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(71) Applicant: **Sandvik Mining and Construction Tools AB**
**81181 Sandviken (SE)**

(72) Inventors:
- **MÅRTENSSON, Malin**
  **12680 Västberga (SE)**
- **ÖSTHOLS, Erik**
  **12680 Västberga (SE)**
- **DE FLON, John**
  **12680 Västberga (SE)**
- **BÖHM, Anna**
  **12680 Västberga (SE)**

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

(54) **METHOD OF SURFACE HARDENING AND TOUGHENING MINING INSERTS**

(57) A method of treating mining inserts wherein said mining inserts are subjected to a surface hardening and toughness process; wherein the surface hardening and toughness process is a shaking process within an enclosed container; characterized in that: the shaking process is conducted with a peak to peak displacement of > 25 mm.

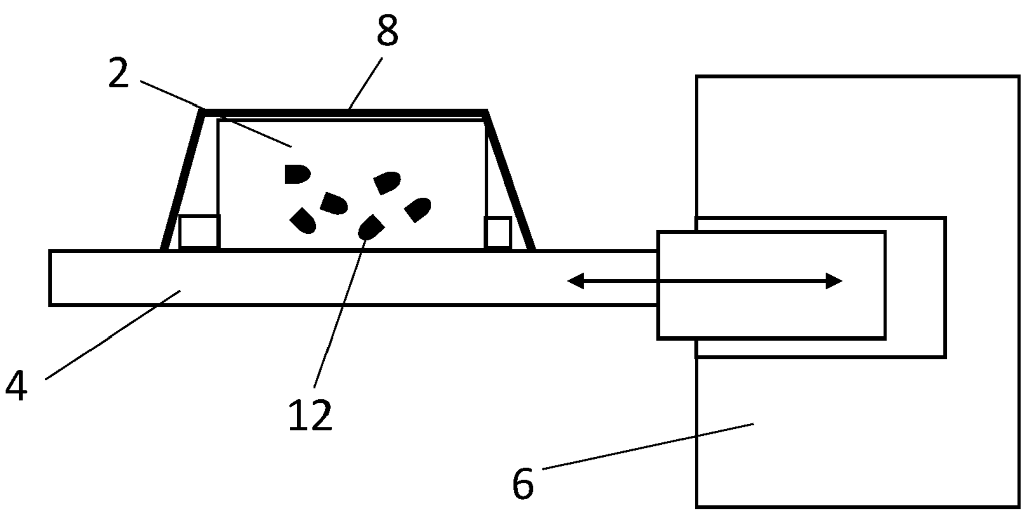


Fig. 2

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## Description

### FIELD OF INVENTION

**[0001]** The present invention relates to a method of surface hardening and toughening mining inserts.

### 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 inserts. Sintered cemented carbide mining inserts are commonly treated with an edge deburring and surface hardening process, such as tumbling, after centreless grinding. The surface hardening process introduces compressive stress into the mining inserts. The presence of the compressive stresses improves the fatigue resistance and fracture toughness of the mining insert. Consequently, the threshold energy necessary to fracture the mining insert is higher and so there is a reduced likelihood of chipping, cracking and / or fracture of the component.

**[0003]** Known methods for introducing compressive stress into mining inserts include tumbling, for example high energy tumbling, the problem with tumbling is that the processing time is long, for example 60 - 120 minutes per batch. An alternative known method is to vibrate the inserts at a resonance frequency, however this also requires quite long treatment time, for example 60 - 75 minutes per batch and has the further problem that the yields are low due to high proportion of the inserts being chipped after treatment.

**[0004]** The problem to be solved is how to find an alternative method of surface hardening and toughening mining inserts that introduces at least the same or preferably higher level of compressive stress, at least as high a yield (i.e., few or preferably no chipped inserts post treatment) but with shorter, more efficient processing times.

### SUMMARY OF THE INVENTION

**[0005]** According to a first aspect of the present invention it is an objective to provide a method of treating mining inserts wherein said mining inserts are subjected to a surface hardening and toughness process; wherein the surface hardening and toughness process is a shaking process within an enclosed container; characterized in that the shaking process is conducted with a peak-to-peak displacement of > 25 mm.

**[0006]** Advantageously, the processing time is significantly reduced compared to the tumbling process currently used in production. The cycle times are between 10- 20 times shorter than the high energy tumbling process and at least the same level of compressive stress introduction is maintained, and the yield is not decreased (i.e., there is no increase in the percentage of chipped inserts) compared to the high energy tumbling process. Furthermore, this inventive method is more production friendly as it is able to easily accommodate different batch sizes by changing the size of the container to keep the same fill rate in order to achieve the same output and large enough batch sizes to be economical. This method also enables different types of inserts to be treated at the same time by placing multiple containers comprising different types of inserts next to each other so that they are kept separated but can still be treated in a single run cycle.

**[0007]** In some example embodiments the maximum acceleration during the shaking process is equal to or greater than 5 G. Advantageously, this introduces sufficient compressive stress into the inserts.

**[0008]** In some embodiments the maximum velocity during the process is between 1.4-2.5 m/s. Advantageously, this introduces sufficient compressive stresses into the insert in a short time.

**[0009]** In some embodiments the maximum shaking frequency during the shaking process is between 5-25 Hz. Advantageously, this introduces sufficient compressive stresses into the insert in a short time without causing chipping.

**[0010]** In some embodiments the minimum operating energy is >0.8 J/kg during the shaking process. Advantageously, this introduces sufficient compressive stresses into the insert.

**[0011]** In some embodiments the treatment is conducted in an electrodynamic vibrator. Advantageously, this type of vibrator is able to produce high peak to peak displacement of the inserts. The device can also accelerate the shaking boxes quickly generating a high velocity and high operating energy.

**[0012]** In some embodiments the acceleration is ramped up to the maximum operating acceleration. Advantageously, this minimizes the risk of chipping and breakages to the inserts. For example, this could be particularly useful if the inserts have a geometry with a sharp radius and / or are composed of a brittle material.

**[0013]** In some embodiments the container is shaken in a vertical direction. Advantageously, this shaking direction introduces higher levels of compressive stresses.

**[0014]** In some embodiments the container is shaken in a horizonal direction. Advantageously, this direction is more production friendly as clamping of container is easier. Furthermore, chipping to the inserts is reduced.

**[0015]** In some embodiments the inserts are pre-heated prior to the shaking process. Advantageously, higher levels of compressive stresses are introduced into the cemented carbide mining insert. The pre-heating also increases the 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.

**[0016]** In some embodiments the shaking is conducted at its maximum operating acceleration for between 2-60 minutes. Advantageously, this provides the optimal balance between introducing sufficient compressive stress without increasing unnecessary operating time and cost or increasing the risk of chipping the inserts.

**[0017]** In some embodiments the fill capacity of the container is between 25-75%. Advantageously, this provides the optimal balance in terms of space for the insert to move and frequency of collision that a balance between introduces sufficient compressive without causing chipping is achieved.

**[0018]** In some embodiments additional media is added in the container with the inserts. For example, the media could be cemented carbide media.

**[0019]** In some embodiments the total mass of inserts plus media in each container is between 2-150 kg.

**[0020]** In some embodiments an internal bottom surface of the container has at least one protrusion or indentation. Advantageously, this creates at least one bump on the internal surface of the container which increases turbulent flow by initiating movement in multiaxial directions. This results in improved crush strength, increased delta hardness and increased delta coercivity (Hc), all of which are an indication of higher levels of compressive stress introduction.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0021]** A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a schematic drawing of the apparatus set up wherein the container is shaken in a vertical direction.

Figure 2 shows a schematic drawing of the apparatus set up wherein the container is shaken in a horizontal direction.

Figure 3 shows a schematic drawing of one example of the container.

## DETAILED DESCRIPTION

**[0022]** The present invention relates a method of treating mining inserts 12 wherein said mining inserts 12 are subjected to a surface hardening and toughness process; wherein the surface hardening and toughness process is a shaking process within an enclosed container 2. characterized in that: the shaking process is conducted with a peak to peak displacement of > 25 mm. For example, the peak to peak displacement is >30 mm, for example > 40 mm, for example >50 mm, for example > 60 mm, for example > 70 mm. Increased displacement results in increased compressive stresses induced, greater surface hardness and increased crush strength. For example, the peak to peak displacement is between 30-150 mm, preferably between 40 - 120 mm, for example between 50 - 100 mm. The maximum possible displacement is likely to be limited by the capabilities of the vibrating equipment.

**[0023]** Peak to peak displacement means the distance between the maximum positive and maximum negative amplitudes of the movement of the inserts. Peak to peak displacement is measured by the distance the shaking platform is moved and is monitored by the shaking device. The shaking may be conducted in a uniaxial or multiaxial manner.

**[0024]** The shaking process could also be referred to as a vibrating process or sinusoidal vibrating process. The shaking process is conducted within an enclosed container 2 comprising a removal lid to expose an opening for adding and removing the inserts. The container 2 is filled with mining inserts and optionally additionally tumbling media. The shaking process may be conducted in wet conditions. For example, water and antioxidant could be added to the container 2 in order to reduce dust and insert chipping. Alternatively, the shaking process may be conducted in dry conditions.

**[0025]** In some examples the inserts 12 treated are cemented carbide inserts 12. Cemented carbide comprises hard constituents in a metallic binder phase. Typically, the cemented carbide comprises at least 50 wt% tungsten carbide, 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. For example, the binder content of the cemented carbide is typically between 2-20 weight % (wt%). The binder phase may also contain additions of Cr, V, Ti. The cemented carbide may also further comprise comprises a gamma phase selected from a carbide or nitride of niobium, tantalum, titanium or a mixture thereof. The binder in the cemented carbide inserts may also have a gradient in concentration from one region of the insert to another region of the insert. Alternatively, the inserts 12 could comprise diamond, for example be made from polycrystalline diamond (PCD).

**[0026]** The inserts 12 may optionally be deburred prior to the surface hardening and toughening process in order to remove sharp edges and smooth the surface of the inserts. This may also be referring to a pre-tumbling step. Including this step will decrease chipping to the inserts. Alternatively, the deburring step may be omitted in order to reduce operating time and cost.

**[0027]** In some examples embodiments the maximum acceleration during the shaking process is equal to or above 5 G, for example > 6G, for example >7G, for example >8 G, for example between 5-20 G, for example between 6 - 18 G, for example between 7 - 15 G, for example between 7-12 G. The acceleration should be selected to provide the balance between introducing high levels of compressive stress without causing chipping.

The acceleration is measured by an IEPE (piezo electric) accelerometer attached to the vibrating table and monitored by the device (vibrating apparatus).

**[0028]** In some example embodiment the maximum velocity during the shaking process is >1.4 m/s, for example >1.7 m/s, for example >1.9 m/s. In some example embodiments the maximum velocity during the treatment process is between 1.4-2.5 m/s, for example between 1.7-2.4 m/s, for example between 1.8-2.4 m/s, for example. Maximum velocity was calculated by $\pi$ x displacement x frequency.

**[0029]** In some example embodiment the maximum shaking frequency during the shaking process is between 5-25 Hz, for example between 6-20 Hz, for example between 8-20 Hz, for example between 8-16 Hz. This is measured by the shaking device (vibrating apparatus).

**[0030]** In some example embodiments the minimum operating energy during the shaking process is >0.8 J/kg, for example >0.9 J/kg, for example >1 J/kg, for example between 1 to 3 J/kg.

The operating energy was calculated according to:

$$\text{Operating } energy \text{ per kg} = \frac{v^2}{2} \qquad [\text{J/kg}]$$

where v is the maximum velocity in meters per second.

**[0031]** In some example embodiment the treatment is conducted in an electrodynamic vibrator. Alternatively, a hydraulic vibrator could be used.

**[0032]** In some example embodiments the acceleration is ramped up to the maximum operating acceleration. The ramp could be performed either in a stepwise manner or as a smooth gradual ramp. The exact conditions of the ramp would be determined and optimized based on the geometry and composition of the insert and on the load of inserts being treated.

**[0033]** In some embodiment the container 2 is shaken in a vertical direction. Figure 1 shows an example apparatus setup where the container 2 is shaken in a vertical direction comprising a container 2 positioned on top of shaking table 4 that is positioned on top of a vibrator 6. The container 2 is fixed to the shaking table with at least one fastener 8.

**[0034]** In some example embodiments the container 2 is shaken in a horizonal direction. Figure 2 shows an example apparatus setup where the container 2 is shaken in a horizontal direction comprising a container 2 position on top of a shaking table 4 that is positioned to the side of a vibrator 6. The container 2 is fixed to the shaking table with at least one fastener 8.

**[0035]** The inserts 12 could also be shaken in any other direction. In another example, the container 2 may be shaken in multiple directions.

**[0036]** In some example embodiments the inserts 12 are pre-heated prior to the shaking process. For example, the inserts 12 may be pre-heating to above 100°C, for example to above 200°C, for example to a temperature of between 200°C and 450°C. The inserts 12 could alternatively or additionally be heated during the shaking operation. The container 2 may be thermally insulated in order to accommodate this option.

**[0037]** In some example embodiments the shaking process is conducted for between 2-60 minutes at its maximum operating acceleration, for example between 2-30 minutes, for example between 3-20 minutes, for example between 4 - 10 mins, for example between 4 - 7 minutes.

**[0038]** In some example embodiments the fill capacity of the container 2 is between 25-75%, for example between 35-65%, for example between 30-70%, for example between 40-60%. The fill capacity is calculated from the volume of the inserts 12 including any optional media being treated compared to the maximum volume of the container 2.

**[0039]** The container 2 could have any suitable geometry, for example but not limited to curved, cylindrical, cubic. The size and geometry of the container 2 used will be determined by the load of inserts 12 being treated and the required fill capacity. The container 2 could be made from metal or plastic or any other suitable material, for example but not limited to the container 2 could be made from polypropene or aluminium coated with polyurethane. The container 2 could be reinforced with a lining 16 on the internal or external surface of the container 2, for example with a high wear and heat resistant material, such as Robalon and / or a rubber or any other suitable material. The container could be sealed closed, for example but limited to by using a neoprene sealing strip.

**[0040]** Figure 3 shows an example embodiment wherein an internal bottom surface 10 of the container has at least one indentation or protrusion 14. For example, the indentation(s) and / or protrusion(s) 14 could be achieved by being incorporating in the lining 16. The protrusion 14 could otherwise be referred to as a bump.

**[0041]** Media, such as but not limited to cemented carbide bodies having different size and or geometry than the target inserts may be mixed in with the inserts 12 during the shaking process. The size, choice of media material and quantity of media will affect chipping and the level of compressive stresses introduced and therefore should be selected in order to achieve the highest possible introduction of compressive stress without causing chipping. The appropriate type and volume of media will be different for different insert grades, geometries and batch sizes. The inserts to media plus insert ratio in weight can range from 0.05 - 1, where 1 means solely inserts in the container.

**[0042]** In some example embodiments the total mass of inserts 12 plus media in each container 2 is between 2-150 kg.

## EXAMPLES

Example 1 - Summary of samples

**[0043]** Details of the shaking parameters used for the different examples are shown in table 1 below:

Table 1: Summary of samples and shaking parameters.

| Example | Shaking frequency (Hz) | Max acceleration (G) | Max velocity (m/s) | Shaking direction | Displacement peak to peak (mm) | Load | Fill capacity (%) | Shaking time at maximum operation accelerati on (mins) | Operational energy (J/kg) |
|---|---|---|---|---|---|---|---|---|---|
| A (inven-tive) | 10 | 10 | 1.57 | vertical | 50 | 0.3 kg Inserts & 3 kg 7 mm media | 40 | 5 | 1.2 |
| B (compar-ati ve) | 15 | 10 | 1.04 | vertical | 22 | 0.3 kg Inserts & 3 kg 7 mm media | 40 | 5 | 0.5 |
| C (inven-tive) | 10 | 11 | 1.73 | vertical | 55 | 23 kg Inserts | 38 | 5 | 1.5 |
| D (inven-tive) | 10 | 11 | 1.73 | Horizontal | 55 | 23 kg Inserts | 30 | 5 | 1.5 |
| E (inven-tive) | 8 | 11 | 216 | Horizontal | 86 | 23 kg Inserts | 30 | 5 | 2.3 |
| F (compar-ati ve) | 23.3 | 11 | 0.73 | Horizontal | 10 | 1 kg Inserts & 14 kg 7 mm media | 37 | 5 | 0.3 |
| G (inven-tive) | 5.4 | 5 | 1.46 | Horizontal | 86 | 1 kg Inserts & 14 kg 7 mm media | 37 | 5 | 1.1 |
| H (inven-tive) | 10.8 | 16.5 | 2.38 | Horizontal | 70 | 1 kg Inserts & 14 kg 7 mm media | 37 | 5 | 2.8 |
| I (inventive) | 8 | 11 | 216 | Horizontal | 86 | 12 kg Inserts & 12 kg 13 mm media | 56 | 5 | 2.3 |

**[0044]** The inserts tested in examples A-H were made of cemented carbide having a composition comprising 6wt% Co, 0.6 wt% Cr, and a balance WC; a magnetic coercivity (Hc) of 10.48 kA/m; and having a 10 mm diameter, this grade would typically be used for top hammer drilling operations. The inserts tested in example I were made of cemented carbide having a composition comprising 11 wt% Co; and a balance of WC; a magnetic coercivity (Hc) of 6.49 kA/m; and having a 16 mm diameter, this grade would typically be used for rotary applications.

**[0045]** A Dongling electrodynamic shaker was used for the samples that were shaken vertically (samples A-B) and an IMV EM2605 electrodynamic shaker shaken vertically was used for the sample C and an IMV EM2605 electrodynamic shaker shaken horizontally was used for samples D-I.

**[0046]** Media in form of 7 mm diameter cemented carbide spherical bodies were added to examples A, B, F, G and H and media in the form of 13 mm diameter spherical cemented carbide bodies were added to example I.

**[0047]** Samples A and B were shaken in 1 litre cylindrical polypropene containers with a lid and a height of approximately 15 cm. Sample C was shaken in 6 litre cylindrical polypropene container with a lid and a height of approximately 24 cm. Samples D and E were shaken in square 10 litre Euro container with a lid, a length in shaking direction of approximately 34 cm and a polymer (Robalon) lining. Example F-I were shaken in square 5 liters Polypropene containers with lid and with Robalon lining, with the length in the shaking direction of approximately 26 cm.

**[0048]** In all tests up to 0.1 litres of grinding liquid comprising water and an antioxidant was added to the containers.

**[0049]** Example J is a benchmark example, where the cemented carbide inserts comprising 6 wt% Co, 0.6wt% Cr and a balance of WC were treated using high energy tumbling with a total treatment time of 100 minutes. The aim was to achieve at least as high a level of compressive stress introduction as these samples but with a reduced processing time and without reducing the yield from an increase in chipping post treatments.

Example 2 - Insert compression test

**[0050]** 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 "Hardmetals - 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. 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. 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 load at fracture was measured and the material strength was calculated and is characterized by means of the total absorbed deformation energy until fracture and calculated from the maximum load at fracture and the displacement of the insert. Delta Crush strength (%) = ((Crush strength post treatment - Crush strength post sintering) / Crush strength post sintering) x 100. Delta Fracture energy (%) = ((fracture energy post treatment - fracture energy post sintering) / fracture energy post sintering) x 100. The summary inserts crush strength (kN), delta crush strength (%) and fracture energy (Ec), in Joules (J), required to crush the samples and delta fracture energy (%) is shown in table 2 below:

Table 2: Insert compression test results.

| Sample | Crush strength (kN) | Delta Crush strength (%) | Fracture energy (J) | Delta fracture energy (%) |
|---|---|---|---|---|
| A (inventive) | 58.8 | 76 | 7.7 | 196 |
| B (comparative) | 52 | 56 | 6.2 | 138 |
| C (inventive) | 61.8 | 85 | 8.3 | 219 |
| D (inventive) | 59.1 | 77 | 7.7 | 196 |
| E (inventive) | 69.7 | 109 | 10.3 | 296 |
| F (comparative) | 52.7 | 58 | 6.1 | 135 |
| G (inventive) | 58 | 74 | 7.3 | 181 |
| H (inventive) | 63.1 | 89 | 9.1 | 250 |
| I (inventive) | 103.6 | 81 | 17.5 | 202 |

(continued)

| Sample | Crush strength (kN) | Delta Crush strength (%) | Fracture energy (J) | Delta fracture energy (%) |
|---|---|---|---|---|
| J (benchmark) | 56.7 | 70 | 7.2 | 177 |

**[0051]** It can be seen that the comparative samples, B and F, where the displacement is too low do not achieve such high insert crush strength or delta crush strength. The inventive samples all achieve at least as high, if not higher, insert crush strength compared to the benchmark sample J, which is an indication that the same or higher levels of compressive stress have been introduced.

Example 3 - Chipping

**[0052]** After treatment, the samples were examined for chipping. Chipping is defined as defects (fractured, deformed or broken off parts) that can be detected by visual inspection. Defects on the bottom part that do not reach the cylindrical part of the samples are deemed acceptable, whereas no defects are accepted on the cylindrical or top parts of the samples.
**[0053]** No chipping was seen in any inserts from examples A-J.
**[0054]** Samples with a 6 wt% Co 1450 Vickers cemented carbide mining grades treated using resonance frequency, for example using the method described in EP2825338, all showed >80% chipping post treatment.

Example 4 - Coercivity

**[0055]** The magnetic coercivity (Hc) was also measured before and after the surface hardening and toughening treatment. The $\Delta$Hc (%) as reported in table 3, where $\Delta$Hc (%) = ((Hc post treatment - Hc post sintering) / Hc post sintering) x 100. Higher $\Delta$Hc(%) post treatment is an indication of higher levels of compressive stress introduction.

Table 3: Coercivity

| Sample | $\Delta$Hc (%) |
|---|---|
| A (inventive) | 2.3 |
| B (comparative) | 1.4 |
| C (inventive) | 5.6 |
| D (inventive) | 3.6 |
| E (inventive) | 6.7 |
| F (comparative) | 1.8 |
| G (inventive) | 2.7 |
| H (inventive) | 4.5 |
| I (inventive) | 20.2 |

**[0056]** It can be seen that the comparative samples, B and F, where the displacement is too low do not achieve as high $\Delta$Hc as the inventive samples. Higher $\Delta$Hc is an indication that higher levels of compressive stress have been introduced.

Example 4 - Hardness mapping

**[0057]** The hardness measurements are performed using a programmable hardness tester, KB30S by KB Prüftechnik GmbH calibrated against test blocks issued by Euro Products Calibration Laboratory, UK. Hardness is measured according to ISO EN6507-01.
**[0058]** HV3 measurements were done in the following way:

- Scanning the edge of the sample.
- Programming the hardness tester to make indentations at specified distances from the edge of the sample.
- Indentation with 3 kg load at all programmed co-ordinates.
- The computer moves the stage to each co-ordinate, locates the microscope over each indentation, and runs auto adjust light, auto focus and the automatically measures the size of each indentation.
- The user inspects all the photos of the indentations for focus and other matters that disturb the result.

**[0059]** Measurements were taken at 0.3 mm from the surface (HV3(surface)) and in the bulk, which was defined as 4.6 mm from the surface, (HV3(bulk)). Then the average HV3 contour change, in percent, was calculated using the following equation:

$$100 \text{ x } ((\text{Average HV3(surface)} - \text{Average HV (bulk)}) / \text{Average HV3 (bulk)})$$

**[0060]** The average contour hardness change is reported in table 4 below:

Table 4: Hardness

| Sample | Average contour change (HV3) | % average contour change |
|---|---|---|
| A (inventive) | 25 | 1.7 |
| B (comparative) | 16 | 1.1 |
| C (inventive) | 48 | 3.3 |
| D (inventive) | 31 | 2.1 |
| E (inventive) | 55 | 3.8 |
| F (comparative) | 16 | 1.1 |
| G (inventive) | 21 | 1.4 |
| H (inventive) | 44 | 3 |
| I (inventive) | 69 | 5.8 |

**[0061]** A higher average HV3 contour change is an indication of higher levels of compressive stresses being introduced. It can be seen that the average HV3 contour change for the inventive samples is higher than for the comparative samples.

## Claims

1. A method of treating mining inserts (12) wherein said mining inserts (12) are subjected to a surface hardening and toughness process;

   wherein the surface hardening and toughness process is a shaking process within an enclosed container (2);
   **characterized in that:**
   the shaking process is conducted with a peak to peak displacement of > 25 mm.

2. The method according to claim 1 wherein the maximum operating acceleration during the shaking process is equal to or above 5 G.

3. The method according to claim 1 or claim 2 wherein the maximum velocity during the shaking process is between 1.4-2.5 m/s.

4. The method according to any of the previous claims wherein the maximum shaking frequency during the shaking process is between 5-25 Hz.

5. The method according to any of the previous claims wherein the minimum operating energy during the shaking process is >0.8 J per kg.

6. The method according to any of the previous claims the shaking process is conducted in an electrodynamic vibrator.

7. The method according to any of the previous claims wherein the acceleration is ramped up to the maximum operating acceleration.

8. The method according to any of the previous claims wherein the container (2) is shaken in a vertical direction.

9. The method according to any of claims 1-7 wherein the container (2) is shaken in a horizonal direction.

**10.** The method according to any of the previous claims wherein the inserts (12) are pre-heated prior to the shaking process.

**11.** The method according to any of the above claims wherein the shaking process is conducted at its maximum operating acceleration for between 2-60 minutes.

**12.** The method according to any of the previous claims wherein the fill capacity of the container (2) is between 25 - 75%.

**13.** The method according to any of the previous claims wherein an internal bottom surface (10) of the container (2) has at least one indentation or protrusion (14).

**14.** The method according to any of the previous claims wherein additional cemented carbide media is added in the container (2) with the inserts (12).

**15.** The method according to any previous claims where the mass of inserts (12) and media in each container (2) is between 2-150 kg.

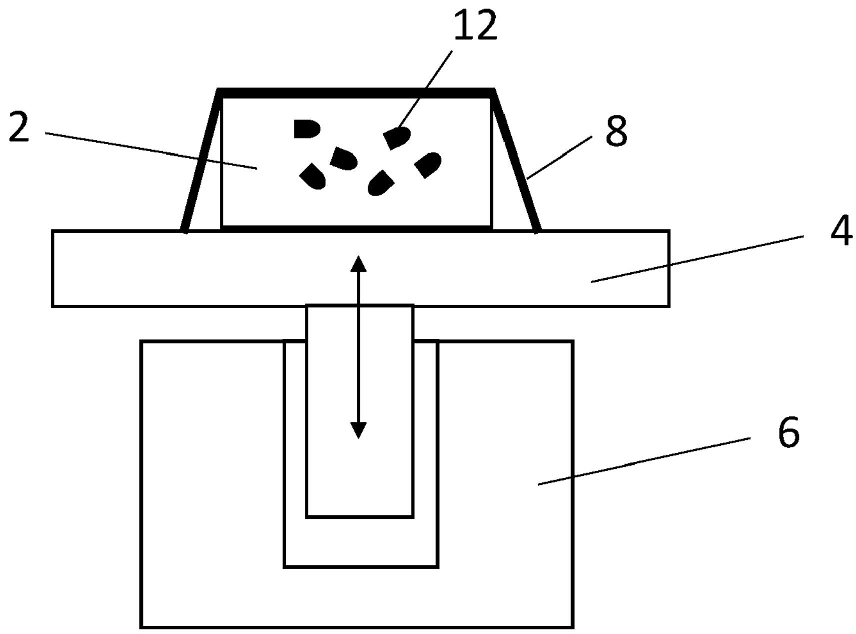


Fig. 1

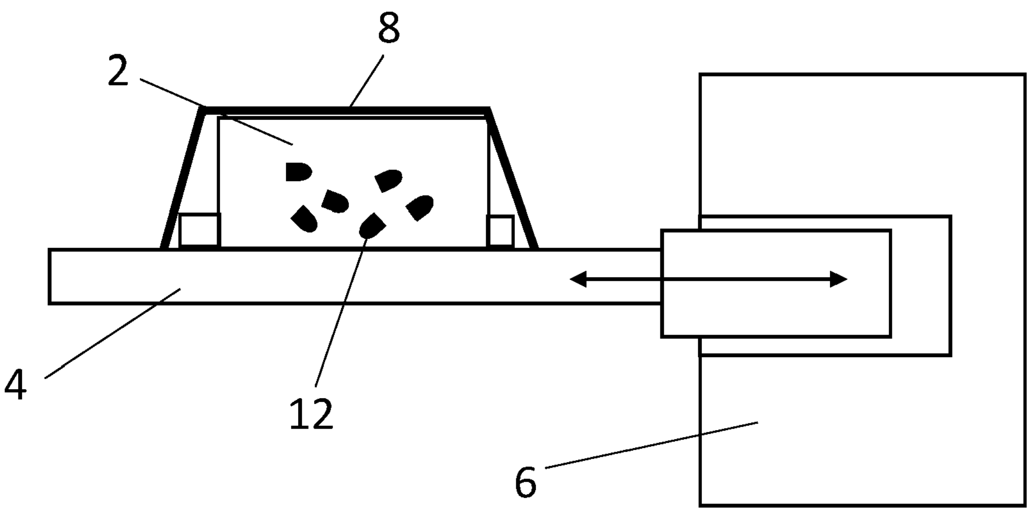


Fig. 2

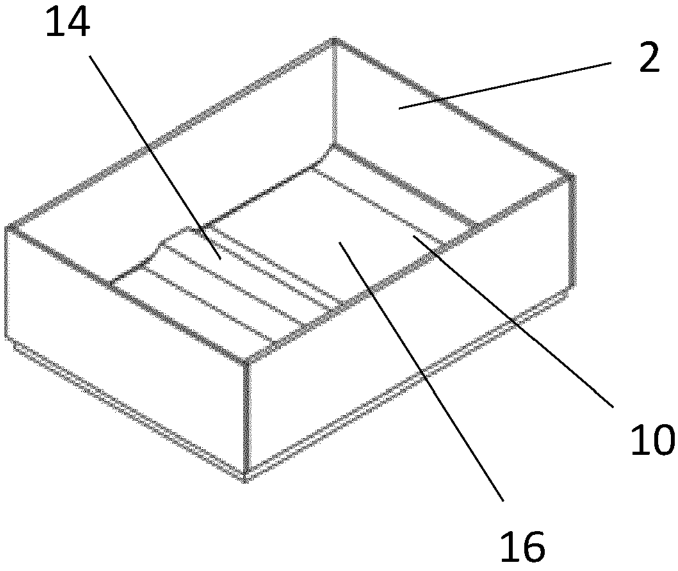


Fig 3

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 23 21 8041

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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