

TITLE

CUTTING TOOLS AND CUTTING INSERTS
INCLUDING INTERNAL COOLING

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BACKGROUND OF THE TECHNOLOGY

FIELD OF THE TECHNOLOGY

[0001] The present disclosure relates to cutting tools and cutting inserts for machining metallic materials.

DESCRIPTION OF THE BACKGROUND OF THE TECHNOLOGY

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[0002] As used herein, the term "metal cutting" broadly refers to machining, turning, milling, drilling, boring, planing, shaping, reaming, and like material removal operations performed on metallic (*i.e.*, metal and metal alloy) materials. Cutting tools used in metal cutting typically are subjected to high loads and high temperatures. During metal cutting, the cutting tool applies a high load to the metallic workpiece to deform the workpiece. Because of the relative motion of the workpiece and the cutting edge of the cutting tool, shear deformation is produced in the metallic workpiece, generating metal chips from the workpiece. A cutting tool tip or cutting insert will generally include a rake face, which is a portion of the tip or insert that encounters and further deforms chips after the chips are formed at the cutting edge of the tip or insert.

20 Cutting inserts may also include additional features that control chip size and shape. The chips produced in metal cutting are hot from deformation and frictional forces and are in close contact for a time with the cutting tip or cutting insert.

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[0003] Because cutting inserts experience high loads and frictional contact with the workpiece and the machined chips, the cutting insert, and particularly the insert's

cutting edge, is heated to very high temperatures. For example, cemented carbide cutting inserts may be heated to temperatures greater than 1,800°F (982°C) during cutting of hard steels. High cutting insert temperatures increase wear during metal cutting and, thus, reduce cutting insert service life. Machine tool operators can reduce tool speed to at least partially counteract high temperature-induced cutting insert wear. Reducing tool speed, however, may adversely affect the finish quality of machined surfaces produced on a metallic workpiece. Instead, a coolant is typically used to cool the cutting edge of a cutting insert during metal cutting.

[0004] Metal cutting coolants, which are also referred to as cutting fluids, serve to lubricate the workpiece and reduce frictional forces at low cutting speeds. At higher cutting speeds, coolants predominantly act to cool the workpiece and the cutting insert, and assist in flushing chips away from the cutting insert. The use of coolants in metal cutting significantly increases cutting insert service life, reduces unintended deformation of the workpiece, improves surface finish quality, and enhances chip removal and handling.

[0005] Traditionally, coolants are fed from an external source to the region of the interface between the cutting edge of a cutting insert and the workpiece. For example, a flow of coolant may be flooded onto both the workpiece and cutting insert through tubing from an external coolant source. Another method of applying coolant to the cutting edge/workpiece interface region is to direct a jet of coolant at the interface region. Still another method of applying coolant involves misting a coolant with an air jet and directing the mist at the cutting edge/workpiece interface region.

[0006] Conventional methods of applying coolants to a cutting edge/workpiece interface region are inefficient. For example, an excess amount of expensive coolant typically is applied during metal cutting to better ensure that coolant will contact the interface region and remove heat from the cutting insert's cutting edge. However, although excess coolant is applied, because of the tight tolerances at the interface region and the continuous generation of chips at the interface, less than an optimal amount of coolant is delivered to the interface region to efficiently and effectively reduce the temperature of the cutting insert's cutting edge. As such, the operating temperature

of the cutting insert's cutting edge may remain very high, reducing cutting insert service life.

[0007] Accordingly, a need exists for an improved arrangement for reducing the temperature of the cutting edge of a metal cutting insert during cutting operations.

- 5 In particular, a need exists for an improved system to deliver coolant to the cutting edge/workpiece interface during cutting operations.

SUMMARY

- 10 [0008] An aspect according to the present disclosure is directed to a cutting insert comprising at least one cutting edge and at least one fastener bore adapted to accept a fastener for removably securing the cutting insert to a tool holder. The fastener bore includes at least one coolant flow recess adapted to direct a coolant through the coolant flow recess and toward the at least one cutting edge when the cutting insert is secured to the tool holder by a fastener.

- 15 [0009] An additional aspect according to the present disclosure is directed to a cutting tool comprising a cutting insert, a tool holder, and a fastener. The cutting insert comprises at least one cutting edge and at least one fastener bore adapted to accept a fastener for removably securing the cutting insert to the tool holder. The at least one fastener bore includes at least one coolant flow recess adapted to direct a coolant
20 through the coolant flow recess and toward a head portion of the fastener when the cutting insert is secured to the tool holder by the fastener. The tool holder comprises at least one insert pocket adapted to accept the cutting insert and allow the cutting insert to be secured to the tool holder by the fastener. The tool holder further comprises at least one coolant bore adapted to direct coolant from the tool holder to the at least one
25 coolant flow recess of the fastener bore. The head portion of the fastener and the coolant flow recess of the fastener bore define a gap that directs coolant toward the cutting edge of the cutting insert.

[0010] An additional aspect according to the present disclosure is directed to a cutting insert including an internal coolant system, wherein the cutting insert comprises at least one cutting edge, at least one fastener bore adapted to accept a fastener for removably fastening the cutting insert to a tool holder, and at least one through cavity positioned adjacent to the fastener bore. The at least one through cavity extends from a top face of the cutting insert to a bottom face of the cutting insert and is adapted to direct a coolant fluid through the cutting insert and toward the at least one cutting edge when the cutting insert is fastened to a tool holder by a fastener.

[0011] Yet an additional aspect according to the present disclosure is directed to a cutting tool comprising a cutting insert, a tool holder, and a fastener. The cutting insert comprises at least one cutting edge, at least one fastener bore adapted to accept a fastener for removably fastening the cutting insert to the tool holder, and at least one through cavity adapted to direct a coolant through the cutting insert and toward a head portion of the fastener when the cutting insert is fastened to the tool holder by the fastener. The tool holder comprises at least one coolant bore adapted to direct a coolant from the tool holder to the at least one through cavity of the cutting insert. The head portion of the fastener and the at least one through cavity of the cutting insert define a gap that directs coolant to the at least one cutting edge of the cutting insert.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The features and advantages of methods described herein may be better understood by reference to the accompanying drawings in which:

[0013] Figure 1(a) is a schematic top view of a non-limiting embodiment of a double-sided milling cutting insert according to the present disclosure including four coolant flow recesses;

[0014] Figure 1(b) is a schematic top view of a non-limiting embodiment of the double-sided milling cutting insert of Figure 1(a) and a fastener according to the present disclosure;

[0015] Figure 1(c) is a schematic cross-section of a non-limiting embodiment of a cutting insert, a fastener, and a portion of a tool holder according to the present disclosure, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion of the fastener;

5 [0016] Figures 2(a) and 2(b) are a schematic side view and a schematic end view, respectively, of a non-limiting embodiment of a cutting (milling) tool according to the present disclosure, showing multiple cutting inserts secured in the holder of the cutting tool with multiple fasteners;

10 [0017] Figure 3(a) is a schematic top view of a non-limiting embodiment of a double-sided milling cutting insert according to the present disclosure including three coolant flow recesses;

[0018] Figure 3(b) is a schematic top view of the double-sided milling cutting insert of Figure 3(a) and a fastener according to the present disclosure;

15 [0019] Figure 3(c) is a schematic cross-section of a non-limiting embodiment of a cutting insert, a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion of the fastener;

[0020] Figure 4(a) is a schematic top view of a non-limiting embodiment of a double-sided milling cutting insert according to the present disclosure, including three coolant flow recesses, and including multiple coolant flow recess segments;

20 [0021] Figure 4(b) is a schematic top view of the double-sided milling cutting insert of Figure 4(a) and a fastener according to the present disclosure;

[0022] Figure 4(c) is a schematic cross-section of a non-limiting embodiment of a cutting insert, and a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion;

25 [0023] Figure 5(a) is a schematic top view of a non-limiting embodiment of a single-sided milling cutting insert according to the present disclosure including four coolant flow recesses;

[0024] Figure 5(b) is a schematic top view of the single-sided milling cutting insert of Figure 5(a) and a fastener according to the present disclosure;

[0025] Figure 5(c) is a schematic cross-section of a non-limiting embodiment of a cutting insert, and a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion;

[0026] Figure 6(a) is a schematic top view of a non-limiting embodiment of a single-sided cutting insert for boring operations according to the present disclosure including four coolant flow recesses;

[0027] Figure 6(b) is a schematic top view of the single-sided cutting insert of Figure 6(a) and a fastener according to the present disclosure;

[0028] Figure 6(c) is a schematic folded section of a non-limiting embodiment of a cutting insert for boring operations, and a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion of the fastener;

[0029] Figures 7(a) through 7(d) are schematic representations of a cutting tool system comprising a boring tool holder, a boring cutting insert, and a fastener according to Figures 6(a) through 6(c);

[0030] Figure 8(a) is a schematic top view of a non-limiting embodiment of a double-sided turning cutting insert for turning operations according to the present disclosure including four coolant flow recesses;

[0031] Figure 8(b) is a schematic top view of a non-limiting embodiment of the double-sided turning cutting insert of Figure 8(a) and a fastener according to the present disclosure;

[0032] Figure 8(c) is a schematic folded section of a non-limiting embodiment of a cutting insert for turning operations, and a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion of the fastener;

[0033] Figures 9(a) through 9(d) are schematic views of a non-limiting embodiment of a cutting tool system comprising a turning tool holder, a turning cutting insert, and a fastener according to Figures 8(a) through 8(c);

5 [0034] Figure 10(a) is a schematic top view of a non-limiting embodiment of a double-sided drilling cutting insert for drilling operations according to the present disclosure including four coolant flow recesses;

[0035] Figure 10(b) is a schematic top view of the double-sided drilling cutting insert for drilling operations of Figure 10(a) and a fastener according to the present disclosure;

10 [0036] Figure 10(c) is a schematic folded section of a non-limiting embodiment of a cutting insert for drilling operations, and a fastener, revealing coolant flow recesses in the fastener bore of the cutting insert and coolant flow guided by a head portion of the fastener;

15 [0037] Figures 11(a) through 11(d) are schematic views of a non-limiting embodiment of an internal coolant system according to the present disclosure adapted for general machining operations;

[0038] Figure 12(a) is a schematic top view of a non-limiting embodiment of a cutting insert according to the present disclosure adapted for general machining operations and including four through cavities;

20 [0039] Figure 12(b) is a schematic top view of the cutting insert of Figure 12(a) and a fastener according to the present disclosure; and

[0040] Figure 12(c) is a schematic folded section of a non-limiting embodiment of a cutting insert for general machining operations, a fastener, and a portion of a tool holder according to the present disclosure, revealing through cavities in the cutting
25 insert and coolant flow guided by a head portion of the fastener.

[0041] The reader will appreciate the foregoing details, as well as others, upon considering the following detailed description of certain non-limiting embodiments of cutting tools, tool holders, and cutting inserts according to the present disclosure.

DETAILED DESCRIPTION OF CERTAIN NON-LIMITING EMBODIMENTS

[0042] In the present description of non-limiting embodiments, other than in the operating examples or where otherwise indicated, all numbers expressing quantities or characteristics are to be understood as being modified in all instances by the term “about”. Accordingly, unless indicated to the contrary, any numerical parameters set forth in the following description are approximations that may vary depending on the desired properties one seeks to obtain in the cutting tools, tool holders, and cutting inserts according to the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0043] Any patent, publication, or other disclosure material that is said to be incorporated, in whole or in part, by reference herein is incorporated herein only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material set forth in the present disclosure. As such, and to the extent necessary, the disclosure as set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein is only incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

[0044] A non-limiting aspect according to the present disclosure is directed to an improved cutting insert that is adapted to internally channel, divert, and/or direct a coolant (*i.e.*, a cutting fluid) through the cutting insert and toward a cutting edge of the cutting insert. By internally directing coolant to the cutting edge, the ability to remove heat from the cutting edge is improved. The improvement in removing heat from the cutting edge made possible by the present invention reduces the quantity of coolant needed during metal cutting, may allow for increased cutting speeds, reduces frictional heating, and increases the service life of cutting inserts.

[0045] Figure 1(a) is a schematic top view of a non-limiting embodiment of a double-sided milling cutting insert 10 according to the present disclosure including four coolant flow recess 11 provided by removing material from a wall of the fastener bore 12 of the cutting insert 10. The center point of the fastener bore 12 is identified as point "O". Figure 1(b) is a schematic top view of the double-sided milling cutting insert 10 shown in Figure 1(a) and with a fastener 13 disposed in the fastener bore 12 of the cutting insert to secure the cutting insert 10 on a milling tool holder (not shown in Figure 1(b)). Figure 1(c) is a sectional view taken at line E-E in Figure 1(b) (center line 14), which passes along the longitudinal axis of fastener 13, showing the cutting insert 10 on a milling tool holder 15 including internal coolant bore 16. The flow of coolant is depicted by the series of arrows 17. The coolant flow 17 passes through the tool holder 15, and emerges from coolant bore 16, passes through the cutting insert 10, and is guided by the head portion 19 of the fastener 13 towards the cutting edge 20 of the cutting insert 10 that is positioned to contact a workpiece during the milling operation.

[0046] As can be seen from Figures 1(a) through 1(c), cutting insert 10 comprises at least one fastener bore 12 adapted to accept a fastener 13. The fastener 13 removably secures the cutting insert 10 to tool holder 15. Fastener bore 12 comprises a plurality of coolant flow recesses 11 in the fastener bore 12, extending axially along the fastener bore 12. The coolant flow recesses 11 are adapted to direct a coolant along the coolant flow recesses 11 and the fastener 13 and toward at least one cutting edge 20 of the cutting insert 10 when the cutting insert 10 is secured to a tool holder by a fastener 13 disposed through the fastener bore 12.

[0047] The coolant flow recesses 11 may be formed by cutting or otherwise removing material from the original wall or surface 23 of the fastener bore 12.

Alternatively, the coolant flow recesses 11 may be built into the tooling dies and created when the cutting insert 10 is pressed in a mold or extruded in an injection machine.. The coolant flow recesses 11 extend from the top face 21 of the cutting insert 10 to the bottom face 22 of the cutting insert 10. The fastener 13 is in physical contact with the cutting insert 10 at the remaining regions of the fastener bore surface 23 and secures the cutting insert 10 to the tool holder 15. In non-limiting embodiments, the cutting

insert 10 includes a chamfer 24 (see detail portion of Figure 1(c)) at the top face 21 and/or at the bottom face 22. In non-limiting embodiments, the profile 25 of a coolant flow recess 11 may be of any geometry, including, but not limited to a portion of circle, a portion of an ellipse, a line, a curve, a spline, a polygon, or any combination of these geometries.

[0048] As shown in Figure 1(c), the fastener 13 serves a function in addition to securing the cutting insert 10 in the fastener bore 12 and to the tool holder 15. In particular, the fastener 13 guides or directs the coolant flow 17 to the active cutting edge 20 in action. As used herein, a cutting edge that is "active" is oriented on a tool holder so that the cutting edge contacts a workpiece during machining operations. Again referring to the detail portion of Figure 1(c), a bottom face 26 of the head portion 19 and the top edge 28 of the fastener bore 12 define a peripheral gap 29. Coolant flows through the gap 29 and is directed towards the active cutting edge 20. The peripheral gap 29 functions as a coolant outlet that is defined between the bottom face 26 of the head portion 19 and the top portion of the fastener bore 12, including the top edge 28 and chamfer 24.

[0049] The peripheral gap 29 may be specifically shaped to account for the type and configuration of the cutting insert 10. For example, the bottom face 26 of the head portion 19 may be parallel to a flat plateau 27 on the top face 21 of a cutting insert. Such a design is advantageous if the cutting edge of the cutting insert and the top edge of the fastener bore are at about the same level (when the cutting insert is in an orientation as shown in Figure 1(c)). Alternatively, for example, the bottom face 26 of the head portion 19 may be angled downwardly with respect to a flat plateau 27 on the top face 21 of a cutting insert in designs wherein the cutting edge is below the top edge of the fastener bore (when the cutting insert is in an orientation as shown in Figure 1(c)). According to another alternative, for example, the bottom face 26 of the head portion 19 may be angled upwardly with respect to a flat plateau 27 on the top face 21 of the cutting insert in designs wherein the cutting edge is generally above the top edge of the fastener bore, which is the specific design shown in the non-limiting embodiment of Figure 1(c).

[0050] As described hereinabove and shown in Figures 1(a) through 1(c), in a non-limiting embodiment of the present disclosure, an internal coolant system for cutting inserts comprises a cutting insert 10, a fastener 13, and a tool holder 15. The wall of the fastener bore 12 is partially cut out to form multiple coolant flow recesses 11. A bottom face 26 of the head portion 19 of the fastener 13 has a predetermined geometrical relationship with the top edge 28 and chamfer 24 of the fastener bore 12 when the fastener 13 is positioned to secure the cutting insert 10 in the fastener bore 12 and tool holder 15, thereby providing a gap 29. A coolant flow recess 11 and a gap 29 provide a channel for coolant to flow from one or more internal coolant bores 16 in the tool holder 15 to the interface between the fastener bore 12 and the fastener 13. The bottom face 26 of the head portion 19 may be specifically designed to account for the type and configuration of the cutting insert 10 to thereby specifically direct the coolant flow 17 to the active cutting edge 20 along the shortest possible distance. The non-limiting embodiments of internal coolant systems for cutting inserts described herein are unique, yet simple in design, effective, and economical. The fastener 13 provides the dual functions of (i) securing the cutting insert 10 to the tool holder 15; and (ii) guiding, channeling, and/or directing coolant precisely toward the active cutting edge 20.

[0051] In the non-limiting embodiment of a cutting insert depicted as cutting insert 10 in Figures 1(a) through 1(c), the cutting insert 10 includes four cutting edges 20. However, it is within the scope of the present disclosure to provide a cutting insert 10 having any number of cutting edges 20 (for example, a round insert with a single cutting edge, or cutting inserts with three, five, or more cutting edges) with the improved coolant delivery features described herein. Further, in the non-limiting embodiment depicted in Figures 1(a) through 1(c), the at least one fastener bore 12 is centrally positioned on a side of cutting insert 10. However, it is within the scope of the present disclosure that the fastener bore is not centrally positioned, but rather is in any other suitable position on the cutting insert and/or that the cutting insert may include more than one fastener bore. In a non-limiting embodiment, the fastener 13 is threadedly received in the tool holder 15.

[0052] Optionally, the cutting insert 10, along with other embodiments of cutting inserts according to the present disclosure, may comprise one or more rake faces and chip control features, and any other cutting insert features known to a person having ordinary skill in the art. Such features are conventional and are known to those having ordinary skill in the art. Thus, they are not further discussed herein.

[0053] Cutting insert 10 may be made from any material suitable for the cutting operations for which the insert 10 is intended. In certain non-limiting embodiments, the cutting insert 10, along with other embodiments of cutting inserts according to the present disclosure, is manufactured from one or more materials selected from high speed steel, cobalt alloys, cemented carbides, cermets, ceramics, diamond, and polycrystalline diamond. In various embodiments of cutting inserts according to the present disclosure, the cutting inserts comprise any material known to a person skilled in the art that is used now or hereinafter for the manufacture of cutting inserts.

[0054] In certain non-limiting embodiments, the cutting insert 10, along with other embodiments of cutting inserts according to the present disclosure, comprises a wear coating, which may be a wear coating composed of single or multiple layers. Examples of non-limiting embodiments of possible wear coatings include one or more of titanium nitride, titanium carbide, aluminum oxide, silicon nitride, and zirconium oxide. In various embodiments of cutting inserts according to the present disclosure, the cutting inserts include coatings of any suitable materials known to a person skilled in the art that is used now or hereinafter for wear coatings on cutting inserts.

[0055] According to a non-limiting aspect of the present disclosure, a cutting tool including an internal coolant system comprises: a cutting insert including at least one internal coolant flow recess adapted to channel, divert, and/or direct a coolant (*i.e.*, a cutting fluid) toward at least one active cutting edge of the cutting insert; a tool body adapted to pass coolant through the tool body and into at least one of the internal coolant flow recesses of the cutting insert, and then on to or towards at least one active cutting edge of the cutting insert. By internally directing coolant to the cutting edge, smaller quantities of coolant are required for metal cutting, cutting speeds may be increased, and frictional heating is reduced, resulting in longer cutting insert life.

[0056] Figure 2(a) depicts a side view of a non-limiting embodiment of a cutting tool 40 according to the present disclosure, and Figure 2(b) depicts a front-end view of the cutting tool 40. The cutting tool 40 comprises: a milling tool holder 41 including a coolant delivery system that is substantially similar in design to the system shown in Figure 1(c); five indexable cutting inserts 42a through 42e, which are substantially similar in design to the cutting insert 10 described above and shown in Figures 1(a) through 1(c); and five fasteners 43a through 43e, which are substantially similar in design to fastener 13 described above and shown in Figures 1(b) and 1(c). In a non-limiting embodiment the fasteners 43a through 43e are threadedly received in the tool holder 41.

[0057] Figures 3(a) through 3(c) illustrate another non-limiting embodiment of a double-sided milling cutting insert 50 including an internal coolant system according to the present disclosure. Figure 3(a) depicts a top view of the cutting insert 50 including three coolant flow recesses 51 formed along a wall of the fastener bore 52. Figure 3(b) depicts a top view of the cutting insert 50 and further depicts a fastener 53 disposed in the fastener bore 52. Figure 3(c) depicts a sectioned view of cutting insert 50 and fastener 52 taken along line P-P (also identified as line 54) in Figure 3(b). The sectioned view of Figure 3(c) illustrates coolant flow 55 from the tool holder (not shown) and through the coolant passage channel 56 defined between a coolant flow recess 51 of the cutting insert 50 and the fastener 53. A peripheral gap 61 that serves as a coolant outlet is defined between the top portion 62 of the fastener bore 52 and the bottom face 63 of the head portion 64 of the fastener 53. The bottom face 63 is specifically shaped to account for the type and configuration of the cutting insert 50 and thereby direct the coolant flow 55 precisely toward the cutting edge 65.

[0058] Figures 4(a) through 4(c) depict another non-limiting embodiment of a double-sided milling cutting insert including an internal coolant system according to the present disclosure. Figure 4(a) depicts a top view of the cutting insert 70, which includes three coolant flow recesses 71 defined along a wall of the fastener bore 72. Figure 4(b) depicts a top view of cutting insert 70 and further depicts a fastener 73 disposed in the fastener bore 72. Figure 4(c) is a sectional view of the cutting insert 70

and fastener 73 taken along line R-R (also identified as line 75) in Figure 4(b). The cutting insert 70 is similar to the cutting insert 50 shown in Figures 3(a) through 3(c), but, as shown in Figure 4(c), each coolant flow recess 71 of cutting insert 70 comprises multiple segments 71a, 71b and 71c. In the embodiment shown in Figure 4(c), segment 71a forms an angle of less than 90° with the axis 77 of the fastener 73, segment 71b is substantially parallel to the axis 77 of the fastener 73, and segment 71c also forms an angle of less than 90° with the axis 77 of the fastener 73. Figure 4(c) also indicates coolant flow 78 through the cutting insert 70, which is directed toward a cutting edge of the cutting insert 70 by a gap defined between a head portion of the fastener 73 and the cutting insert 70.

[0059] Figures 5(a) through 5(c) illustrate a non-limiting embodiment of a single-sided milling cutting insert including an internal coolant system according to the present disclosure. Figure 5(a) is a top view of the cutting insert 80 including four recesses 81 along the wall of the fastener bore 82. Figure 5(b) is a top view of the cutting insert 80 and further depicts a fastener 83 disposed in the fastener bore 82. Figure 5(c) is a sectional view of the cutting insert 80 and fastener 83 taken along line A-A (also identified as line 85) in Figure 5(b). As shown in the detail section of Figure 5(c), a peripheral gap 91 that functions as a coolant outlet is defined between a top portion 92 of the fastener bore 82 and the bottom face 93 of the head portion 94 of the fastener 83. The bottom face 93 is specifically shaped to interact with the top portion 92 of the fastener bore 82 and direct coolant flow 95 precisely towards cutting edge 96.

[0060] Figures 6(a) through 6(c) illustrate a non-limiting embodiment of a single-sided boring cutting insert including an internal coolant system according to the present disclosure. Figure 6(a) depicts a top view of the cutting insert 100 including four coolant flow recesses 101 along the wall of the fastener bore 102. Figure 6(b) is a top view of the cutting insert 100 and further depicts a fastener 103 disposed in the fastener bore 102. Figure 6(c) is a sectional view taken along B-B in Figure 6(b) (i.e., the folded section line 105), which passes through a coolant flow recess 101 at point N1, changes direction at the center point of the cutting insert 100, and passes through the original fastener bore periphery 106 at point N2 (see Figure 6(a)). A peripheral gap 111 that

functions as a coolant outlet is defined between a top portion 112 of fastener bore 102 and a bottom face 113 of a head portion 114 of the fastener 103. The bottom face 113 is specifically shaped so that the coolant flow 115 is directed precisely towards the active cutting edge 116.

5 **[0061]** Figures 7(a) through 7(d) depict a non-limiting embodiment of a boring tool according to the present disclosure, wherein the boring tool 120 comprises a boring tool holder 121, a boring cutting insert 100 as presented in Figures 6(a) through 6(c), and a fastener 103 as shown in Figures 6(b) and 6(c). Figure 7(a) is a perspective view of a working end of the cutting tool 120, with coolant flow 125 emerging between the
10 fastener 103 and the cutting insert 100. Figure 7(b) is a top view of a working end of the cutting tool 120 with coolant flow 125 emerging from between the fastener 103 and the cutting insert 100. Figure 7(c) is a top view of the tool holder 121 (with the cutting insert 100 and the fastener 103 removed) showing internal coolant bores 122, 123, and 124 formed in the tool holder 121. Figure 7(d) is a top view of the tool holder 121 and the
15 cutting insert 100 showing the positional relationship between a coolant flow recess 101 and the fastener bore 122. As indicated in Figure 7(c), coolant passes through bore 124 along the length of the tool holder 121, passes into bore 123, and emerges from bore 122 positioned on a surface of the insert pocket of the tool holder 121. As indicated in Figures 7(a), 7(b), and 7(d), coolant emerging from bore 122 passes
20 through the interior of cutting insert 100 and emerges from a gap defined between the cutting insert 120 and the fastener 103 as coolant flow 125. In this way, coolant may be fed axially through the tool holder 121, introduced into the interior of the cutting insert 100, and directed towards a cutting edge of the cutting insert 100.

[0062] Figures 8(a) through 8(c) illustrate a non-limiting embodiment of a
25 turning cutting insert 130 including an internal coolant system according to the present disclosure. Figure 8(a) is a top view of the cutting insert 130 including four coolant flow recesses 131 formed along the wall of the fastener bore 132. Figure 8(b) is a top view of cutting insert 130 and further depicts a fastener 133 disposed in the fastener bore 132. Figure 8(c) is a sectional view taken along C-C in Figure 8(b) (i.e., the folded
30 section line 135), which passes through a coolant flow recess 131 at point M2, changes

direction at the center point of the cutting insert 130, and passes through the original fastener bore periphery 134 at point M1 (see Figure 8(a)). As shown in the detail section of Figure 8(c), a peripheral gap 141 that functions as a coolant outlet is defined between the top portion 142 of the fastener bore 132 and the bottom face 143 of the head portion 144 of fastener 133. The bottom face 143 is specifically shaped to account for the type and configuration of the cutting insert 130 and direct the coolant flow 145 precisely towards the active cutting edge 146 of cutting insert 130. Contact between original fastener bore periphery 134 at M1 and the fastener 133 partially secures the fastener to an insert pocket of a tool holder.

[0063] Figures 9(a) through 9(d) show a non-limiting embodiment of a cutting tool according to the present disclosure. Turning tool 150 comprises a turning tool holder 151, a turning cutting insert 130 as described in Figures 8(a) through 8(c), and a fastener 133 as described in Figures 8(b) and 8(c). Figure 9(a) is a perspective view of the cutting tool 150, and Figure 9(b) is a top view of a working end of the cutting tool 150, wherein both figures show coolant flow 159 directed from a peripheral gap 141 that functions as a coolant outlet and is defined between the head portion 144 of the fastener 133 and the cutting insert 130 (see Figure 8(c)). Figure 9(c) is a top view of the tool holder 151, with the cutting insert 130 and the fastener 133 removed, showing internal coolant bores 152, 153, 154, 155, and 156. Figure 9(d) is a top view showing the tool holder 151 and the cutting insert 150 and indicating the positional relationship between one of the coolant flow recesses 131 (see Figure 8) and coolant bore 152 which is perpendicular to the pocket seat face 157. The ends of the internal coolant bores 153, 154 and 155 may be blocked by set screws (not shown), to prevent flow of coolant from the bores.

[0064] Figures 10(a) through 10(c) illustrate another non-limiting embodiment of a drilling cutting insert 160 including an internal coolant system according to the present disclosure. Figure 10(a) is a top view of the cutting insert 160 including four coolant flow recesses 161 along the wall of the fastener bore 162. Figure 10(b) is a top view of cutting insert 160 and further depicts a fastener 163 disposed in the fastener bore 162. Figure 10(c) is a sectional view taken along H-H in Figure 10(b) (i.e., the

folded section line 165), which passes through a coolant flow recess 161 at point L2, changes direction at the center point of the cutting insert 160, and passes through the original fastener bore periphery 164 at point L1 (see Figure 10(a)). As shown in the detail portion of Figure 10(c), a peripheral gap 171 that functions as a coolant outlet is defined between the top portion 172 of the fastener bore 162 and the bottom face 173 of the head portion 174 of the fastener 163. The bottom face 173 is specifically shaped to account for the type and configuration of the cutting insert 160 so that the coolant flow 175 is directed precisely towards the active cutting edge 176.

[0065] Further, as shown in Figure 10(a) and Figure 10(c), each coolant flow recess 161 comprises multiple segments 161a and 161b, wherein segment 161a defines an angle with the axis 177 of the fastener 163, while segment 161b defines an angle in the opposite direction with the axis 177 of the fastener 163.

[0066] Figures 11(a) through 11(d) show a non-limiting embodiment of a drilling tool 180 according to the present disclosure comprising a drilling tool holder 181, two drilling cutting inserts 182 and 183 (with the drilling insert 182 as a peripheral insert and the drilling insert 183 as a center insert), and two fasteners identical to fastener 163 shown in Figure 10(c). The geometry and shape of the coolant flow recesses of both drilling cutting inserts 182 and 183 are the same as those of the drilling cutting insert 160 described in regards to Figures 10(a) through 10 (c). Each of the drilling cutting inserts 182 and 183 are secured by a fastener 163 threadedly received in a fastener bore in each cutting insert. Figure 11(a) is a perspective view of the drilling tool 180, and Figure 11(b) is a top view of the drilling tool 180. Figure 11(c) is a top view of the tool holder 181 (wherein the pocket seat face 197 for seating the peripheral drilling insert 182 faces out of the page) showing internal coolant bores 190 through 196 passing through the tool holder 181 and exiting on the pocket seat faces. Figure 11(d) is a bottom view of the tool holder 181 (wherein the pocket seat face 198 for seating the center drilling insert 183 faces out of the page) showing internal coolant bores 190 through 196 passing through the tool holder 181 and exiting on the pocket seat faces. As can be seen from Figure 11(c) and Figure 11(d), two coolant bores 195 and 196 (internally connected by coolant bore 194 from the pocket seat 198 of the tool holder

181) exit on the pocket seat for the center drill insert 183 and, therefore, two coolant flows 186 and 187 are directed toward cutting edges of the center drill insert. Only one coolant bore 193 exits on pocket seat 197 supporting the peripheral drill insert 182 and, therefore, only a single coolant flow 185 is directed to a cutting edge of the peripheral drill insert. However, if desired, the tool holder 180 can be easily modified to provide coolant flows from two or more coolant outlets to the peripheral drill insert 182.

[0067] Figures 12(a) through 12(c) illustrate another non-limiting embodiment of a cutting insert including an internal coolant system and adapted for general machining operations according to this disclosure. Figure 12(a) is a top view of cutting insert 210 including four through cavities 211 extending from top face 214 to bottom face 216 of the cutting insert 210 adjacent fastener bore 212. Figure 12(b) is a top view of cutting insert 210 including a fastener 213 through fastener bore 212. Figure 12(c) is a sectional view taken along V-V in Figure 12(b) (i.e., the folded section line 215), which passes through a through cavity 211, changes direction at the center point of the cutting insert 210, and passes through a section of the cutting insert 210 that does not include a through cavity 211. Further, each through cavity 211 includes a pair of side extrusions 217 flanking each through cavity 211 on both top and bottom faces 214, 216, and with function as side blocks to limit coolant flow 225. A gap 221, which functions as a coolant outlet 221, is defined between the top portion 222 of a through cavity 211 and a bottom face 223 of a head portion 224 of the fastener 213. The bottom face 223 is specifically shaped to account for the type and configuration of the cutting insert 210 so that the coolant flow 225 is directed precisely towards an active cutting edge 226. Further, the side extrusions 217 on the cutting insert 210 define a small gap with the bottom face 223 of the head portion 224 once secured on a tool holder by the fastener 213. In certain non-limiting embodiments, the through cavities 211 are drilled (in the case of being a cylindrical hole) prior to furnace sintering the cutting insert 210. Alternatively, and without limitation, the through cavities may be built into the tooling dies and created when the cutting insert 210 is pressed in a mold or extruded in a powder injection machine. The through cavities 211 may have any suitable geometry

including, but not limited to, a circle, an ellipse, lines, curve(s), spline(s), polygons, and combinations of any of those geometries.

[0068] Fasteners, according to certain non-limiting embodiments of this enclosure, may be selected from screws, bolts, clamps, pins, rivets, and any other
5 fasteners known now or heretofore to a person skilled in the art suitable for securing a cutting insert to a tool holder. Possible materials of construction for fasteners include, for example, steels, stainless steels, titanium alloys, and any other materials known now or heretofore by a person skilled in the art to have suitable mechanical properties and corrosion resistance for use in securing a cutting insert to a tool holder. In addition, the
10 fastener must have a configuration and must comprise one or more materials suitable for directing coolant (which may have corrosive properties) toward the cutting edge in action of a cutting insert.

[0069] The present disclosure has been written with reference to various exemplary, illustrative, and non-limiting embodiments. However, it will be recognized by
15 persons having ordinary skill in the art that various substitutions, modifications, or combinations of any of the disclosed embodiments (or portions thereof) may be made without departing from the scope of the invention as defined solely by the claims. Thus, it is contemplated and understood that the present disclosure embraces additional embodiments not expressly set forth herein. Such embodiments may be obtained, for
20 example, by combining and/or modifying any of the disclosed steps, ingredients, constituents, components, elements, features, aspects, and the like, of the embodiments described herein. Thus, the present disclosure is not limited by the description of the various exemplary, illustrative, and non-limiting embodiments, but rather solely by the claims. In this manner, it will be understood that the claims may be
25 amended during prosecution of the present patent application to add features to the claimed invention as variously described herein.

CLAIMS

We claim:

1. A cutting insert, comprising:
5 at least one cutting edge;
at least one fastener bore adapted to accept a fastener for removably fastening the cutting insert to a tool holder; and
at least one coolant flow recess in the fastener bore adapted to direct a coolant through the coolant flow recess and toward the at least one cutting edge when the
10 cutting insert is fastened to a tool holder by a fastener.
2. The cutting insert of claim 1, wherein the coolant flow recess comprises multiple coolant flow recess segments.
- 15 3. The cutting insert of claims 1 or 2, wherein the cutting insert comprises a substrate comprising one or more of a high speed steel, cobalt alloy, a cemented carbide, a cermet, a ceramic, and a diamond.
4. The cutting insert of claims 1 or 2, wherein the cutting insert comprises a wear
20 coating.
5. The cutting insert of claim 4, wherein the wear coating comprises one or more of titanium nitride, titanium carbide, aluminum oxide silicon nitride, and zirconium oxide.
- 25 6. A cutting tool, comprising:
a tool holder;
a fastener; and
a cutting insert;
wherein the cutting insert comprises
30 at least one cutting edge,

at least one fastener bore adapted to accept a fastener and removably fasten the cutting insert to the tool holder, and

at least one coolant flow recess in the fastener bore adapted to direct a coolant through the coolant flow recess and toward a head portion of the fastener when the cutting insert is fastened to the tool holder by the fastener; and

wherein the tool holder comprises

at least one coolant bore adapted to direct the coolant from the tool holder to the at least one coolant flow recess of the fastener bore, and

wherein the head portion of the fastener and the at least one coolant flow recess of the fastener bore define a gap that directs the coolant to the at least one cutting edge of the cutting insert.

7. The cutting tool of claim 6, wherein the coolant flow recess of the cutting insert comprises multiple coolant flow recess segments

8. The cutting tool of claims 6 or 7, wherein the cutting insert comprises a substrate comprising one or more of a high speed steel, cobalt alloy, a cemented carbide, a cermet, a ceramic, and a diamond.

9. The cutting tool of claims 6 or 7, wherein the cutting insert comprises a wear coating.

10. The cutting tool of claim 9, wherein the wear coating comprises one or more of titanium nitride, titanium carbide, aluminum oxide, silicon nitride, and zirconium oxide.

11. The cutting tool of claims 6 or 7, wherein the cutting tool is one of a milling tool, a boring tool, a turning tool, a drilling tool, and a general machining tool.

12. A cutting insert having an internal coolant system, comprising
at least one cutting edge;
at least one fastener bore adapted to accept a fastener for removably fastening
the cutting insert to a tool holder; and
5 at least one through cavity positioned adjacent to the fastener bore;
wherein the at least one through cavity extends from a top face of the
cutting insert to a bottom face of the cutting insert and is adapted to direct a coolant fluid
through the cutting insert and toward the at least one cutting edge when the cutting
insert is fastened to a tool holder by a fastener.

10 13. The cutting insert of claim 12, further comprising at least two side extrusions on
each on the top face and bottom face of the cutting insert positioned adjacent to the at
least one through cavity and adapted to further direct the coolant to the at least one
cutting edge.

15 14. The cutting insert of claim 12, wherein the cutting insert comprises a substrate
comprising one or more of a high speed steel, cobalt alloy, a cemented carbide, a
cermet, a ceramic, and a diamond.

20 15. The cutting insert of claims 12, wherein the cutting insert comprises a wear
coating.

25 16. The cutting insert of claim 15, wherein the wear coating comprises one or more
of titanium nitride, titanium carbide, aluminum oxide silicon nitride, and zirconium oxide.

30 17. A cutting tool having an internal coolant system, comprising:
a cutting insert;
a tool holder; and
a fastener;
wherein the cutting insert comprises

at least one cutting edge,
at least one fastener bore adapted to accept a fastener to removably
fasten the cutting insert to the tool holder, and
at least one through cavity adapted to direct a coolant through the cutting
insert and toward a head portion of the fastener when the cutting insert is
fastened to the tool holder by the fastener; and

wherein the tool holder comprises

at least one coolant bore adapted to direct the coolant from the tool holder
to the at least one through cavity of the cutting insert, and

wherein the head portion of the fastener and the at least one through
cavity of the cutting insert define a gap that directs the coolant to the at least
one cutting edge of the cutting insert.

18. The cutting tool of claim 17, wherein the cutting insert comprises a substrate
comprising one or more of a high speed steel, cobalt alloy, a cemented carbide, a
cermet, a ceramic, and a diamond.

19. The cutting tool of claim 17, wherein the cutting insert comprises a wear coating.

20. The cutting tool of claim 19, wherein the wear coating comprises one or more of
titanium nitride, titanium carbide, aluminum oxide, silicon nitride, and zirconium oxide.

21. The cutting tool of claim 17, wherein the cutting tool is one of a milling tool, a
boring tool, a turning tool, a drilling tool, and a general machining tool.