A rotatable cutting tool for use in impinging earth strata wherein the rotatable cutting tool includes a cutting tool body and a hard tip affixed to the cutting tool body. The cutting tool body includes a forward end for receiving the hard tip and a rearward end, a head portion, a collar portion, and a shank portion. In one aspect, the head portion includes a continuous arcuate outer surface providing a slim profile.
ROTATABLE CUTTING TOOL WITH CONTINUOUS ARCUATE HEAD PORTION

BACKGROUND OF THE INVENTION

[0001] The invention pertains to a rotatable cutting tool that is useful for the impingement of earth strata such as, for example, asphaltic roadway material, coal deposits, mineral formations and the like. More specifically, the present invention pertains to a rotatable cutting tool that is useful for the impingement of earth strata wherein the cutting tool body possesses an improved design so as to provide for improved performance characteristics for the entire rotatable cutting tool.

[0002] Rotatable cutting tools have been used to impinge earth strata such as, for example, asphaltic roadway material or ore bearing or coal bearing earth formations or the like. Generally speaking, these kinds of rotatable cutting tools have an elongate cutting tool body, typically made from steel, and a hard tip (or insert) affixed to the cutting tool body at the axial forward end thereof. The hard tip is typically made from a hard material such as, for example, cemented (cobalt) tungsten carbide. The rotatable cutting tool is rotatably retained or held in the bore of a tool holder or, in the alternative, in the bore of a sleeve that is in turn held in the bore of a holder.

[0003] The holder is affixed to a driven member such as, for example, a driven drum of a road planing machine. In some designs, the driven member (e.g., drum) carries hundreds of holders wherein each holder carries a rotatable cutting tool. Hence, the driven member may carry hundreds of rotatable cutting tools. The driven member is driven (e.g., rotated) in such a fashion so that the hard tip of each one of the rotatable cutting tools impinges or impacts the earth strata (e.g., asphaltic roadway material) thereby fracturing and breaking up the material into debris.

[0004] As can be appreciated, during operation the entire rotatable cutting tool is typically subjected to a variety of extreme cutting forces and stresses in an abrasive and erosive environment. It would be undesirable for the cutting tool body to prematurely wear or fail (whether it be through catastrophic fracture or the like or through abrasive or erosive wear) prior to the hard cutting tip wearing to the point of its useful life. In such a circumstance, the rotatable cutting tool would have to be replaced prior to the normally scheduled time for replacement. Further, the premature failure of the rotatable cutting tool would negatively impact the cutting or milling efficiency of the overall earthworking apparatus. It thus becomes apparent that it is important that the cutting tool body possess the requisite design and strength to maintain its integrity during the intended useful life of the rotatable cutting tool.

SUMMARY OF THE INVENTION

[0005] The present invention provides a rotatable cutting tool for use in impinging earth strata wherein the rotatable cutting tool includes a head portion having an arcuate outer surface from an axial forward end to an axial rearward end thereof. The arcuate outer surface of the head portion of the rotatable cutting tool provides for a slimmer profile while maintaining sufficient strength to withstand the forces and stresses that the rotatable cutting tool is subjected to during operation.

[0006] An aspect of the present invention is to provide a rotatable cutting tool for use in impinging earth strata wherein the rotatable cutting tool includes a cutting tool body and a hard tip affixed to the cutting tool body. The cutting tool body includes an axial forward end for receiving the hard tip and an axial rearward end, a head portion axially rearward of the axial forward end, a collar portion axially rearward of the head portion, and a shank portion axially rearward of the collar portion and axially forward of the axial rearward end. The head portion includes an axial forward generally circular cross-section having an axial forward diameter and an axial rearward generally circular cross-section having an axial rearward diameter. The diameter of the head portion decreases non-linearly from the axial rearward diameter to the axial forward diameter.

[0007] Another aspect of the present invention is to provide a rotatable cutting tool for use in impinging earth strata wherein the rotatable cutting tool includes a cutting tool body and a hard tip affixed to the cutting tool body. The cutting tool body includes an axial forward end for receiving the hard tip and an axial rearward end, a head portion axially rearward of the axial forward end, a collar portion axially rearward of the head portion, and a shank portion axially rearward of the collar portion and axially forward of the axial rearward end. The head portion includes an axial forward periphery and an axial rearward periphery, wherein the head portion further includes a continuous arcuate outer surface extending from the axial forward periphery to the axial rearward periphery.

[0008] A further aspect of the present invention is to provide a rotatable cutting tool body with a central longitudinal axis wherein the rotatable cutting tool body includes a head portion, a shank portion, and a collar portion mediate of and contiguous with the head portion and shank portion. The cutting tool body further includes an axial forward end adjacent to the head portion and an axial rearward end adjacent to the shank portion. The head portion includes an axial forward periphery and an axial rearward periphery, wherein the head portion further includes a continuous arcuate outer surface extending from the axial forward periphery to the axial rearward periphery.

[0009] These and other aspects of the present invention will be more fully understood following a review of this specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 illustrates a side view of a rotatable cutting tool, in accordance with an aspect of the invention.

[0011] FIG. 2 is a forward end view of the rotatable cutting tool shown in FIG. 1 (with the hard insert removed), in accordance with an aspect of the invention.

[0012] FIG. 3 is an enlarged side view of a portion of the rotatable cutting tool shown in FIG. 1 (with the hard insert removed), in accordance with an aspect of the invention.

DETAILED DESCRIPTION

[0013] FIG. 1 illustrates a rotatable cutting tool, generally designated as 20, in accordance with an aspect of the invention. Rotatable cutting tool 20 comprises an elongate cutting tool body, generally designated as 22. The cutting tool body 22 is typically made of steel such as those grades disclosed, for example, in U.S. Pat. No. 4,886,710 to Greenfield, which is hereby incorporated by reference.

[0014] Still referring to FIG. 1, the cutting tool body 22 has an axial forward end 24 and an axial rearward end 26. A hard tip or insert 30 is affixed (such as by brazing or the like) in a
socket 31 in the axial forward end 24 of the cutting tool body 22. Hard insert 30 is typically made from cemented carbide such as, for example, cemented (cobalt) tungsten carbide wherein U.S. Pat. No. 6,375,272 to Ojanen, which is hereby incorporated by reference, discloses examples of acceptable grades of cemented (cobalt) tungsten carbide. The geometry of the hard insert 30 can vary depending upon the specific application. U.S. Pat. No. 6,375,272 to Ojanen discloses an exemplary geometry for the hard insert. It should be appreciated that as an alternative to the socket, the axial forward end of the cutting tool body may present a projection that is received within a socket in the bottom of the hard tip. This alternate structure can be along the lines of that disclosed, for example, in U.S. Pat. No. 5,141,289 to Stiffler, which is hereby incorporated by reference.

[0015] The cutting tool body 22 is divided into three principal portions; namely, a head portion, a collar portion and a shank portion. These portions will now be described.

[0016] The most axial forward portion is a head portion (see bracket 32). The head portion 32 begins at the axial forward end 24 and extends along longitudinal axis X-X in the axial rearward direction for a distance A. In one aspect of the invention, distance A is in the range of about 2.0 centimeters to about 16.0 centimeters.

[0017] The mediate portion is the collar portion (see bracket 38). Beginning at the juncture with the collar portion 32 and extending along the longitudinal axis X-X in the axial rearward direction for a distance B, the collar portion 38 comprises a tapered neck section 40 followed by a cylindrical collar section 42.

[0018] The most axial rearward portion is the shank portion (see bracket 44). Beginning at the juncture with the collar portion 38 and extending along the longitudinal axis X-X in the axial rearward direction for a distance C, the shank portion 44 comprises a beveled section 46 followed by a forward cylindrical tail section 48, followed by a retainer groove 50, followed by a rearward cylindrical tail section 52 and terminating in a beveled section 54. As is known by those skilled in the art, the shank portion 44 is the portion of the cutting tool body 22 that carries the retainer (not illustrated). The retainer rotatably retains the rotatable cutting tool in the bore of a tool holder (not illustrated) or the bore of the sleeve carried by a holder. While the retainer can take on any one of many geometries, a retainer suitable for use with this cutting tool body is shown and described, for example, in U.S. Pat. No. 4,850,649 to Beach et al., which is hereby incorporated by reference.

[0019] Referring to FIGS. 1 and 2, the head portion 32 includes an axial forward periphery 56 adjacent to the axial forward end 24 thereof. The axial forward periphery 56 defines an axial forward generally circular cross section of the head portion 32 having an axial forward diameter (labeled as FD). The axial forward diameter FD is in the range of about 0.50 centimeters to about 5.50 centimeters. Similarly, the head portion 32 includes an axial rearward periphery 58 adjacent to the collar portion 38. The axial rearward periphery 58 defines an axial rearward generally circular cross section of the head portion 32 having an axial rearward diameter (labeled as RD). The axial rearward diameter RD is in the range of about 0.60 centimeters to about 7.70 centimeters.

[0020] As shown in FIGS. 1 and 3, the head portion 32 includes a continuous arcuate outer surface 60 extending from the axial forward periphery 56 to the axial rearward periphery 58. The outer surface 60 thus has a radius of curvature, labeled as arrow RC, to provide the arcuate outer surface 60 extending from the axial forward periphery 56 to the axial rearward periphery 58. The radius of curvature RC is in the range of about 12.0 centimeters to about 130.0 centimeters.

[0021] Still referring to FIGS. 1 and 3, the diameter of the head portion 32 decreases non-linearly from the axial rearward periphery 58 to the axial forward periphery 56. In other words, the head portion 32 includes a maximum diameter at the axial rearward diameter RD thereof and the diameter of the head portion 32 decreases non-linearly to a minimum diameter at the axial forward diameter FD of the head portion. The term “non-linearly” as used herein generally refers to the changing diameter of the head portion being such that the outer surface 60 of the head portion 32 remains continuously arcuate from the axial rearward periphery 58 to the axial forward periphery 56 and that the outer surface is not straight or flat along any section thereof from the axial rearward periphery 58 to the axial forward periphery 56.

EXAMPLE

[0022] An exemplary set of dimensions for head portion 32 (wherein the head portion 32 is formed, for example, of 4140 steel that has been heat treated to have a Rockwell C hardness in the range of about 45-50) is as follows:

<table>
<thead>
<tr>
<th>Distance L (centimeters)</th>
<th>Diameter d (centimeters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.635</td>
<td>1.2127738</td>
</tr>
<tr>
<td>1.27</td>
<td>2.52023504</td>
</tr>
<tr>
<td>1.905</td>
<td>2.8609872</td>
</tr>
<tr>
<td>2.54</td>
<td>2.074790</td>
</tr>
<tr>
<td>3.175</td>
<td>2.249796</td>
</tr>
<tr>
<td>3.81</td>
<td>2.4019255</td>
</tr>
<tr>
<td>4.445</td>
<td>2.53746</td>
</tr>
<tr>
<td>5.08</td>
<td>2.6602944</td>
</tr>
<tr>
<td>5.715</td>
<td>2.7729482</td>
</tr>
<tr>
<td>6.35</td>
<td>2.877439</td>
</tr>
</tbody>
</table>

Where:

[0023] L = Distance from axial forward end 24 to point of calculated diameter d (see FIG. 3)

[0024] d = Diameter of head portion 32 at distance L (see FIG. 3)

[0025] The dimensions set forth in Table 1 were calculated using the following equations:

Maximum Nominal Tensile Stress

\[ \sigma_t = \frac{1.2723}{d^2} \left( \frac{8LF_v}{d} - F_r \right) \]

Maximum Nominal Compressive Stress

\[ \sigma_c = \frac{1.2723}{d^2} \left( \frac{8LF_v}{d} + F_r \right) \]
Maximum Nominal Shear Stress

\[ \tau_\text{Nom} = 0.5 \sigma_\text{m} \]

where \( \tau_\text{Nom} \) is the maximum nominal shear stress and \( \sigma_\text{m} \) is the maximum allowable stress.

7. The rotatable cutting tool of claim 6, wherein the continuous arcuate outer surface has a radius of curvature in the range of about 12.0 centimeters to about 130.0 centimeters.

8. The rotatable cutting tool of claim 1, wherein the head portion has an axial length in the range of about 2.0 centimeters to about 16.0 centimeters.

9. A rotatable cutting tool for use in impinging earth strata, the rotatable cutting tool comprising:
   - a cutting tool body;
   - a hard tip affixed to the cutting tool body;
   - the cutting tool body having an axial forward end for receiving the hard tip and an axial rearward end, a head portion axially rearward of the axial rearward end, a collar portion axially rearward of the head portion, a collar portion axially rearward of the collar portion and a shank portion axially rearward of the collar portion and axially forward of the axial rearward end; and wherein the head portion includes an axial forward generally circular cross section having an axial forward diameter and an axial rearward generally circular cross section having an axial rearward diameter, wherein the diameter of the head portion decreases non-linearly from the axial rearward diameter to the axial forward diameter.

10. The rotatable cutting tool of claim 9, wherein the continuous arcuate outer surface has a radius of curvature in the range of about 12.0 centimeters to about 130.0 centimeters.

11. The rotatable cutting tool of claim 9, wherein the head portion has an axial length in the range of about 2.0 centimeters to about 16.0 centimeters.

12. The rotatable cutting tool of claim 9, wherein a diameter of the head portion decreases non-linearly from the axial rearward periphery to the axial forward periphery.

13. A rotatable cutting tool body with a central longitudinal axis, the rotatable cutting tool body comprising:
   - a head portion, a shank portion, and a collar portion mediate of and contiguous with the head portion and the shank portion;
   - an axial forward end adjacent to the head portion and an axial rearward end adjacent to the shank portion;
   - wherein the head portion includes an axial forward peripheral and an axial rearward peripheral, wherein the head portion further includes a continuous arcuate outer surface extending from the axial forward peripheral to the axial rearward periphery.

14. The rotatable cutting tool body of claim 13, wherein the continuous arcuate outer surface has a radius of curvature in the range of about 12.0 centimeters to about 130.0 centimeters.

15. The rotatable cutting tool body of claim 13, wherein the head portion has an axial length in the range of about 2.0 centimeters to about 16.0 centimeters.

16. The rotatable cutting tool body of claim 13, wherein a diameter of the head portion decreases non-linearly from the axial rearward periphery to the axial forward periphery.

17. The rotatable cutting tool body of claim 13, wherein the head portion includes an axial forward generally circular cross section having an axial forward diameter and an axial rearward generally circular cross section having an axial rearward diameter, wherein the diameter of the head portion decreases non-linearly from the axial rearward diameter to the axial forward diameter.

18. The rotatable cutting tool body of claim 17, wherein the axial forward diameter is in the range of about 0.50 centimeters to about 5.50 centimeters.
19. The rotatable cutting tool body of claim 17, wherein the axial rearward diameter is in the range of about 0.60 centimeters to about 7.70 centimeters.

20. A rotatable cutting tool body with a central longitudinal axis, the rotatable cutting tool body comprising:
   a head portion, a shank portion, and a collar portion mediate of and contiguous with the head portion and the shank portion;
   an axial forward end adjacent to the head portion and an axial rearward end adjacent to the shank portion;
   wherein the head portion includes an axial forward generally circular cross section having an axial forward diameter and an axial rearward generally circular cross section having an axial rearward diameter, wherein the diameter of the head portion decreases non-linearly from the axial rearward diameter to the axial forward diameter.

21. The rotatable cutting tool body of claim 20, wherein the axial forward diameter is in the range of about 0.50 centimeters to about 5.50 centimeters.

22. The rotatable cutting tool body of claim 20, wherein the axial rearward diameter is in the range of about 0.60 centimeters to about 7.70 centimeters.

***