample density, the results are presented in table 5.

TABLE 4

Wear rates	
Sample	Wear rate mm ³ /m sliding
B (comparative)	8.79×10^{-4}
E (invention)	3.86×10^{-4}
I (invention)	4.97×10^{-4}
O (invention)	2.96×10^{-4}
Q (invention)	3.03×10^{-4}

Example 5—Fracture Toughness

[0098] Fracture toughness measurements were made according to ISO/DIS 28079 using 30 kg load on 10 mm in diameter spherical domed samples that had been subjected to a 5 min HET treatment. The samples were sectioned in half through the dome area, mounted in bakelite, polished with diamond paste and the crack length and diameter of 10 indentations 0.5 mm below the surface evenly distributed around the insert and at least 0.75 mm apart. The diameter of the indentations and the length of the cracks were measured using light optical microscope and 200× magnification. The K1C of each indentation was calculated using Shetty's formula $K1C = A \cdot \sqrt[3]{H/(P \cdot \text{Sum of } L)}$, where H is the hardness in N/mm², P is the applied load in N, Sum of L is the sum of crack length in mm, A is a constant with value of 0.0028 and K1C is given in MPa·m^{0.5}. The average K1C value calculated and reported as K1C_surface and the crack length and diameter of 5 indentations in the middle of the 10 mm inserts were measured and the average calculated and reported as K1C_bulk. The K1C measurement and Delta K1C-values are shown in table 5.

TABLE 5

K1C measurements and Delta K1C calculations			
Sample	Average K1C_surface (MPa·m ^{0.5})	Average K1C_bulk (MPa·m ^{0.5})	Delta K1C (MPa·m ^{0.5})
E (invention)	16.3	11.8	4.5
I (invention)	13.7	10.9	2.8
O (invention)	13.3	10.7	2.6
Q (invention)	14.5	11.4	3.1

[0099] For an untreated sample delta K1C is zero or close to zero or even a slightly negative value.

Example 6—Field Trial 1

[0100] Table 6 shows the results from a wet underground top hammer application test. Inserts with diameter 13 mm diameter 11 mm and with spherical shaped dome geometries were tested. The inserts were manufactured according to the description in example 1. The outer diameter of all inserts were ground. The HET-treatments of the inserts were performed according to the description in example 1 and the inserts were not pre-heated.

[0101] The different grades and treatments were mounted in steel bits having eight 13 mm inserts on the periphery/gauge and three 11 mm inserts on the front. The bits were tested in an underground gold mine in the north of Sweden in a top hammer application. The rock conditions were classified as very hard and very abrasive. Before drilling started the maximum diameter of each bit was measured to be around 56 mm. Each bit was drilled until the inserts were too blunt and the penetration rate went down. The maximum diameter of the bit was then measured again and the difference in diameter was evaluated as wear from drilling. Another important factor in determining the success of the inserts is the number of insert breakage(s). Both wear and breakage results are shown in table 6.

TABLE 6

Results from the percussive drilling field test using spherical inserts						
	No of holes	Total drilled meter (DM)	Diameter loss (mm)	Average diameter wear from drilling (mm/m)	Number of insert chipped or broken at the periphery/gauge (8 in total)	Number of inserts chipped at the front (3 in total)
F (invention)	4	18	0.70	0.039	0	0
DP65™ (comparative)	4	18	0.70	0.039	1	0
M (comparative)	4	16	0.75	0.047	0	0
R (comparative)	1	3.8	0.10	0.026	1	0
Outside invention R*	>2	6.5	n/a	n/a	8	3

*continued drilling with the same bit as in the row above

[0102] The results show clearly that the inventive samples have both has a good wear resistance and no insert chipping or breakages, which would have normally been expected for a gamma phase containing grade in a percussive drilling operation. By combining a gamma phase containing grade with a HET treatment the full potential of the material can be utilized, and the performance is better than the state of the art grade DP65™ in terms of resistance towards chipping/insert failure and still having the same high wear resistance. That the site is challenging to drill in is also seen since the sub-micron (WC) and chromium-containing grade R failed completely after only 6.3 m in operation and that the prior

art chromium containing grade M wears more than the gamma phase containing grade of the present invention.

Example 7—Field Trial 2

[0103] Table 7 shows results from a wet underground top hammer application test inserts with diameter 8 mm diameter and 10 mm and with semi-ballistical shaped dome geometries. The inserts were manufactured according to the description in example 1. The outer diameter of all inserts was ground. The HET-treatments of the inserts were performed according to the description in example 1 and the invention samples was HOTHET-treated according to the description in example 1.

[0104] The different grades and treatments were mounted in steel bits having six 10 mm inserts on the periphery/gauge and three 8 mm inserts on the front. Four bits/variant were produced and tested in an underground construction site in Stockholm in Sweden in a top hammer application. The rock conditions were classified as hard and abrasive. Before starting the drilling, the maximum diameter of each bit was measured and to be around 51 mm. The drilling was started, and each bit was used until the inserts were too blunt rate went down. The meters drilled before the penetration went down and the maximum diameter of the bit was then measured, and the difference in diameter divided by drilled meters was calculated, this provides a good measure on the wear resistance of the grade. In this test no insert failures were observed.

TABLE 7

Results from the percussive drilling field test using semi-ballistical inserts				
	No of bits	Total drilled meter (DM)	Average diameter wear from drilling (mm/m)	Number of insert chipped or broken
G (invention)	4	354	0.088	0
A (comparative)	4	221	0.094	0

[0105] The results show clearly that the gamma phase containing grade G (invention) has a higher wear resistance and can drill significantly longer before it needs to be re-ground than the current benchmark percussive grade A. Importantly, no insert breakages occurred for the gamma phase containing HOTHET treated inserts.

Example 8—Field Trial 3

[0106] Table 8 shows the results from a dry (air cooled) surface top hammer application test. Inserts with diameter 7 mm diameter with ballistic shaped dome geometries were tested. The inserts were manufactured according to the description in example 1. The outer diameter of all inserts was ground. The HET-treatments of the inserts were performed according to the description in example 1 and the inserts were not pre-heated.

[0107] The different grades and treatments were mounted in steel bits having six 7 mm inserts on the periphery/gauge. The two front inserts in this test does not contribute to the diameter wear and for all bits they were in the reference grade XT49 (sample B). The bits were tested in a stone quarry in the south west of Sweden in a top hammer

application. The rock conditions were classified as homogenous but very hard and very abrasive with a quartz content of about 50% and during drilling significantly amount of heat was generated. A rig with two hammers was used simultaneously which allowed a good comparison between the variants. Before drilling started the maximum diameter of each bit was measured on three positions (D1, D2, D3) and was around 33 mm. Each bit was drilled until the inserts got a significant wear but only two were drilled to end of life (either loss of penetration rate or if insert failures occurred). FIG. 2 shows a top hammer bit with ballistic inserts with the diameter measuring points indicated.

[0108] The maximum diameter of the bit was then measured again on all three (if no failures) positions and the difference in diameter was evaluated as wear from drilling. Another important factor in determining the success of the inserts is the number of insert breakage(s). Both wear and breakage results are shown in table 8.

TABLE 8

Results from the percussive drilling field test using ballistic inserts					
	No of holes	Total drilled meter (DM)	Diameter loss (mm)	Average diameter wear from drilling (mm/m)	Number of insert chipped or broken at the periphery/gauge (6 in total)
O (invention)	~90	137.2 ^a	0.655	0.0048	0
B (comparative)	~90	139.2 ^b	0.992	0.0071	0
L (comparative)	~60	95.6	0.560	0.0059	0
S (comparative)	~110	168 ^c	1.03	0.0061	0

^a, ^bRun simultaneously one of the left hammers and one of the right hammers.

^c Run until end of life

[0109] The results show clearly that the inventive samples have both good wear resistance and no insert chipping or breakages, which would have normally been expected for a gamma phase containing grade in a percussive drilling operation and the wear resistance of a gamma phase (y)+Cr grade is even better than two high Cr-containing grades having the same binder content and similar room temperature hardness (HV20). By combining a gamma phase (y)+Cr containing grade with a HET treatment the full potential of the material can be utilized, and the wear resistance is significantly better than the state of the art grade XT49™, despite that XT49 has a lower Co-content that would be beneficial in dry (air cooled) drilling since the heat generated is significantly higher than in a water cooled percussive drilling.

Example 9—Field Trial 4

[0110] Table 9 shows the results from a dry (air cooled) surface top hammer application test. Inserts with diameter 7 mm diameter with ballistic shaped dome geometries were tested. The inserts were manufactured according to the description in example 1 and the inventive sample, I, had a gamma phase free zone of about 20 microns after sintering, which will wear off quickly during drilling or be ground away during the outer diameter grinding. The outer diameter of all inserts was ground. The HET-treatments of the inserts were performed according to the description in example 1 and the inserts were not pre-heated.

[0111] The different grades and treatments were mounted in steel bits having six 7 mm inserts on the periphery/gauge. The two front inserts in this test does not contribute to the diameter wear and for all bits they were in the reference grade XT49 (sample B). The bits were tested in a stone quarry in the south west of Sweden in a top hammer application. The rock conditions were classified as homogenous but very hard and very abrasive with a quartz content of about 50% and during drilling significantly amount of heat was generated. A rig with two hammers was used simultaneously which allowed a good comparison between the variants. Before drilling started the maximum diameter of each bit was measured on three positions (D1, D2, D3) and was around 33 mm. Each bit was drilled until the inserts got a significant wear. The maximum diameter of the bit was then measured again on all three (if no failures) positions and the difference in diameter was evaluated as wear from drilling. Another important factor in determining the success of the inserts is the number of insert breakage(s). Both wear and breakage results are shown in table 9.

TABLE 9

Results from the percussive drilling field test using ballistic inserts					
	No of holes	Total drilled meter (DM)	Diameter loss (mm)	Average diameter wear from drilling (mm/m)	Number of insert chipped or broken at the periphery/gauge (6 in total)
I (invention)	~30	51 ^a	0.42	0.0082	0
B (comparative)	~30	51 ^b	0.50	0.0099	0

^a, ^bRun simultaneously one of the left hammers and one of the right hammers.

[0112] The results show that the inventive sample 1, despite having a quite high gamma phase content also including Ti and nitrogen ((Ti, Ta, Nb, W)(C,N)) had enough toughness & strength from the HET-treatment to be used in a percussive drilling application in a very sensitive ballistic insert geometry. Sample I also showed an improved wear resistance compared to the state of the art grade XT49™ (sample B), despite that XT49 has a lower Co-content that would be beneficial in dry (air cooled) drilling since the heat generated is significantly higher than in a water cooled percussive drilling.

1. A sintered cemented carbide insert for mining or cutting applications comprising:
- a mean WC grain size of between 0.8-18 μm;
 - a binder phase in a weight between 4-18 wt %;
 - gamma phase with the cubic gamma phase precursors in a weight of between 0.8-10 wt %; and

- any unavoidable impurities and a balance of WC, wherein a difference between a hardness at any point 0.3 mm from a surface of the insert and a hardness of a bulk of the insert is at least 25 HV3 when measured according to ISO EN6507 3:2005.
- 2. The insert according to claim 1, wherein the binder phase includes at least 80 wt % of one or more of cobalt, nickel, iron or a combination thereof.
- 3. The insert according to claim 1, wherein the cubic gamma phase precursors is tantalum carbide or niobium carbide or a mixture thereof.
- 4. The insert according to claim 1, wherein the cemented carbide also includes Cr in such an amount that a mass ratio Cr/Co in the bulk is 0.04-0.19.
- 5. The insert according to claim 1, wherein the cemented carbide includes M₇C₃ carbides and/or M₂₃C₆ carbides and wherein a ratio vol % (M₇C₃ carbides and/or M₂₃C₆ carbide)/vol % Co is between 0.01 to 0.5.
- 6. The insert according to claim 1, wherein a delta K1C fracture toughness at 0.5 mm below the surface compared to a K1C in the bulk is at least 1.5 MPa*m^{0.5} higher measured according to ISO/DIS 28079.
- 7. A rock drill bit body comprising one or more mounted cemented carbide inserts according to claim 1.
- 8. A method of producing a cemented carbide insert according to claim 1, comprising the steps of:
 - providing a green cemented carbide insert comprising between 0.8-10 wt % cubic carbides and or carbonitrides and or nitrides, between 4-18 wt % binder, any unavoidable impurities and a balance of WC hard phase;
 - sintering the green carbide mining insert to form a sintered cemented carbide insert; and
 - subjecting the sintered cemented carbide insert to a high energy post-treatment process.
- 9. The method according to claim 8, wherein the high energy post-treatment is high energy tumbling.
- 10. The method according to claim 8, wherein the high energy post-treatment is conducted at an elevated temperature of or above 100° C.
- 11. The method according to claim 8, wherein the high energy post-treatment is conducted by a bi-directional shaking process.
- 12. The method according to claim 8, wherein the bi-directional shaking process has a main movement is in a vertical direction and a minor movement is in a horizontal direction.
- 13. The method according to claim 8, wherein the treatment is conducted at between 400-700 rpm for 5-30 min.

* * * * *