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(54) Cutting elements

(57) A cutting element for a cutting tool that is particularly resistant to premature wear through reverse rotation, comprises a matrix including support material and particles of abrasive material, characterised in that the particles comprise a mixture of natural and synthetic diamond. The proportion of natural diamond in the mixture ranges from around 2% up to around 70-80%. A preferred mixture contains approximately 40% natural diamond and approximately 60% synthetic diamond.

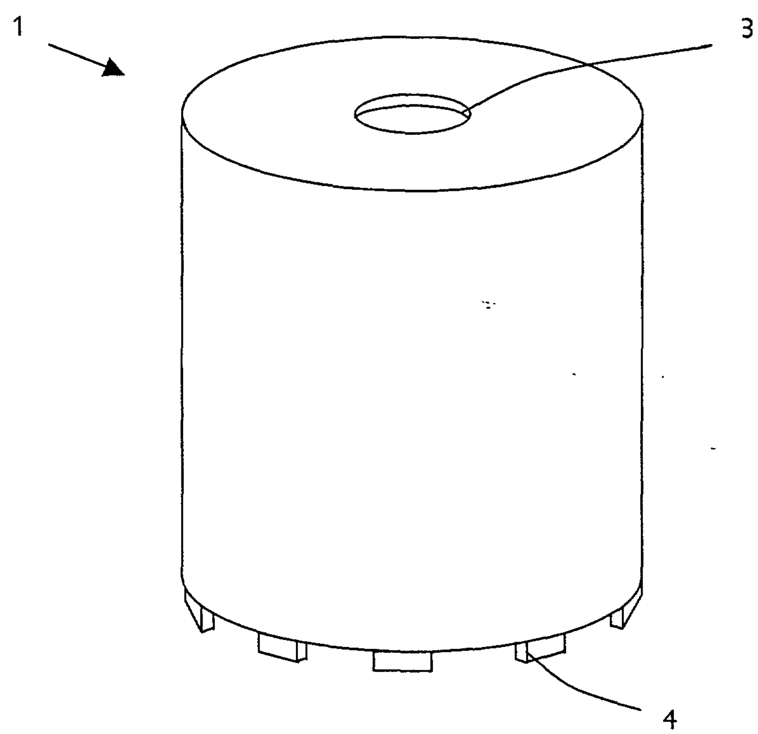

Fig 1

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Description

Field of the Invention

[0001] This invention relates generally to cutting elements, typically those used for drills, hole cutters and the like. More particularly, the invention relates to cutting elements composed of a mixture of natural and synthetic diamond.

Background to the Invention

[0002] Cutting elements in drills, hole cutters and so on were traditionally made of natural diamond. The cutting elements would be disposed as required around the operative part of a cutting tool, for example the peripheral edge of a cylindrical hole cutter, the circumference of a disc cutter or the face(s) of a disc used as a grinder. Particles of diamond are carried in a support matrix and fashioned into cutting elements that can be fixed to the operative part of the cutting tool. Alternatively, the matrix, complete with diamond particles, can be deposited directly onto the operative part of the cutting tool.

[0003] The qualities of diamond need no elaboration here, suffice to say that it is the hardest natural element known to man and is therefore ideally suited to cutting other natural materials, such as rock and stone, and for cutting, smoothing or abrading natural or man-made materials, such as iron, steel etc and the more exotic new materials.

[0004] The performance of diamond particles in a matrix was nothing short of remarkable and became the accepted standard against which other cutting tools were measured. However, performance came at a price and natural diamond came at a premium. Market forces in the diamond industry had a significant impact on the cost of diamond tipped cutting tools, irrespective of their cutting prowess.

[0005] Consequently, natural diamonds in cutting tools were replaced by synthetic diamonds. Synthetic diamond particles are, like natural diamond, mixed into a support matrix and disposed on cutting tools in the same way as natural diamond. The results were surprisingly good and surpassed all expectations. Performance was also enhanced by improvements in the composition of the matrix, so that there was a greater binding force and homogeneity to the cutting elements, causing them to be more robust and therefore longer lived.

[0006] Synthetic diamond is generally accepted as being more uniform in shape and, because of a controlled manufacturing process, more consistent in quality. When synthetic diamond is bonded into a matrix, this consistency leads to a theoretically enhanced performance in terms of quality, durability and resistance to fracture but its uniformity in shape has a distinct disadvantage in that synthetic diamond particles are difficult to bond into the matrix. They tend to be torn out of the bond before reaching the end of their useful life.

[0007] This problem is more acute when cutting elements made of synthetic diamond are used in cutters that are not always run in one direction. For example, Gang Saws reciprocate, so there are always times when the cutting elements are being run in the "wrong" direction. Coating the diamond to give better bond retention alleviates the problem to a certain extent but the root of the problem is not overcome.

[0008] Small natural diamond particles used for diamond sawing and drilling are broken/crushed from a larger diamond. The resultant particles are more irregular in shape and cutting edge than synthetic diamond, so bond retention is improved and premature diamond loss much reduced.

[0009] A diamond blade should therefore be used in the same direction. Arrows or other indicia on the cutter are usually provided for this purpose. Despite such measures, research by Applicant has shown that 48% of diamond blades are consistently run in the opposite direction.

[0010] Therefore, if performance is to be preserved, there is a demand for cutters that are insensitive to the direction of usage, whether by incorrect installation/operation or by operation where the direction varies regularly, such as in reciprocating action.

[0011] The present invention concerns a cutting element which is a departure from prior art cutting elements but which loses nothing in performance and yet overcomes a public prejudice against synthetic diamond tipped cutting tools that are somehow perceived as not being as good as "the real thing".

Summary of the Invention

[0012] According to the present invention, a cutting element for a cutting tool comprises a matrix including support material and particles of abrasive material, characterised in that the particles comprise a mixture of natural and synthetic diamond.

[0013] The proportion of natural diamond in the mixture may range from around 2% up to around 70-80%. Preferably, the mixture contains approximately 40% natural diamond and approximately 60% synthetic diamond.

[0014] The invention also includes a cutting tool having at least one cutting element as defined in any of the preceding paragraphs.

[0015] In a cutting element according to the invention, the synthetic diamond provides the consistent cutting ability whilst the natural diamond provides the ability to achieve good cutting performance even when the rotation direction is reversed.

Brief Description of the Drawings

[0016] The invention will be described with reference to the drawings, in which:

Figure 1 is a schematic drawing of a hole cutting tool, and
Figure 2 is a schematic drawing of a disc cutter.

Detailed Description of the Illustrated Embodiments

[0017] Figure 1 illustrates a typical hole cutter 1 having a tubular structure with one end provided with an aperture 3 for mounting the cutter to eg a drill. The other end of the cutter has a peripheral edge provided with one or more cutting elements 4 consisting of a matrix of support material and particles of abrasive material.
[0018] Figure 2 illustrates a disc cutter 2, also with a central mounting hole 5 and provided with cutting elements such as 6 spaced as desired around the circumference of the disc. The cutting elements are the same as in Figure 1.
[0019] In both cases, the cutting elements are made of a support matrix in which are dispersed particles of diamond. In the prior art, as discussed above, the diamond would have been natural diamond or, nowadays more usually, synthetic diamond. In each case, the diamond particles would be wholly of one or the other type.
[0020] In accordance with the invention, however, applicants have realised that good performance can be achieved with a mixture of both types of diamond, namely synthetic and natural. Among the benefits are reduced cost, compared to wholly natural diamond, removal of prejudice against using synthetic diamond, and improved performance compared to using one type alone.
[0021] As previously mentioned, the synthetic diamond provides the consistent cutting ability, whilst the natural diamond provides the ability to achieve good cutting performance even when the rotation direction is reversed.
[0022] Furthermore, synthetic diamond tends to chip the material being cut more so than natural diamond because of its consistency, whereas natural diamond tends to produce a cut with less chipping. This can be of particular importance when cutting materials with an aesthetic appearance, such as ceramic or natural stone tiles.
[0023] The theoretical performance of synthetic diamond in a matrix more often than not fails to be achieved, unless the cutting tool is used in perfect conditions, namely with the cutter always operating in the one direction and without the blade (in the case of a disc cutter) being allowed to twist in the cut and to vibrate and "hammer". In situations where these ideal conditions are not met, cutters with a mixture of synthetic and natural diamond have proven to offer more consistent real performance, especially a much faster and more consistent speed of cut.
[0024] Applicant has carried out comparative performance tests and has produced the following results based on cuts on concrete paving slabs and grey granite slabs, using natural diamond and a natural/synthetic diamond mixture according to the invention.

<u>Test Materials</u>:

[0025]

(1) British standard concrete paving slab 500 × 500 × 50 mm
Size of cut 500mm long 50mm depth
(2) Grey granite slab, granite grade 5
Size of cut 280mm long 60mm depth

<u>Test Machine</u>:

[0026] Bosch angle grinder 230mm 2200 watts.

<u>Blade I</u>

[0027] Blade turbo rim, 230mm × 2.8mm diam., 25 concentration.
100% synthetic diamond particles MBS 910 grit 40/50, cobalt bond

Blade II

[0028] Blade turbo rim, 230mm × 2.8mm diam., 25 concentration.
60% diamond particles MBS 910 grit 40/50
40% natural diamond, cobalt bond

Test Procedure:

[0029] Each blade carried out 3 cuts in the direction of the arrow of the blade. Having completed the cuts, the blade was turned to run in the opposite direction of the arrow and 3 cuts were carried out this way. Both blades were used identically by the same operator and in the same machine and on the same material.

Material (1)

[0030] Concrete paving slab
500 × 50mm

	Blade Running in direction of Arrow					Blade Running in opposite direction to the Arrow				
	Cut 1 Seconds	Cut 2 Seconds	Cut 3 Seconds	TOTAL		Cut 1 Seconds	Cut 2 Seconds	Cut 3 Seconds	TOTAL	COMBINED TOTAL
Blade I (All synthetic)	57	59	53	169		126	99	97	322	491
Blade II (synthetic and natural)	63	61	60	184		74	68	63	205	389

Material (2)

[0031] Granite Slab
280mm × 60mm

	Blade Running in direction of Arrow					Blade Running in opposite direction to the Arrow				
	Cut 1 Seconds	Cut 2 Seconds	Cut 3 Seconds	TOTAL		Cut 1 Seconds	Cut 2 Seconds	Cut 3 Seconds	TOTAL	COMBINED TOTAL
Blade I (All synthetic)	71	76	82	158		112	116	119	347	505
Blade II (synthetic and natural)	72	81	79	232		88	86	81	255	487

Conclusion

[0032] Although the material being cut, the machinery, the operator and the blade bond remained unchanged, it is striking how much better Blade II copes with the adverse conditions of reverse rotation.

[0033] On material 1 (concrete), Blade I (all synthetic) took 90.5% longer to make the 3 cuts when rotated in the opposite direction than when rotated in the intended direction. On Material 2, the time increased by 119.62% under the same circumstances.

[0034] In stark contrast, Blade II (natural/synthetic diamond mixture) increased cutting time by only 11.41% and 9.91% in concrete and granite respectively.

[0035] Similar test results were achieved when the blades were rubber mounted to allow vibrations and/or twisted in the cuts. In above scenarios, Blade II (natural/synthetic diamond mixture) coped with the adverse conditions much better than Blade I, although on a straight line performance Blade I had given better performance in terms of speed of cut when run in the intended rotation direction.

[0036] Applicant has also investigated different proportions of natural to synthetic diamond, ranging from around 2% natural diamond up to around 70-80%. Different proportions have different impacts on performance and obviously on price but the same relative performance of the natural/synthetic diamond mixture compared to the solely synthetic diamond was demonstrated.

[0037] Although the invention has only been particularly described with reference to the hole cutter embodiment of Figure 1 and the disc cutter embodiment of Figure 2, it is to be appreciated that the invention, in that it concerns the cutting elements themselves, is not confined to the type of cutter in which the cutting elements are deployed. As previously indicated, cutters may take many configurations. Disc cutters are also known in which the disc face is dished and cutting elements are disposed on the planar part of the face so as to act as an abrasive cutter. Alternatively, cutting elements may be disposed over the face of a planar cutting disc. Many configurations are possible without affecting the nature and qualities of the cutting element of the invention.

[0038] The cutting elements may be pre-fabricated and subsequently fixed to the appropriate support structure, such as a disc or cylinder. Welding, for example by laser, is the most favoured method of attaching the cutting elements to the support structures. However, the cutting elements may be fixed/formed in situ by sintering the matrix and diamond particles en *masse* directly onto the support. Any technique is applicable to fixing and/or forming the cutting elements of the invention onto a support structure of a cutting tool.

[0039] The invention has therefore been shown to demonstrate unexpectedly good results in terms of cutting ability, resistance to reverse rotation and prolonged life.

Claims

1. A cutting element for a cutting tool, comprising a matrix including support material and particles of abrasive material, **characterised in that** the particles comprise a mixture of natural and synthetic diamond.

2. A cutting element as claimed in Claim 1, wherein the proportion of natural diamond in the mixture ranges from around 2% up to around 70-80%.

3. A cutting element as claimed in Claim 2, wherein the mixture is composed of approximately 40% natural diamond and approximately 60% synthetic diamond.

4. A cutting tool comprising a support structure provided with at least one cutting element (4, 6), said cutting element comprising a matrix including support material and particles of abrasive material, **characterised in that** the particles comprise a mixture of natural and synthetic diamond.

5. A cutting tool as claimed in Claim 4, wherein the support structure is a disc (2) and at least one said cutting element (6) is located at the rim of the disc.

6. A cutting tool as claimed in Claim 4, wherein the support structure is a disc and at least one said cutting element is located on a face of said disc.

7. A cutting tool as claimed in Claim 4, wherein the support structure is a hollow cylinder (1) and at least one said cutting element (4) is located at a peripheral edge of one end of the cylinder.

8. A cutting tool as claimed in any of Claims 4 to 7, wherein said cutting element (4, 6) is pre-formed and fixed to

said support structure.

9. A cutting tool as claimed in Claim 8, wherein said pre-formed cutting element (4, 6) is fixed to said support structure by laser welding.

10. A cutting tool as claimed in any of Claims 4 to 7, wherein said cutting element is formed in situ on said support structure.

11. A cutting tool as claimed in Claim 10, wherein said cutting element is formed by sintering said matrix to said support structure in situ.

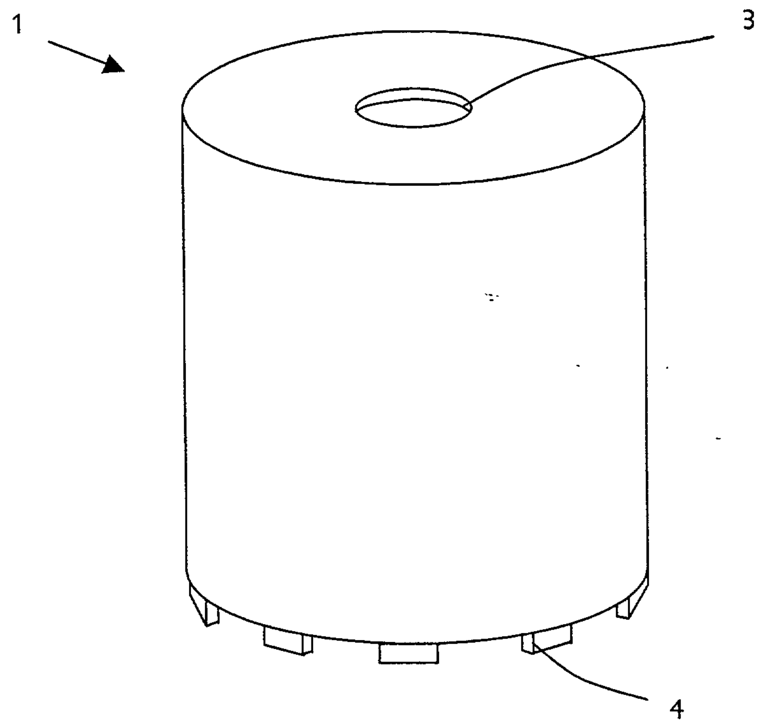

Fig 1

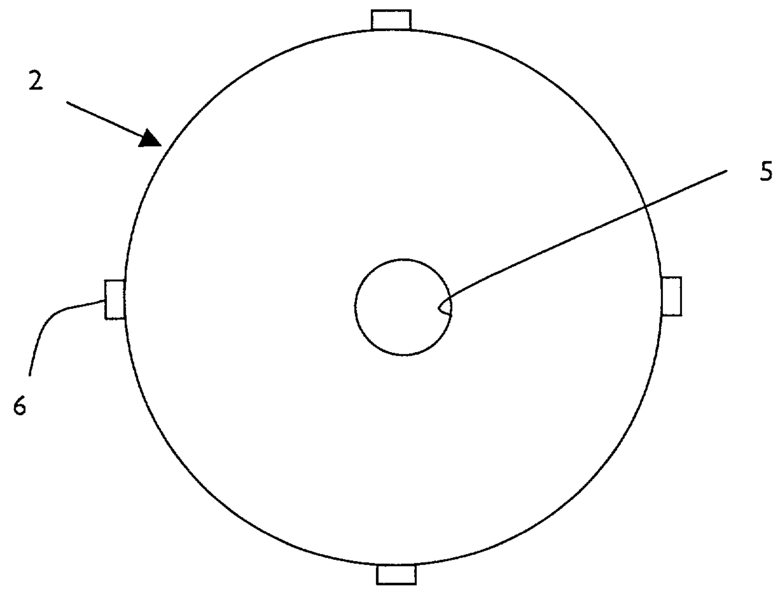

Fig 2

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EUROPEAN SEARCH REPORT

Application Number
EP 01 30 5661

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 370 199 A (GEN ELECTRIC) 30 May 1990 (1990-05-30) * column 1, line 18 - column 3, line 26; claims 15,16 *	1-3	B23B27/14 B23B27/20 E21B10/46
X	GB 2 081 347 A (CHRISTENSEN INC) 17 February 1982 (1982-02-17) * page 1, line 68 - page 2, line 95; figure 1 *	1,4,7,8	
X	EP 0 916 804 A (GEN ELECTRIC) 19 May 1999 (1999-05-19) * column 6, line 8 - column 7, line 6; figure 20 *	1,4,7,8, 11	
A	EP 0 264 674 A (CHRISTENSEN INC NORTON) 27 April 1988 (1988-04-27) * the whole document *	1-4	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
B23B
E21B
B28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	22 October 2001	Kornmeier, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 30 5661

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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