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FOUR-WAY INDEXABLE CUTTING INSERT AND CUTTING TOOL

Abstract

A four-way indexable plate-shaped cutting insert that is indexable about a central insert axis and a cutting tool. The cutting includes a base body, a first insert side surface, a second insert side surface opposite the first insert side surface, a peripheral insert surface that connects the first insert side surface and the second insert side surface, and four cutting arms. The peripheral insert surface of each cutting arm includes a rake surface, a relief surface facing in the opposite direction, and a cutting edge formed at an intersection of the rake surface and the relief surface. The first insert side surface includes a first portion that is farther away from an insert median plane than the another portion thereof. The first insert abutment portion defines a coolant groove that is recessed in the first insert abutment portion. The coolant groove opening out to the first arm side portion.

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Background/Summary

FIELD OF THE INVENTION

[0001] The subject matter of the present application relates to a four-way indexable cutting insert for metal turning operations. Specifically, the cutting insert is to be used in grooving and parting operations.

BACKGROUND OF THE INVENTION

[0002] In the field of turning operations, specifically in metal machining operations, it is known to provide a four-way indexable cutting insert which is indexable via rotation of the insert along a central axis. For example, such cutting inserts are disclosed in JP6162544, DE102006017458, U.S. Pat. No. 4,169,690 and KR20180028569.

[0003] Also known is a four-way indexable cutting insert which is secured to an insert holder via abutment between three of the insert's four abutment zones, located at opposing imaginary quadrants, and the insert holder's three reaction zones, two reaction zones being located at a lower bulge and the remaining reaction zone being located at an upper bulge. For example, such a cutting insert is disclosed in U.S. Pat. No. 8,678,718.

[0004] It is an object of the subject matter of the present application to provide a cutting tool with improved repeatability and clamping. It is also an object of the subject matter of the present application to provide a cutting insert with improved repeatability.

SUMMARY OF THE INVENTION

[0005] In accordance with an aspect of the subject matter of the present application there is provided a cutting tool including a tool holder, a four-way indexable plate-shaped cutting insert, and a fastener. The tool holder defines a central longitudinal holder axis, a forward holder direction extending in a direction parallel to the central longitudinal holder axis, and a rearward holder direction that is opposite the forward holder direction. The tool holder includes an insert coupling portion that includes a forward facing forward holder surface that is located at a forward tool end of the tool holder. The forward tool end delimits the tool holder in the forward holder direction. The insert coupling portion defines an insert seat that opens out through the forward facing forward holder surface. The insert seat is defined by a top holder abutment surface, a bottom holder abutment surface that opposes the top holder abutment surface, and a holder side abutment surface that connects the top holder abutment surface at the bottom holder abutment surface.

[0006] The four-way indexable plate-shaped cutting insert is releasably secured to the tool holder. The cutting insert is indexable about a central insert axis thereof. The cutting insert has a first axial insert direction along the central insert axis and a second insert direction along the central insert axis that is opposite the first axial insert direction. The cutting insert has a circumferential insert direction about the central insert axis. The cutting insert defines an insert median plane that is orthogonal to the central insert axis. The cutting insert includes a base body that is centered about the central insert axis, a first insert side surface, a second insert side surface opposite the first insert side surface, a peripheral insert surface, and four cutting arms. The insert median plane is disposed between the first insert side surface and the second insert side surface. The peripheral insert surface connects the first insert side surface and the second insert side surface. The four cutting arms are circumferentially distributed about the central insert axis. The four cutting arms including, in the circumferential insert direction, an active arm, an upper arm, an inner arm, and a lower arm. The active arm is the cutting arm that extends farthest in the forward holder direction and protrudes in the forward holder direction from the forward holder surface. Each cutting arm extends from the base body in a direction away from the central insert axis. The peripheral insert surface of each cutting arm includes a rake surface facing in the circumferential insert direction, a relief surface facing in the opposite direction, a cutting edge formed at an intersection of the rake surface and the relief surface, a top arm surface that extends from the rake surface towards the base body, and a bottom arm surface that extends from the relief surface towards the base body. The fastener releasably secures the cutting insert in the insert seat with abutting surfaces therebetween. The four pairs of abutting surfaces defined as the first insert side surface abutting the holder side abutment surface, the bottom arm surface of the upper arm abutting the top holder abutment surface, the bottom arm surface of the lower arm abutting the bottom holder abutment surface, and the top arm surface of the inner arm abutting the bottom holder abutment surface. In some embodiments, there are exactly four pairs of abutting surfaces.

[0007] In aspects, the tool holder includes a shank portion a top holder surface, and a front holder surface. The shank portion may include a rearward tool end that delimits the tool holder in the reward holder direction. The front holder surface and the top holder surface may be connected to one another and to the forward holder surface. The insert seat may open out through the front holder surface. The top holder surface may include a top coupling segment located in the insert coupling portion, a top shank segment located in the shank portion and closer to the central longitudinal holder axis than the top coupling segment, and a rearwardly facing coupling segment stopper located between the top coupling segment and the top shank segment. A tool overhang length OL may be defined parallel to the central longitudinal holder axis from the coupling segment stopper to the cutting edge of the active arm. An outer diameter OD of an imaginary circumscribing circle may be defined as the smallest circle circumscribing the cutting insert that fulfills the following condition: $0.7*OD \leq OL \leq 1.2*OD$. The holder overhang length may be defined parallel to the central longitudinal axis from the coupling segment stopper to the forward holder surface being in a range of 10 mm to 25 mm.

[0008] In certain aspects, an outer diameter OD belonging to an imaginary circumscribing circle may defined as the smallest circle that circumscribes the cutting insert and an inner diameter ID belonging to an imaginary inscribed circle may be defined as the largest circle inscribed by the cutting insert, which fulfills the following condition: $0.3*OD \leq ID \leq 0.6*OD$. The tool holder may further define an inlet and a top outlet in fluid communication with one another. The top outlet may open out to the forward holder surface. In a top view, the top outlet may be located directly in the rearward holder direction from the active arm.

[0009] In particular aspects, the first insert side surface includes a first insert abutment portion that is located in the base body. The first arm side portion may be located at the four cutting arms with the first insert abutment portion being farther away from the insert median plane than at least a portion of the first arm side portion. The second insert side surface may include a second insert abutment portion that is located at the base body and a second arm side portion that is located at the four cutting arms with the second insert abutment portion being farther away from the insert median plane than at least a portion of the second arm side portion. The first insert side surface may include a coolant groove that is recessed into the first insert abutment portion and opening out to the first arm side portion. The tool holder may define a side outlet and an inlet that are in fluid communication with one another. The side outlet may open out to the holder side abutment surface.

[0010] In accordance with another aspect of the subject matter of the present application there is provided a four-way indexable plate-shaped cutting insert that is indexable about a central insert axis. The cutting insert has a first axis insert direction along the central insert axis, a second insert direction along the central insert axis opposite the first axial insert direction, and a circumferential insert direction about the central insert axis. The cutting insert defines an insert median plane that is orthogonal to the central insert axis. The cutting insert includes a base body centered about the central insert axis, a first insert side surface, a second insert side surface opposite the first insert side surface with the insert median plane disposed between the first insert side surface and the second insert side surface, a peripheral insert surface that connects the first insert side surface and the second insert side surface, and four cutting arms that are circumferentially distributed about the central insert axis and extending from the base body in a direction away from the central insert

axis. The peripheral insert surface of each cutting arm including a rake surface facing in the circumferential insert direction, a relief surface facing in the opposite direction, a cutting edge formed at an intersection of the rake surface and the relief surface, a top arm surface that extends from the relief surface towards the base body, and a bottom arm surface that extends from the relief surface towards the base body. The first insert side surface includes a first insert abutment portion that is located at the base body and a first arm side portion that is located at the four cutting arms. The first insert abutment portion is farther away from the insert median plane than the first arm side portion. The first insert abutment portion defines a coolant groove that is recessed in the first insert abutment portion. The coolant groove opening out to the first arm side portion.
[0011] In aspects there are exactly four cutting arms equally distributed about the central insert axis. An arm angle that is defined between the bottom arm surface of one of the four cutting arms and the top arm surface of an adjacent cutting arm is in a range of 80 degrees to 120 degrees.
[0012] In some aspects, the peripheral insert surface further includes four concave transition surfaces. Each transition surface may connect the bottom arm surface of one of the cutting arms and the top arm surface of an adjacent cutting arm. Each transition surface may be curved along an imaginary transition circle defining a transition radius in a range of 2 mm to 4 mm.
[0013] Further, to the extent consistent, any of the embodiments or aspects described herein may be used in conjunction with any or all of the other embodiments or aspects described herein.

Description

BRIEF DESCRIPTION OF THE FIGURES
[0014] For a better understanding of the present application and to show how the same may be carried out in practice, reference will now be made to the accompanying drawings, in which:
[0015] FIG. **1** is a perspective view of a portion of a cutting tool according to a first aspect of the present application;
[0016] FIG. **2** is an exploded view of the cutting tool shown in FIG. **1**;
[0017] FIG. **3** is a perspective view of a cutting insert shown in FIG. **1**;
[0018] FIG. **4** is a side view of the cutting insert shown in FIG. **3**;
[0019] FIG. **5** is a first side view of the cutting insert shown in FIG. **3**;
[0020] FIG. **6** is a second side view of the cutting insert shown in FIG. **3**;
[0021] FIG. **7** is a perspective view of a tool holder shown in FIG. **1**;
[0022] FIG. **8** is a first side view of the tool holder shown in FIG. **7**;
[0023] FIG. **9** is a front view of the tool holder shown in FIG. **7**;
[0024] FIG. **10** is a top view of the tool holder shown in FIG. **7**;
[0025] FIG. **11** is an enlarged first side view of the cutting tool shown in FIG. **1**;
[0026] FIG. **12** is a front view of the cutting tool shown in FIG. **1**;
[0027] FIG. **13** is an enlarged top view of the cutting tool shown in FIG. **1**; and
[0028] FIG. **14** is a first side view of the cutting tool shown in FIG. **1**.
[0029] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity, or several physical components may be included in one functional block or element. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.
DETAILED DESCRIPTION OF THE INVENTION
[0030] In the following description, various aspects of the subject matter of the present application will be described. For purposes of explanation, specific configurations and details are set forth in sufficient detail to provide a thorough understanding of the subject matter of the present

application. However, it will also be apparent to one skilled in the art that the subject matter of the present application can be practiced without the specific configurations and details presented herein.

[0031] Attention is first drawn to FIGS. **1** and **2**, showing a cutting tool **1** including a four-way indexable plate-shaped cutting insert **10** releasably secured to a tool holder **100** by a fastening means **150**. The cutting insert **10** may be made from harder material than the tool holder **100**, for example cemented carbide. As used herein, the term “plate-shaped” is directed to a disc shape or a short cylinder where the height is less than the diameter thereof.

[0032] The cutting insert **10** is indexable about a central insert axis C. The central insert axis C defines a circumferential insert direction Dc and opposing first and second axial insert directions D**1**, D**2**. The first and second axial insert directions D**1**, D**2** are parallel to the central insert axis C, with the circumferential insert direction Dc being radial about the central insert axis C, e.g., clockwise when viewing the cutting insert in the first axial insert direction D**1**.

[0033] The tool holder **100** has a longitudinal holder axis L. The longitudinal holder axis L defines opposing forward and rearward holder directions Fw, Rw parallel to the longitudinal holder axis L.

[0034] As seen in FIGS. **3** to **6**, the cutting insert **10** includes a base body **16**, four cutting arms **22**, first and second insert side surfaces **64**, **70**, and a peripheral insert surface **76**. In some embodiments, the four cutting arms **22** are identical to one another. The base body **16** is centered about the central insert axis C. The four cutting arms **22** are circumferentially distributed about the central insert axis C. In some embodiments, the four cutting arms **22** are equally distributed about the central insert axis C.

[0035] In some embodiments, a central bore **18**, centered about the central insert axis C, opens out to the first and second insert side surfaces **64**, **70**, at the base body. The central bore **18** may then be used to releasably secure the cutting inert **10** to the tool holder **100** using a fastening means **150** (for example, a fastener or screw **150** as seen in FIGS. **1** and **2**).

[0036] Each cutting arm **22** extends from the base body **16** in a direction away from the central insert axis C. The first and second insert side surfaces **64**, **70** are located on opposite sides of an insert median plane M. The insert median plane M is perpendicular to the central insert axis C. The peripheral insert surface **76** connects the first and second insert side surfaces **64**, **70**.

[0037] The first side surface **64** includes a first insert abutment portion **65** and a first arm side portion **66**. The first insert abutment portion **65** is located at the base body **16** and the first arm side portion **66** is located at the four cutting arms **22**. That is to say, in a top view, the first insert abutment portion **65** is confined by the base body **16** and the first arm side portion **66** is confined by each of the four cutting arms **22**.

[0038] In some embodiments, the first insert abutment portion **65** is farther away from the median plane M than at least a portion of the first arm side portion **66**. Creating such a difference in the location of the first insert abutment portion **65** and the first arm side portion **66** may ensure reliable abutment between the cutting insert **10** and the tool holder **100** when abutment is facilitated using the first insert side surface **64**.

[0039] The second side surface **70** includes a second insert abutment portion **71** and a second arm side portion **72**. The second insert abutment portion **71** is located at the base body **16** and the second arm side portion **72** is located at the four cutting arms **22**. That is to say, in a top view, the second insert abutment portion **71** is confined by the base body **16** and the second arm side surface **72** is confined by each of the four cutting arms **22**.

[0040] In some embodiments, the second insert abutment portion **71** is farther away from the median plane M than at least a portion of the second arm side portion **72**. Specifically, the second insert abutment portion **71** may be farther away from the median plane M than the second arm side portion **72**. As mentioned above, this is advantageous for having the cutting insert **10** abut the tool holder **100** with the second insert side surface **70**.

[0041] In some embodiments, the first and second insert side surfaces **64**, **70** are parallel to the insert median plane M. In particular embodiments, the first and second insert side surfaces **64**, **70** are equally distanced from the insert median plane M. Further, the first and second insert side surfaces **64**, **70** may exhibit mirror symmetry relative to one another about the insert median plane M. This mirror symmetry may allow using the cutting insert **10** for both left-hand and right-hand machining operations.

[0042] Each cutting arm **22** includes, at the peripheral insert surface **76**, opposing rake and relief surfaces **26**, **30**, a cutting edge **34**, and opposing top and bottom arm surfaces **38**, **42**. Differently worded, each section of the peripheral insert surface **76** constituting a part of one of the cutting arms **22** includes the above-specified features (i.e. surfaces **26**, **30**, **38**, **42** and the cutting edge **34**). The rake surface **26** faces in the circumferential insert direction Dc. The cutting edge **34** is formed at an intersection of the rake and relief surfaces **26**, **30**. The top arm surface **38** extends from the rake surface **26** towards the base body **16**. The bottom arm surface **42** extends from the relief surface **30** towards the base body **16**. A transition surface **40** connects adjacent top and bottom arm surfaces **38**, **42**, each belonging to a different cutting arm **22**.

[0043] In some embodiments, the first insert side surface **64** may include at least one coolant groove **80**. In certain embodiments, the first insert side surface **64** may include a plurality of coolant grooves **80**. The at least one coolant groove **80** is recessed into the first insert abutment portion **65** and opens out to the first arm side portion **66**. Such grooves may supply coolant to the cutting edge **34** from a side outlet **147** (mentioned below) during machining operations. The coolant grooves **80** may also direct the coolant more accurately to flow in the direction of the cutting edge **34**.

[0044] Likewise, in some embodiments, the second insert side surface **70** may include at least one coolant groove **80**. In certain embodiments, the first insert side surface **64** may include a plurality of coolant grooves **80**. The at least one coolant groove **80** is recessed into the second insert abutment portion **71** and opens out to the second arm side portion **72**.

[0045] Such coolant grooves **80** may be located farther away from the median plane M than the respective portion of either the first or second arm side portions **66**, **72**. Such embodiments, may allow the coolant grooves **80** to guide the coolant being supplied in a direction roughly parallel to the cutting insert **10**. Further, this can be preferable to having grooves (not shown) serving a similar purpose recessed into the tool holder **100**. For example, this may be preferable due to improved proximity of a channel created between the coolant groove **80** and the tool holder **100** to the cutting edge **34** during machining operations, which may in turn lead to better supply of coolant to the cutting edge **34**.

[0046] In some embodiments, the cutting insert **10** further includes first and second cutting planes P**1**, P**2**. In a side view, the first cutting plane P**1** connects the cutting edges **34** of two opposing cutting arms **22** out of the four cutting arms **22**, and the second cutting plane P**2** connects the cutting edges **34** of the two remaining cutting arms **22**. The first and second cutting planes P**1**, P**2** intersect one another at the central insert axis C. Specifically, the first and second cutting planes P**1**, P**2** connect two cutting edges **34** opposing one another about the central insert axis C. In cases where the cutting edges **34** are not perpendicular to the side view (i.e., to the first insert side surface **64**) the first and second cutting planes specifically connect the opposing cutting edges **34** at the extent of each cutting edge **34** farthest from the central insert axis C.

[0047] In some embodiments, as seen in FIG. **11**, the first and second cutting planes P**1**, P**2** are located closer to the bottom arm surfaces **42** belonging to their respective cutting arms **22** than to their respective top arm surfaces **38**. Respective cutting arms **22** refers to cutting arms **22** which include the cutting edges **34** which are connected by the first and second cutting planes P**1**, P**2**, respectively. In other words, the first and second cutting planes P**1**, P**2** each splits two different opposing cutting arms **22** out of the four cutting arms, with the bottom arm surface **42** of each opposing pair of cutting arms **22** being located closer to the first and second cutting planes P**1**, P**2**, respectively, than the top arm surface **38** of each opposing pair of cutting arms **22.** Such geometrical constraints can help to ensure that the positioning of the cutting insert **10** in the tool holder **100** is a desirable one, taking into account the forces arising during machining operations.

[0048] In some embodiments, the cutting insert **10** includes a bisector plane Pb and an edge connector plane Pc. The edge connector plane Pc connects two adjacent cutting edges **34**. The bisector plane Pb is perpendicular to the edge connector plane Pc and the central insert axis C lies within the bisector plane Pb. In some embodiments, in a side view as seen in FIG. **11**, the bisector plane Pb further passes through the respective transition surface **40**. The respective transition surface **40** is located between the connected cutting edges **34**. Such geometrical constraints can help to ensure that the positioning of the cutting insert **10** in the tool holder **100** is desirable.

[0049] Referring now to FIGS. **7** to **10**, the tool holder **100** includes a peripheral holder portion **104** and an insert coupling portion **110**. The tool holder **100** may further include a shank portion **120** located rearwardly of the insert coupling portion **110**. The peripheral holder portion **104** extends about the longitudinal holder axis L.

[0050] In some embodiments, the peripheral holder portion **104** includes opposing top and bottom holder surfaces **124***a*, **124***b* and opposing front and back holder surfaces **126***a*, **126***b* connecting the top and bottom holder surfaces **124***a*, **124***b*. At the shank portion **120**, the peripheral holder portion **104** may have a rectangular cross-section. The shank portion **120** may include a rearward tool end **122** delimiting the tool holder **100** in the rearward holder direction Rw. The top, bottom, front, and back holder surfaces **124***a*, **124***b*, **126***a*, **126***b* may extend from the rearward tool end **122** to a forward tool end **114**.

[0051] In some embodiments, the top holder surface **124***a* may include a top coupling segment **125***a* and a top shank segment **127***a*. The bottom holder surface **124***b* may include a bottom coupling segment **125***b* and a bottom shank segment **127***b*. The top and bottom coupling segments **125***a*, **125***b* are located at the insert coupling portion **110**. The top and bottom shank segments **127***a*, **127***b* are located at the shank portion **120**. A rearwardly facing coupling segment stopper **128** may be located between the top coupling segment **125***a* and the top shank segment **127***a*. The top and bottom shank segments **127***a*, **127***b* may be closer to the longitudinal holder axis L than the top and bottom coupling segments **125***a*, **125***b*, respectively. This may be done, for example, to ensure that the extent of the cutting tool **1** is easily repeatable when placed in a turret (or its equivalent).

[0052] The insert coupling portion **110** includes the forward tool end **114**, a forwardly facing forward holder surface **118** and an insert seat **130**. The forward tool end **114** delimits the tool holder **100** in the forward holder direction Fw. The forward holder surface **118** faces in the forward holder direction Fw and is located at the forward tool end **114**. In some embodiments, the forward holder surface **118** delimits the tool holder **100** in the forward holder direction Fw.

[0053] The insert seat **130** is recessed in the peripheral holder portion **104** and opens out to the forward holder surface **118**. In some embodiments, the insert seat **130** further opens out to the front holder surface **126***a*. The insert seat **130** includes a top holder abutment surface **132**, a bottom holder abutment surface **136** and a holder side abutment surface **140**. The top and bottom holder abutment surfaces **132**, **136** oppose one another. In some embodiments, the top and bottom holder abutment surfaces **132**, **136** oppose one another about the longitudinal holder axis L. The holder side abutment surface **140** connects the top and bottom holder abutment surfaces **132**, **136**. The insert seat **130** may further include a forwardly facing rear surface **144**.

[0054] In some embodiments, a fastening bore **142** opens out to the holder side abutment surface **140**. The fastening means **150** engages the fastening bore **142** and clamps the cutting insert **10**, through the central bore **18**, to the holder side abutment surface **140**.

[0055] When the cutting tool **1** is assembled, for example as seen in FIGS. **11** to **14**, a fastening means **150**, for example a screw passing through the central bore **18** as shown in the present embodiment, releasably secures the cutting insert **10** to the insert seat **130** of the tool holder **100**. On assembly, one of the cutting arms **22** extends farther in the forward holder direction Fw relative to the other cutting arms **22**. The forwardmost cutting arm **22** will hereinafter be interchangeably referred to as an "active arm **46**". The active arm **46** extends farthest in the forward holder direction Fw and protrudes outwards of the forward holder surface **118**.

[0056] In some embodiments, as seen in FIGS. **4** and **11**, a tool overhang length OL and an outer diameter OD fulfill the following condition: 0.7*OD≤OL≤1.2*OD. In some embodiments, the tool overhang length OL and the outer diameter OD further fulfill the following condition: 0.8*OD≤OL≤OD. The tool overhang length OL is defined as parallel to the longitudinal holder axis L and is measured from the coupling segment stopper **128** to the cutting edge **34** of the active arm **46**. The outer diameter OD is the diameter of an imaginary circumscribing circle CO, defined as the smallest circle circumscribing the cutting insert **10**. The greater the tool overhang length OL is, the more the cutting tool **1** may be prone to unfavorable conditions such as, for example, vibrations. Thus, it may be advantageous to minimize the tool overhang length OL. Due to the dimensions of the cutting insert **10** relative to those of the tool holder **100**, the tool overhang length may depend on the outer diameter OD, among other considerations. Thus, the above-mentioned ratio was found desirable in consideration of things such as forces arising during machining operations and the possible positioning of the cutting insert **10** relative to the tool holder **100**.

[0057] It will be noted that such a dependency as specified above may not always be true. For example, this may be irrelevant in cases where the tool holder **100** has a greater height than the cutting insert **10** because the coupling segment stopper **128** can then be chosen to be located anywhere on the tool holder **100**. However, in the embodiments shown in FIGS. **1** to **14**, the cutting insert **10** extends beyond the tool holder **100**, meaning that there are constraints on the tool overhang length OL.

[0058] In some embodiments, with the outer diameter OD fulfilling the following condition: 26 mm≤OD≤34 mm, a holder overhang length OH may fulfill the following condition: 10 mm≤OH≤25 mm. In some embodiments, the holder overhang length OH further fulfills the following condition: 12 mm≤OH≤20 mm. Specifically, the holder overhang length OH may further fulfill the following condition: 13 mm≤OH≤17 mm. The holder overhang length OH is defined parallel to the longitudinal holder axis L and is measured from the coupling segment stopper **128** to the forward holder surface **118**. Smaller values of the holder overhang length OH may negatively impact the rigidity of the clamping of the cutting insert **10** in the insert seat. For example, more vibrations may occur during machining operations due to weakening of the top holder abutment surface **132**. Larger values of the holder overhang length OH can shorten the extent of the cutting insert **10** which can participate in the cutting operations. Thus, taking the aforementioned considerations, the above condition is found desirable.

[0059] In some embodiments, the outer diameter OD and an inner diameter ID fulfill the following condition: 0.3*OD≤ID≤0.6*OD. The inner diameter ID is the diameter of an imaginary inscribed circle CI, defined as the largest circle circumscribed by the cutting insert **10**. The larger the inner diameter ID is, the shorter the cutting arms **22** are, which can negatively impact the depth of cut possible during machining. At the same time, smaller values of the inner diameter ID may mean that the cutting insert **10** is weaker (for example, due to the central bore **18**). The above-mentioned ratio is desirable given these considerations.

[0060] The fastening means **150** clamps the cutting insert **10**, biasing the cutting insert **10** in the first axial insert direction D**1**. In some embodiments, the fastening means **150** further biases the cutting insert **10** in the forward holder direction Fw and in a direction towards the bottom holder abutment surface **136**. This may ensure repeatability and that there are exactly four abutment sections between the cutting insert **10** and the tool holder **100** as explained below.

[0061] The first insert side surface **64** abuts the holder side abutment surface **140**. The bottom arm surface **42** of an upper arm **50** abuts the top holder abutment surface **132**. The bottom arm surface **42** of a lower arm **54** abuts the bottom holder abutment surface **136**. The top arm surface **38** of an inner arm **58** abuts the bottom holder abutment surface **136**. In some embodiments, the abutment between the top and bottom arm surfaces **38**, **42** and the tool holder **100** occurs adjacent to transition surfaces **40**. This may ensure that the cutting insert **10** is more securely fastened to the tool holder **100**.

[0062] The upper arm **50** is defined as the cutting arm **22** rotationally adjacent the active arm **46** in the circumferential insert direction Dc. The lower arm **54** is defined as the cutting arm **22** rotationally adjacent the active arm **46** in a direction opposite to the circumferential direction Dc. The inner arm **58** is defined as the cutting arm **22** rotationally adjacent the upper and lower arms **50**, **54**.

[0063] In some embodiments, there are exactly four concave transition surfaces **40**, each transition surface **40** connecting the bottom arm surface **42** of one of the cutting arms **22** and the top arm surface **38** of an adjacent cutting arm **22**. Specifically, each transition surface **40** connects one of the top arm surfaces **38** to the bottom arm surface **42** rotationally adjacent to said top arm surface **38** in the circumferential insert direction Dc. The transition surfaces **40** are spaced apart from the tool holder **100**. The transition surfaces **40** being concave can ensure that the areas of abutment between the top and bottom arm surfaces **38**, **42** and the tool holder **100** are closer to the central insert axis C (relative to flat or convex transition surfaces **40**). Specifically, in some embodiments, the areas of abutment of the bottom arm surface **42** of an upper arm **50**, the bottom arm surface **42** of a lower arm **54**, and the top arm surface **38** of an inner arm **58** with the tool holder **100** are located adjacent to the respective transition surfaces **40**.

[0064] In some embodiments, each transition surface **40** is concavely curved, in a top view, along an imaginary transition circle Ct. A transition radius R of the imaginary transition circle Ct fulfills the following condition: 2 mm≤R≤4 mm. In some embodiments, the transition radius R further fulfills the following condition: 2.4 mm≤R≤3.6 mm. In certain embodiments, the transition radius R further fulfills the following condition: 2.7 mm≤R≤3.3 mm.

[0065] Larger values of the transition radius R may mean a larger transition surface **40** which cuts into the top and bottom arm surfaces **38**, **42**. This causes the abutment between the cutting insert **10** and the tool holder **100**, which as discussed above does not happen at the transition surfaces **40** which are spaced apart from the tool holder **100**, to be located farther away from the base body **16**. Abutment between the cutting insert **10** and the tool holder **100** may be as close as possible to the base body **16**. This may, for example, ensure stability of the cutting insert **10**.

[0066] Smaller values of the transition radius R may mean a smaller transition surface **40**. This causes the top and bottom arm surfaces **38**, **42** to be elongated, taking material away from the base body **16** which may compromise the rigidity and lifespan of the cutting insert **10**. Thus, advantageous values of the transition radius R were found, striking a balance between the length of the top and bottom arm surfaces **38**, **42**, which affect the location of the abutment between the cutting insert **10** and the tool holder **100**, and the size of the base body **16**.

[0067] In some embodiments, as seen in FIG. **4**, an arm angle aa is defined between the bottom arm surface **42** of one of the four cutting arms **22** and the top arm surface **38** of an adjacent cutting arm **22**. That is to say, the arm angle aa is defined between adjacent top and bottom arm surfaces **38**, **42**, each surface belonging to a different one of the four cutting arms **22**. The adjacent top and bottom arm surfaces **38**, **42** are connected to one another via a respective one of the four transition surfaces **40**.

[0068] The arm angle aa may fulfill the following condition: 80 degrees≤aa≤120 degrees. In embodiments, the arm angle aa fulfills the following condition: 90 degrees≤aa≤110 degrees. In some embodiments, the arm angle aa fulfills the following condition: 95 degrees≤aa≤100 degrees. For greater values of the arm angle aa each of the cutting arms **22** may be sturdier and less inclined to vibrations. For smaller values of the arm angle aa each of the cutting arms **22** may extend farther from the base body **16**. Thus, advantageous values of the arm angle aa were found, which strike a balance between the length of the cutting arms **22** and their resilience.

[0069] In some embodiments, as shown in FIGS. **7** to **10** and **12** to **14**, the tool holder **100** may include a fluid system to supply the cutting edge **34** with coolant and/or lubricant during machining operations. In such case the tool holder **100** includes at least one inlet **145** and at least one outlet. Specifically, the outlet may be a top outlet **146**, a side outlet **147**, a bottom outlet **148** or any combination thereof in the case of more than one outlet. Any of the top, side and bottom outlets **146**, **147**, **148** are in fluid communication with at least one inlet **145**. In some embodiments, there may be a plurality of inlets **145**, allowing the passage of coolant from different locations for ease of access.

[0070] The top outlet **146** opens out in the forward holder direction Fw on a portion of the forward holder surface **118** located near the insert seat **130**. Specifically, when the cutting tool **1** is assembled, the top outlet **146** may open out to the forward holder surface **118**, intersecting the insert median plane M, as shown in the top view seen in FIG. **13**. Specifically, upon assembly of the cutting tool **1**, the top outlet **146** may be located directly in the rearward holder direction Rw from the active arm **46**. This may be advantageous as such a configuration allows coolant to be easily supplied directly to the cutting edge **34** of the active arm **46** when inside a groove being machined during machining operations.

[0071] The bottom outlet **148** opens out facing the longitudinal holder axis L. Specifically, the bottom outlet **148** may open out to an extension of the bottom holder abutment surface **136**. More specifically, when the cutting tool **1** is assembled, the bottom outlet **148** may intersect the insert median plane M.

[0072] In some embodiments, as shown in FIG. **6**, the base body **16** of the cutting insert **10** has a greater width than the cutting arms **22** of the cutting insert **10**. Differently worded, a base width Wb may be greater than an arm width Wa. The base width Wb is defined, at the base body **16**, as parallel to the central insert axis C and measured between the first and second insert side surfaces **64**, **70**. The arm width Wa is defined, at the cutting arms **22**, as parallel to the central insert axis C and measured between the first and second insert side surfaces **64**, **70**.

[0073] In some embodiments, the base width Wb and the arm width Wa fulfill the following condition: $0.5*Wb \leq Wa \leq Wb$. Specifically, the base width Wb and the arm width Wa may further fulfill the following condition: $0.55*Wb \leq Wa \leq 0.9*Wb$. More specifically, the base width Wb and the arm width Wa may further fulfill the following condition: $0.6*Wb \leq Wa \leq 0.8*Wb$. Lower values of the arm width Wa may, for example, lead to a less stable abutment between the cutting insert **10** and the tool holder **100**.

[0074] In some embodiments, the base body **16** includes coolant grooves **80**, recessed into one, or both, of the first and second insert side surfaces **64**, **70**. The coolant grooves **80** open out the cutting arms **22** and may each be directed towards one of the four cutting edges **34**. In some embodiments, for a better coolant supply effect, each of the coolant grooves **80** may be elongated in a direction from the central bore **18** towards the one of the four cutting arms **22** closest thereto.

[0075] The side outlet **147** opens out to the holder side abutment surface **140**. In some embodiments, the side outlet **147** may open out of the holder side abutment surface **140** closer to the forward holder surface **118** than the fastening bore **142**. On assembly of the cutting tool **1**, the side outlet **147** directly faces at least one of the coolant grooves **80** mentioned above, and together they supply and direct coolant to the cutting insert **10**. More specifically, the coolant directed by the coolant grooves **80** may be directed to the cutting edge **34** of the active arm **46**, during machining operations. This may be achieved by having the coolant grooves **34** being elongated in a direction towards the cutting edge **34**, for example.

[0076] In some embodiments, as seen in FIG. **5**, the first insert side surface **64** may further include a first arm abutment portion **67**. The first arm abutment portion **67** is located at the four cutting arms **22** (i.e., each cutting arm **22** may include a first arm abutment portion **67**). The first arm abutment portion **67** connects the first insert abutment portion **65** and the first arm side portion **66**. The first arm abutment portion **67** may be located farther away from the median plane M relative to the first arm side portion **66** (not shown). In cases where, for thin cutting inserts (for example inserts with a cutting edge width of less than 1 mm), the abutment between the cutting insert **10** and the tool holder **100** takes place at the cutting arms **22**, it may be necessary to thicken the cutting arms **22** at the abutment areas to ensure stable abutment. This may hamper the cutting insert **10** from entering machined grooves as deep as it otherwise could, however this results in wider top and bottom arm surfaces **38**, **42** which may result in better clamping of the cutting insert **10** to the tool holder **100**.

[0077] Likewise, the second insert side surface **70** may further include a second arm abutment portion **73**. The second arm abutment portion **73** is located at the four cutting arms **22** (i.e., each cutting arm **22** may include a second arm abutment portion **73**). The second arm abutment portion **73** connects the second insert abutment portion **71** and the second arm side portion **72**. The second arm abutment portion **73** may be located farther away from the median plane M relative to the second arm side portion **72** (not shown).

[0078] While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Any combination of the above embodiments is also envisioned and is within the scope of the appended claims. Therefore, the above description should not be construed as limiting, but merely as exemplifications of particular embodiments. Those skilled in the art will envision other modifications within the scope of the claims appended hereto.

Claims

1. A cutting tool comprising: a tool holder defining a central longitudinal holder axis, a forward holder direction extending in a direction parallel to the central longitudinal holder axis, and a rearward holder direction opposite the forward holder direction, the tool holder including an insert coupling portion comprising a forward facing forward holder surface located at a forward tool end of the tool holder, the forward tool end delimiting the tool holder in the forward holder direction, the insert coupling portion defining an insert seat, the insert seat opens out through the forward facing forward holder surface, the insert seat defined by: a top holder abutment surface; a bottom holder abutment surface opposing the top holder abutment surface; and a holder side abutment surface connecting the top holder abutment surface and the bottom holder abutment surface; a four-way indexable plate-shaped cutting insert releasably secured to the tool holder, the cutting insert being indexable about a central insert axis thereof, the cutting insert having a first axial insert direction along the central insert axis, a second insert direction along the central insert axis opposite the first axial insert direction, and a circumferential insert direction about the central insert axis, the cutting insert defining an insert median plane orthogonal to the central insert axis, the cutting insert comprising: a base body centered about the central insert axis; a first insert side surface; a second insert side surface opposite the first insert side surface, the insert median plane disposed between the first insert side surface and the second insert side surface; a peripheral insert surface connecting the first insert side surface and the second insert side surface; and four cutting arms circumferentially distributed about the central insert axis, the four cutting arms including, in the circumferential insert direction, an active arm, an upper arm, an inner arm, and a lower arm, the active arm being the cutting arm that extends farthest in the forward holder direction and protrudes in the forward holder direction from the forward holder surface, each cutting arm extending from the base body in a direction away from the central insert axis, the peripheral insert surface of each cutting arm comprising: a rake surface facing in the circumferential insert direction; a relief surface facing in a circumferential direction opposite the circumferential insert direction; a cutting edge formed at an intersection of the rake surface and the relief surface; a top arm surface extending from the rake surface towards the base body; and a bottom arm surface extending from the relief surface towards the base body; a fastener releasably securing the cutting insert in the insert seat with exactly four pairs of abutting surfaces therebetween defined as: the first insert side surface abutting the holder side abutment surface; the bottom arm surface of the upper arm abutting the top holder abutment surface; the bottom arm surface of the lower arm abutting the bottom holder abutment surface; and the top arm surface of the inner arm abutting the bottom holder abutment surface.

2. The cutting tool according to claim 1, wherein the tool holder further comprises: a shank portion comprising a rearward tool end, the rearward tool end delimiting the tool holder in the rearward holder direction; a top holder surface; and a front holder surface, the top holder surface and the front holder surface connected to one another and to the forward holder surface.

3. The cutting tool according to claim 2, wherein: the insert seat opens out through the front holder surface; the top holder surface comprises: a top coupling segment located in the insert coupling portion; a top shank segment located in the shank portion and closer to the central longitudinal holder axis than the top coupling segment; and a rearwardly facing coupling segment stopper located between the top coupling segment and the top shank segment; a tool overhang length OL defined parallel to the central longitudinal holder axis from the coupling segment stopper to the cutting edge of the active arm; and an outer diameter OD of an imaginary circumscribing circle, defined as the smallest circle circumscribing the cutting insert, fulfills the following condition: $0.7*OD \leq OL \leq 1.2*OD$.

4. The cutting tool according to claim 3, wherein a holder overhang length, defined parallel to the central longitudinal holder axis from the coupling segment stopper to the forward holder surface, is in a range of 10 mm to 25 mm.

5. The cutting tool according to claim 1, wherein an outer diameter OD belonging to an imaginary circumscribing circle, defined as the smallest circle circumscribing the cutting insert, and an inner diameter ID belonging to an imaginary inscribed circle, defined as the largest circle inscribed by the cutting insert, fulfills the following condition: $0.3*OD \leq ID \leq 0.6*OD$.

6. The cutting tool according to claim 1, wherein the tool holder further defines an inlet and a top outlet, the top outlet in fluid communication with the inlet, the top outlet opening out to the forward holder surface; and wherein in a top view, the top outlet is located directly in the rearward holder direction from the active arm.

7. The cutting tool according to claim 1, wherein the first insert side surface comprises a first insert abutment portion, located at the base body, and a first arm side portion, located at the four cutting arms, the first insert abutment portion being farther away from the insert median plane than at least a portion of the first arm side portion.

8. The cutting tool according to claim 7, wherein the second insert side surface comprises a second insert abutment portion, located at the base body, and a second arm side portion, located at the four cutting arms, the second insert abutment portion being farther away from the insert median plane than at least a portion of the second arm side portion.

9. The cutting tool according to claim 7, wherein the first insert side surface further comprises a coolant groove recessed into the first insert abutment portion and opening out to the first arm side portion, the tool holder defining a side outlet and an inlet, the side outlet in fluid communication with the inlet, the side outlet opening out to the holder side abutment surface.

10. A four-way indexable plate-shaped cutting insert indexable about a central insert axis, the cutting insert having a first axial insert direction along the central insert axis, a second insert direction along the central insert axis opposite the first axial insert direction, and a circumferential insert direction about the central insert axis, the cutting insert defining an insert median plane orthogonal to the central insert axis, the cutting insert comprising: a base body centered about the central insert axis; a first insert side surface; a second insert side surface opposite the first insert side surface with the insert median plane disposed between the first insert side surface and the second insert side surface; a peripheral insert surface connecting the first insert side surface and second insert side surface; and four cutting arms circumferentially distributed about the central insert axis and extending from the base body in a direction away from the central insert axis, the peripheral insert surface of each cutting arm comprising: a rake surface facing in the circumferential insert direction; a relief surface facing in a circumferential direction opposite the circumferential insert direction; a cutting edge formed at an intersection of the rake surface and the relief surface; a top arm surface extending from the rake surface towards the base body; and a bottom arm surface extending from the relief surface towards the base body; wherein the first insert side surface comprises a first insert abutment portion, located at the base body, and a first arm side portion, located at the four cutting arms, the first insert abutment portion being farther away from the insert median plane than the first arm side portion, the first insert abutment portion defining a coolant groove recessed in the first insert abutment portion, the coolant groove opening out to the first arm side portion.

11. The cutting insert according to claim 10, wherein there are exactly four cutting arms equally distributed about the central insert axis.

12. The cutting insert according to claim 11, wherein an arm angle, defined between the bottom arm surface of one of the four cutting arms and the top arm surface of an adjacent cutting arm, is in a range of 80 degrees to 120 degrees.

13. The cutting insert according to claim 10, wherein the peripheral insert surface further comprises four concave transition surfaces, each transition surface connecting the bottom arm surface of one of the cutting arms and the top arm surface of an adjacent cutting arm.

14. The cutting insert according to claim 13, wherein each transition surface is curved along an imaginary transition circle defining a transition radius in a range of 2 mm to 4 mm.

15. A cutting tool comprising: a tool holder defining a central longitudinal holder axis, a forward holder direction extending in a direction parallel to the central longitudinal holder axis, and a rearward holder direction opposite the forward holder direction, the tool holder including an insert coupling portion comprising a forward facing forward holder surface located at a forward tool end of the tool holder, the forward tool end delimiting the tool holder in the forward holder direction, the insert coupling portion defining an insert seat, the insert seat opens out through the forward facing forward holder surface, the insert seat defined by: a top holder abutment surface; a bottom holder abutment surface opposing the top holder abutment surface; and a holder side abutment surface connecting the top holder abutment surface and the bottom holder abutment surface; a four-way indexable plate-shaped cutting insert releasably secured to the tool holder, the cutting insert being indexable about a central insert axis thereof, the cutting insert having a first axial insert direction along the central insert axis, a second insert direction along the central insert axis opposite the first axial insert direction, and a circumferential insert direction about the central insert axis, the cutting insert defining an insert median plane orthogonal to the central insert axis, the cutting insert comprising: a base body centered about the central insert axis; a first insert side surface; a second insert side surface opposite the first insert side surface, the insert median plane disposed between the first insert side surface and the second insert side surface; a peripheral insert surface connecting the first insert side surface and second insert side surface; four cutting arms circumferentially distributed about the central insert axis, the four cutting arms including, in the circumferential insert direction, an active arm, an upper arm, an inner arm, and a lower arm, the active arm being the cutting arm that extends farthest in the forward holder direction and protrudes in the forward holder direction from the forward holder surface, each cutting arm extending from the base body in a direction away from the central insert axis, the peripheral insert surface of each cutting arm comprising: a rake surface facing in the circumferential insert direction; a relief surface facing in a circumferential direction opposite the circumferential insert direction; a cutting edge formed at an intersection of the rake surface and the relief surface; a top arm surface extending from the rake surface towards the base body; and a bottom arm surface extending from the relief surface towards the base body; a fastener releasably securing the cutting insert in the insert seat with four pairs of abutting surfaces therebetween defined as: the first insert side surface abutting the holder side abutment surface; the bottom arm surface of the upper arm abutting the top holder abutment surface; the bottom arm surface of the lower arm abutting the bottom holder abutment surface; and the top arm surface of the inner arm abutting the bottom holder abutment surface.

16. The cutting tool according to claim 15, wherein an outer diameter belonging to an imaginary circumscribing circle, defined as the smallest circle circumscribing the cutting insert, and an inner diameter belonging to an imaginary inscribed circle, defined as the largest circle inscribed by the cutting insert, fulfills the following condition: $0.3*OD \leq ID \leq 0.6*OD$.

17. The cutting tool according to claim 15, wherein the tool holder further defines an inlet and a top outlet, the top outlet in fluid communication with the inlet, the top outlet opening out to the forward holder surface; and wherein in a top view, the top outlet is located directly in the rearward holder direction from the active arm.

18. The cutting tool according to claim 15, wherein the first insert side surface comprises a first insert abutment portion, located at the base body, and a first arm side portion, located at the four cutting arms, the first insert abutment portion being farther away from the insert median plane than at least a portion of the first arm side portion.

19. The cutting tool according to claim 18, wherein the second insert side surface comprises a second insert abutment portion, located at the base body, and a second arm side portion, located at the four cutting arms, the second insert abutment portion being farther away from the insert median plane than at least a portion of the second arm side portion.

20. The cutting tool according to claim 18, wherein the first insert side surface further comprises a coolant groove recessed into the first insert abutment portion and opening out to the first arm side portion, the tool holder defining a side outlet and an inlet, the side outlet in fluid communication with the inlet, the side outlet opening out to the holder side abutment surface.