(54) Title: ROTATABLE CUTTING TOOL WITH HARD CUTTING MEMBER

(57) Abstract: A rotatable cutting tool (30) for impinging a substrate while rotatably retained within a holder bore. The rotatable cutting tool (30) includes a hard cutting member (70, 90, 110) affixed in a socket (44) at the axial forward end (34) of a cutting tool body (32). The hard cutting member (70, 90, 110) has an axial forward functional portion (80, 100, 120) which has a starting transverse functional dimension (C, C'), and further has a base portion (86, 98, 118) which has a maximum transverse base dimension (D, D', D'') and there is a ratio of the starting transverse functional dimension (C, C') to the maximum transverse base dimension (D, D', D'') ranging between equal to 0.42 and less than 0.48.
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). Published: 

— with international search report (Art. 21(3))
ROTATABLE CUTTING TOOL WITH HARD CUTTING MEMBER

CROSS-REFERENCE TO EARLIER PATENT APPLICATION


BACKGROUND OF THE INVENTION

[0002] The invention pertains to a rotatable cutting tool, which typically mounts in a stationary block (or holder) on a rotatable drum. The rotatable cutting tool, which is rotatable about its central longitudinal axis, carries a hard cutting insert at the axially forward end thereof. The hard cutting insert is of a hard material such as, for example, cemented (cobalt) tungsten carbide. The rotatable cutting tool engages or impinges a substrate upon the rotation of the drum. The hard cutting insert exhibits a geometry that provides a number of benefits both in the operational efficiency of the rotatable cutting tool and the cost of materials to manufacture the rotatable cutting tool.

[0003] A rotatable cutting tool typically presents a generally elongate, cylindrical geometry. The rotatable cutting tool comprises an elongate steel cutting tool body, which has an axially forward end and an opposite axially rearward end. The cutting tool body typically carries an assembly or means by which the rotatable cutting tool is rotatable carried by the stationary block or holder on the drum. Exemplary structures useful for the rotatable attachment of a rotatable cutting tool to a block or holder include those shown and described in U.S. Patent No. 4,201,41 to Den Besten et

[0004] A hard cutting member typically affixes, such as by brazing, to the axial forward and of the cutting tool body. As mentioned above, typically, the hard cutting member is made from a hard material like cemented cobalt tungsten carbide. U.S. Patent No. 4,389,074 to Greenfield, U.S. Patent No. 5,131,725 to Rowlett et al., U.S. Patent No. 5,429,199 to Sheirer et al., U.S. Patent No. 6,375,272 to Ojanen, and U.S. Patent No. 6,478,383 to Ojanen et al. disclose braze alloys that have heretofore been suitable for such a brazing operation and suitable compositions of cemented tungsten carbide.

[0005] Heretofore, a hard cutting member suitable for use in a rotatable cutting tools have exhibited many different geometries. One exemplary geometry is shown and described in U.S. Patent No. 4,497,520 to Ojanen.

[0006] In the case of a road planing machine, the rotatable drum can in many cases carry hundreds of individual blocks or holders. Each individual block or holder carries its own corresponding rotatable cutting tool, which is rotatable relative to its corresponding block or holder. It is not unusual that a rotatable drum will carry hundreds of individual rotatable cutting tools.

[0007] The road planing machine powers the rotatable drum so as to cause it to rotate. The orientation of the rotatable cutting tools with respect to the drum is such so that upon rotation of the drum, the drum drives the rotatable cutting tools into the substrate. Upon the rotatable cutting tools impinging the substrate, the substrate typically breaks thereby forming larger chunks of debris, as well as smaller particles and pieces of debris. Typically, the debris generated in a road planing operation is highly abrasive which causes the rotatable cutting tool to experience wear.

[0008] The rotatable cutting tool can experience wear in a number of ways. The hard cutting member, which is the portion of the rotatable cutting bit that first impinges the substrate, can experience wear. The initial impact of the hard cutting member against the substrate, as well as the travel of the debris along the hard cutting member, can cause this wear. Over the course of the cutting operation, the hard cutting
member can lose material to the point where it becomes dull and ineffective to accomplish efficient cutting.

[0009] Another wear mechanism pertains to the braze joint between the hard cutting member and the elongate cutting tool body. Throughout the course of the cutting operation, the braze joint experiences severe stresses due to the continual intermittent violent impingement of the rotatable cutting tool against the substrate material. Over the course of time, the braze joint can experience sufficient stress so as to fail thereby allowing the hard cutting member to separate from the cutting tool body. Obviously, if the rotatable cutting tool loses the hard cutting member, the rotatable cutting tool is no longer useful for the cutting operation.

[0010] Further, during a cutting operation such as, for example, a road planing operation, debris travels down the elongate cutting tool body. Due to the abrasive nature of the debris, the elongate cutting tool body experiences wear and erosion. Since the cutting tool body typically comprises steel, those in the pertinent art characterize this wear phenomenon as "steel wash". The result of "steel wash" is to cause the axial forward portion of the cutting tool body beneath or axially behind the hard cutting member to reduce in diameter. Such a reduction in diameter causes this portion of the cutting tool body to take on an hourglass shape. As the cutting operation continues, the axial forward portion of the cutting tool body continues to reduce in diameter to a point where it eventually breaks thereby ending the useful life of the rotatable cutting tool due to the failure of the cutting tool body.

[0011] One way to retard steel was has been to enlarge the size of the base portion of the hard cutting insert. By enlarging the size of the base portion, the hard cutting insert provides a greater amount of protection to the axial forward end of the steel cutting tool body. Along with enlarging the size of the base portion of the hard cutting insert, there has been an enlargement of the overall geometry of the hard cutting insert. By enlarging the overall size of the hard cutting insert, there has been an increase in the cost of materials for the rotatable cutting tool. Further, by enlarging the overall size of the hard cutting insert, resistance to the penetration of the hard cutting insert increases, and thus, more power or energy is needed to drive the rotatable cutting tool through the strata.
Steel wash has been (or can be) particularly acute in cutting operations in which the substrate is soft asphalt. In cutting soft asphalt, the rotatable cutting tool may cut to a depth such that the steel body enters the cut. When this occurs, the erosion or wash of the steel cutting tool body becomes significant whereby the steel cutting tool body wears to an end of useful condition prior to the hard cutting insert wearing to an end of useful condition. This can be a disadvantageous condition because the hard cutting insert contains an amount of useful cemented tungsten carbide, and yet, the rotatable cutting tool is not useful for cutting.

It would thus be highly desirable to provide an improved rotatable cutting tool, which is rotatably carried by an individual block or holder of a rotatable drum of a cutting machine (e.g., a road planing machine), wherein the hard cutting insert does not contain an amount of useful cemented tungsten carbide at the time the steel cutting tool body reaches an end of useful life condition. Further, it would be desirable to provide a hard cutting insert that provides protection to the steel cutting tool body and yet does not increase the power or energy necessary to drive the rotatable cutting tool through the strata.

**SUMMARY OF THE INVENTION**

In one form thereof, the invention is a rotatable cutting tool that is for impingement upon a substrate and adapted to be rotatably retained within the bore of a holder. The rotatable cutting tool includes an elongate cutting tool body, which has an axial forward end and an axial rearward end with a socket at the axial forward end thereof. The rotatable cutting tool further has a hard cutting member, which is affixed to the cutting tool body within the socket. The hard cutting member has an axial forward end and an axial rearward end. The hard cutting member has an axial forward functional portion which has a starting transverse functional dimension, and further has a base portion which has a maximum transverse base dimension. There is a ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.48.

In yet another form, the invention is a hard cutting member for attachment to a cutting tool body. The hard cutting member comprises an axial forward end, an axial rearward end, and an axial forward functional portion, which has a
starting transverse functional dimension. The hard cutting member further has a base portion, which has a maximum transverse base dimension. A ratio of the starting transverse functional dimension to the maximum transverse base dimension ranges between equal to 0.42 and less than 0.48.

[0016] In still another form, the invention is a hard cutting member for attachment to a cutting tool body. The hard cutting member comprises an axial forward end and an axial rearward end. The axial length is the distance between the axial forward end and the axial rearward end. The hard cutting member has an axial forward functional portion, which has a starting transverse functional dimension, and a base portion which has a maximum transverse base dimension. A ratio of the starting transverse functional dimension to the maximum transverse base dimension ranges between equal to 0.42 and less than 0.48. A ratio between the axial length and the maximum transverse base dimension ranges between equal to 0.75 and less than 0.78.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0017] The following is a brief description of the drawings that form a part of this patent application:

[0018] FIG. 1 is a side view of a rotatable cutting tool with a hard cutting member at the axial forward end;

[0019] FIG. 2 is a side view of the hard cutting member of FIG. 1 wherein a portion of the axial forward end of the steel cutting tool body is broken away showing the hard cutting member in the socket and the braze joint between the hard cutting member and the surface that defines the socket;

[0020] FIG. 3 is a side view of the hard cutting member of FIG. 2 shown not in the socket;

[0021] FIG. 4 is a side view of a second specific embodiment of a hard cutting member; and

[0022] FIG. 5 is a side view of a third specific embodiment of a hard cutting member.
DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0023] Referring to the drawings, FIG. 1 illustrates a first specific embodiment of the rotatable cutting tool of the invention, generally designated as 30. The specific embodiments illustrated herein pertain to road planing tools. However, one should appreciate that the invention has application to other kinds of cutting tool useful in other kinds of cutting operations. Exemplary operations include without limitation road planing (or milling), coal mining, concrete cutting, and other kinds of cutting operations wherein a cutting tool with a hard cutting member impinges against a substrate (e.g., earth strata, pavement, asphaltic highway material, concrete, and the like) breaking the substrate into pieces of a variety of sizes including larger-size pieces or chunks and smaller-sized pieces including dust-like particles.

[0024] Rotatable cutting tool 30 has a central longitudinal axis A-A. In operation, rotatable cutting tool 30 rotates about the axis A-A. Rotatable cutting tool 30 includes an elongate cutting tool body generally designated as 32, which typically is made of steel. Exemplary compositions of the steel for the cutting tool body include without limitation those disclosed in the following document: U.S. Patent No. 4,886,710 to Greenfield, and U.S. Patent No. 5,008,073 to Greenfield. Elongate cutting tool body 32 presents a generally cylindrical geometry, and has an axial forward end 34 and an axial rearward end 36.

[0025] Elongate cutting tool body 32 includes a head portion 38, which has an enlarged transverse dimension adjacent the axial forward end 34 relative to the overall transverse dimension of the cutting tool body. The elongate cutting tool body 32 further includes an integral shank portion 40, which has a reduced transverse dimension, adjacent the axial rearward end 36 relative to the overall transverse dimension of the cutting tool body. The shank portion 40 contains an annular groove 42 adjacent the axial rearward end 36.

[0026] The head portion 38 contains a socket 44 at the axial forward end of the cutting tool body 32. The socket 44 presents a so-called flat-bottom geometry wherein the socket 44 has a generally circular bottom surface 46 and a generally cylindrical surface 48. One should appreciate that other geometries of a socket may be suitable for
use with the rotatable cutting tool provided that the geometry of the hard cutting member corresponds to that of the socket.

[0027] The elongate cutting tool body 32 carries an elongate resilient retainer 52. Resilient retainer 52 presents an axial forward end 54 and an axial rearward and 56. Resilient retainer 52 contains a longitudinal slit 58 along the entire longitudinal length thereof. The presence of the slit 58 provides a radial resiliency to the resilient retainer 52. Although not directly shown, retainer 52 includes a radially inward projection that is received within the groove 42 so as to assist with the retention of the retainer on the shank of the rotatable cutting tool.

[0028] A generally circular washer 60 (see solid line illustration), which has a collar 62 extending in an axial rearward direction, surrounds and radially compresses the resilient retainer 52. Although not illustrated, washer 60 contains a central aperture. Washer 60 as illustrated by solid lines is in a condition prior to the insertion of the rotatable cutting tool 30 into the bore of a block or holder. Upon the insertion of the rotatable cutting tool 30 into the bore of a block or holder, the washer 60 is forced in an axial forward direction along the surface of the resilient retainer 52 until it abuts against the rearward surface of the enlarged head portion 38.

[0029] Rotatable cutting tool 30 further includes a hard cutting member generally designated as 70 affixed by brazing within socket 44 at the axial forward end 34 of the cutting tool body 32. Grades of cemented (cobalt) tungsten carbide suitable for use herein include those disclosed in U.S. Patent No. 4,859,543 to Greenfield and U.S. Patent No. 6,197,084 to Smith.

[0030] FIG. 2 shows the hard cutting member 70 brazed into the socket 44 wherein there is a braze joint 68 between the hard cutting member 70 and the surfaces that define the socket 44. Dimension "B" represents the axial length of hard cutting member 70 axially forward of the axial forward end 34 of the cutting tool body 32 when the hard cutting member 70 is affixed within the socket 44 of the cutting tool body 32.

[0031] Still referring to FIG. 2 and to FIG. 3, hard cutting member 70 includes an axial forward end 72 and an axial rearward end 74, which is flat has a has plurality of spacer bumps 76 that project from the rearward end 74. Hard cutting member 70
includes a functional portion shown by bracket 80. Functional portion 80 has a
transverse starting dimension equal to "C". Hard cutting member 70 further has a base
portion 86, which has a transverse base dimension "D".

[0032] Referring to FIG. 4, there is shown a second embodiment of the hard
cutting member generally designated as 90. Hard cutting member 90 includes an axial
forward end 92 and an axial rearward end 94, which is flat has a has plurality of spacer
bumps 96 that project from the rearward end 94. Hard cutting member 90 includes a
functional portion shown by bracket 100. Functional portion 100 has a transverse
starting dimension equal to "C". Hard cutting member 90 further has a base portion
98, which has a transverse base dimension "D".

[0033] Referring to FIG. 5, there is shown a third embodiment of the hard
cutting member generally designated as 110. Hard cutting member 110 includes an
axial forward end 112 and an axial rearward end 114, which is flat has a has plurality of
spacer bumps 116 that project from the rearward end 114. Hard cutting member 110
includes a functional portion shown by bracket 120. Functional portion 120 has a
transverse starting dimension equal to "C"'. Hard cutting member 110 further has a
base portion 118, which has a transverse base dimension "D".

[0034] Table I below sets forth the dimensions B-B", C-C" and D-D" of these
specific embodiments.

Table 1. Specific Dimensions (in millimeters) for the First, second and Third
Embodiments

<table>
<thead>
<tr>
<th>Embodiment</th>
<th>Dimension B/B&quot; (mm)</th>
<th>Dimension C/C&quot; (mm)</th>
<th>Dimension D/D&quot; (mm)</th>
<th>Ratio of C:D</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>14.1</td>
<td>8.54</td>
<td>18.75</td>
<td>0.455</td>
</tr>
<tr>
<td>Second</td>
<td>14.46</td>
<td>8.54</td>
<td>18.75</td>
<td>0.455</td>
</tr>
<tr>
<td>Third</td>
<td>14.46</td>
<td>8.54</td>
<td>18.75</td>
<td>0.455</td>
</tr>
</tbody>
</table>

Table II below sets forth the dimensions (in millimeters) of various
specific embodiments of the hard cutting members.

Table II
Dimensions for the Specific Embodiments Hard Cutting Members

<table>
<thead>
<tr>
<th>Embodiment</th>
<th>Starting Diameter of Functional Portion (mm)</th>
<th>Diameter of the Base Portion (mm)</th>
<th>Ratio of the Starting Diameter of Functional Portion to the Diameter of the Base Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.0</td>
<td>19</td>
<td>0.42</td>
</tr>
<tr>
<td>B</td>
<td>8.2</td>
<td>19</td>
<td>0.43</td>
</tr>
<tr>
<td>C</td>
<td>8.16</td>
<td>18.87</td>
<td>0.432</td>
</tr>
<tr>
<td>D</td>
<td>8.4</td>
<td>19</td>
<td>0.44</td>
</tr>
<tr>
<td>E</td>
<td>8.6</td>
<td>19</td>
<td>0.45</td>
</tr>
<tr>
<td>F</td>
<td>8.54</td>
<td>18.75</td>
<td>0.455</td>
</tr>
<tr>
<td>G</td>
<td>8.7</td>
<td>19</td>
<td>0.46</td>
</tr>
<tr>
<td>H</td>
<td>8.9</td>
<td>19</td>
<td>0.47</td>
</tr>
<tr>
<td>I</td>
<td>9.0</td>
<td>19</td>
<td>0.474</td>
</tr>
<tr>
<td>J</td>
<td>8.92</td>
<td>18.61</td>
<td>0.479</td>
</tr>
</tbody>
</table>

There should be an appreciation that in one sense, the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.48. In one range, the ratio of the starting diameter of the functional portion to the diameter of the base portion varies between 0.42 and 0.479. In a narrower range, the ratio of the starting diameter of the functional portion to the diameter of the base portion varies between 0.43 and 0.455. In a still narrower range, the ratio of the starting diameter of the functional portion to the diameter of the base portion varies between 0.432 and 0.45. A mid-point of the ratio of the starting diameter of the functional portion to the diameter of the base portion is equal to 0.44.

There should be an appreciation that the smaller ratio provides for a narrower or smaller axial forward portion of the hard cutting member. By doing so, the hard cutting member experiences less resistance. By experiencing less resistance, less power or energy is needed to drive the rotatable cutting tool through the strata.

It thus becomes apparent that the present invention provides an improved rotatable cutting tool, which is rotatably carried by an individual block or
holder of a rotatable drum of a cutting machine (e.g., a road planing machine), wherein the hard cutting insert does not contain an amount of useful cemented tungsten carbide at the time the steel cutting tool body reaches an end of useful life condition.

[0039] The patents and other documents identified herein are hereby incorporated by reference herein. Other embodiments of the invention will be apparent to those skilled in the art from a consideration of the specification or a practice of the invention disclosed herein. It is intended that the specification and samples are illustrative only and are not intended to be limiting on the scope of the invention. The true scope and spirit of the invention is indicated by the following claims.
WHAT IS CLAIMED IS:

1. A rotatable cutting tool for impingement upon a substrate and adapted to be rotatably retained within the bore of a holder, the rotatable cutting tool comprising:

   - an elongate cutting tool body having an axial forward end and an axial rearward end, the cutting tool body containing a socket at the axial forward end thereof;
   - a hard cutting member being affixed to the cutting tool body within the socket, and the hard cutting member having an axial forward end and an axial rearward end;
   - the hard cutting member having an axial forward functional portion which has a starting transverse functional dimension;
   - the hard cutting member further having a base portion which has a maximum transverse base dimension; and
   - a ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.48.

2. The rotatable cutting tool according to claim 1 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.479.

3. The rotatable cutting tool according to claim 1 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.43 and less than 0.455.

4. The rotatable cutting tool according to claim 1 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.432 and less than 0.45.
5. A hard cutting member for attachment to a cutting tool body, the hard cutting member comprising:

an axial forward end and an axial rearward end; an axial forward functional portion which has a starting transverse functional dimension; a base portion which has a maximum transverse base dimension; and a ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.48.

6. The hard cutting member according to claim 5 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.479.

7. The hard cutting member according to claim 5 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.43 and less than 0.455.

8. The hard cutting member according to claim 5 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.432 and less than 0.45.

9. A hard cutting member for attachment to a cutting tool body, the hard cutting member comprising:

an axial forward end and an axial rearward end, an axial length being the distance between the axial forward end and the axial rearward end; an axial forward functional portion which has a starting transverse functional dimension; a base portion which has a maximum transverse base dimension; a ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.48, a ratio between the axial length and the maximum transverse base dimension ranging between equal to 0.75 and less than 0.78.
10. The hard cutting member according to claim 9 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.42 and less than 0.479.

11. The hard cutting member according to claim 9 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.43 and less than 0.455.

12. The hard cutting member according to claim 9 wherein the ratio of the starting transverse functional dimension to the maximum transverse base dimension ranging between equal to 0.432 and less than 0.45.

13. The hard cutting member according to claim 9 wherein the ratio of the axial length to the maximum transverse base dimension ranging between equal to 0.76 and less than 0.78.

14. The hard cutting member according to claim 9 wherein the ratio of the axial length to the maximum transverse base dimension ranging between equal to 0.768 and less than 0.771.
FIG. 3
FIG. 5
INTERNATIONAL SEARCH REPORT

International application No. PCT/US2010/048917

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21C 35/18 (2010.01)
USPC - 299/111

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E21C 35/18, 35/183, 35/19 (2010.01)
USPC - 299/104, 106, 107, 110, 111

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO EAST System (US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERTWENT), PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 4,981,328 A (STIFFLER et al) 01 January 1991 (01.01.1991) entire document</td>
<td>1-14</td>
</tr>
<tr>
<td>A</td>
<td>US 6,019,434 A (EMMERICH) 01 February 2000 (01.02.2000) entire document</td>
<td>1-14</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search
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Date of mailing of the international search report
16 DEC 2010

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer: Blaine R. Copenhagen
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