

DOUBLE-SIDED CUTTING INSERT AND MILLING CUTTER

FIELD OF THE INVENTION

The present invention relates to a double-sided indexable cutting insert and a milling cutter for use in metal cutting processes.

5 BACKGROUND OF THE INVENTION

There is disclosed in WO 97/17157 a face milling cutter employing a double-sided indexable cutting insert having a prismatic shape with two opposed generally rectangular rake surfaces connected by side surfaces. The cutting insert has a basic "negative" geometry and therefore in order to provide
10 the necessary clearance between the cutting insert and the workpiece, when mounted in a face-mill, the cutting insert is oriented with a negative axial rake angle. However, negative axial rake angles may be disadvantageous, e.g., they have been found to be deficient in cutting efficiency for applications involving difficult to machine materials.

15 A double-sided indexable cutting insert for a boring tool head is disclosed in US 5,333,972. The insert is provided at each end with a protruding flat island. Each long cutting edge is inclined at an angle of 3° relative to the protruding flat island, defining an "insert axial rake angle". Rearward of each cutting edge is a descending land surface that merges with an increasing incident

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angle surface to form a chip breaker groove. Each increasing incident angle surface extends from its associated descending land surface to an adjacent island, at either the top or the bottom of the cutting insert. The cutting insert is left or right handed. It is manufactured to be right-handed and, when flipped around, is left-handed. It will be appreciated that the magnitude of the insert axial rake angle is limited for practical reasons. Any increase in the insert axial rake angle will result in an increase in the "vertical" extent of the increasing incident angle surface (see Fig. 3 of US 5,333,972) that may have an adverse effect on chip development and evacuation.

There is disclosed in WO 96/35536 a double-sided indexable cutting insert which when mounted in a face-mill has a positive axial rake angle, even when the necessary clearance between the cutting insert and the workpiece is provided. This cutting insert presents two peripheral edges for a right-hand face mill and two peripheral edges for a left-hand face mill. In a side view (see Fig. 9) the cutting insert is generally rhomboidal in shape. The main cutting edges of each end surface are parallel (see also Figs. 7 and 8) to each other and to a centrally located protruding abutment member 12. The cutting insert is retained in an insert pocket with the abutment member of a non-operative end surface and an adjacent non-operative relief surface in abutment with respective support surfaces of the insert pocket. The abutment member of the non-operative end surface and the adjacent non-operative relief surface merge at an acute-angled mounting corner. In order to change the axial rake angle of the operative cutting edge, either the insert pocket has to be rotated, or a cutting insert having a mounting corner with a different mounting angle has to be used. In either case, a different milling cutter has to be used. Moreover, the axial rake and relief angles are interdependent and any change in the axial relief angle results in a corresponding change in the relief angle, which is not always desirable.

US 5,853,267 describes a single-sided "reversed-relief" indexable cutting insert having side surfaces with, adjacent to the cutting edges, upper

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primary reliefs that are inclined to the insert base at an acute interior angle, that is, the reverse of positive inserts. Cutting inserts having side surfaces which are inclined to the insert base at an obtuse interior angle are known as "positive" inserts. Cutting inserts having side surfaces which are at right angles to the insert base are known as "negative" or "neutral" inserts. A principal advantage of negative inserts is that they can be designed to be double-sided and therefore provide twice as many indexable cutting edges in comparison with positive inserts. There are also known in the art double positive inserts, which also provide twice as many indexable cutting edges in comparison with positive inserts. However, the cutting edges of such inserts may be weaker than those of negative inserts since the cutting wedge angles of double positive inserts are smaller than those of negative inserts.

Cutting inserts of the type described in US '267, that is, single-sided reversed-relief inserts, are advantageous in that the cutting edges of these inserts are generally stronger than in negative or positive inserts. However, the cutting insert disclosed in US '267 is a one-sided beveled relief cutting insert. Moreover, the through bore for receiving a clamping screw opens out to the upper chip surface. This sets a limit on the minimum width (distance between the major cutting edges) of the cutting insert. In addition, the cutting insert disclosed in US '267 is "radially" oriented when seated in a milling cutter. In such cutting inserts, the distance between the cutting edges and the base of the cutting insert defines a minimal dimension of the cutting insert. During a cutting operation, the cutting forces are directed generally along the minor dimension. On the other hand, tangential cutting inserts, also known as on-edge, or lay down, cutting inserts, are oriented in an insert holder in such a manner that during a cutting operation on a workpiece the cutting forces are directed along a major (thicker) dimension of the cutting insert. An advantage of such an arrangement being that the cutting insert can withstand greater cutting forces than when oriented in such a manner that the cutting forces are directed along a minor

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(thinner) dimension of the cutting insert. The present invention preferably relates to double-sided reversed-relief cutting inserts.

Although it is conceivable to obtain double-sided reversed-relief inserts by grinding primary relief adjacent the cutting edges at both ends of a
5 negative insert, grinding is an additional manufacturing operation that increases time and production costs of the cutting inserts.

It is an object of the present invention, to provide an improved double-sided cutting insert and an improved milling cutter.

This object is attained with the subject-matter in accordance with the
10 respective claims. In particular, there is provided a double-sided tangential reversed-relief cutting insert which is preferably pressed or molded into its final shape, having a through bore for receiving a clamping screw which does not pass through the chip surfaces. Since double-sided inserts do not have a base opposite the chip surface, the angle of the primary relief is measured with respect to a
15 median plane of the cutting insert.

SUMMARY OF THE INVENTION

In accordance with the present invention there is preferably provided a double-sided cutting insert, for use in a milling cutter, comprising:

20 two identical opposing end surfaces and a peripheral side surface extending therebetween, the peripheral side surface comprising two opposing identical major side surfaces with a through bore extending between, and opening out to, the major side surfaces;

four spaced apart major cutting edges, each major cutting edge formed at
25 the intersection of each major side surface with each end surface; and

a primary relief surface adjacent each major cutting edge, wherein

in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces, a line tangent to each primary relief surface extending from the major cutting edge adjacent each primary relief

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surface is inclined to a median plane of the cutting insert at an acute interior angle.

In accordance with one further preferred embodiment, in each cross section of the cutting insert taken in a plane generally perpendicular to the major
5 side surfaces the cross section of each primary relief surface is a straight line.

In accordance with another preferred embodiment, in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces the cross section of each primary relief surface is a convex curve.

In accordance with another embodiment each end surface may
10 comprise a rake surface adjacent each major cutting edge, the rake surface extending from the major cutting edges in a generally inward direction of the cutting insert to an inner end surface.

In accordance with one further preferred embodiment, in each cross section of the cutting insert taken in a plane generally perpendicular to the major
15 side surfaces the cross section of each rake surface is a straight line.

In accordance with another preferred embodiment, in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces the cross section of each rake surface is a concave curve.

Generally, the peripheral side surface may further comprise two
20 opposing identical minor side surfaces, with a minor cutting edge formed at the intersection of each minor side surface with each end surface.

Further generally, the major side surfaces may be of a generally parallelogrammatic shape.

If desired, the inner end surface of each end surface is flat and the
25 inner end surfaces of each end surface are parallel to each other.

In accordance with the present invention, each end surface has four corners, two diagonally opposed lowered corners and two diagonally opposed raised corners, the lowered corners being closer to the median plane than the raised corners.

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There is also provided in accordance with the present invention, a milling cutter preferably comprising:

at least one cutting insert in accordance with the present invention; and

a cutter body having at least one insert pocket in which the at least one
5 cutting insert is retained, the at least one insert pocket comprising adjacent side
and rear walls generally transverse to a base; the base being provided with a
threaded bore for receiving a clamping screw for securing the cutting insert in the
insert pocket, the side wall being provided with an axial location surface that abuts
a given minor side surface of the at least one cutting insert; the rear wall being
10 provided with two protruding tangential location surfaces, located on either side of
a central recessed region of the rear wall, that abut a given inner end surface of the
at least one cutting insert.

BRIEF DESCRIPTION OF THE DRAWINGS

15 For a better understanding, the invention will now be described, by
way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of a cutting insert in accordance with the present
invention;

Fig. 2 is a first side view of the cutting insert in Fig. 1;

20 **Fig. 3** is an end view of the cutting insert shown in Fig. 1;

Fig. 4 is a second side view of the cutting insert shown in Fig. 1;

Fig. 5A is a partial cross section of the cutting insert shown in Fig. 1 taken
along the line VA-VA in Fig. 3;

25 **Fig. 5B** is a partial cross section of the cutting insert shown in Fig. 1 taken
along the line VB-VB in Fig. 3;

Fig. 5C is a partial cross section of the cutting insert shown in Fig. 1 taken
along the line VC-VC in Fig. 3;

Fig. 6 is a cross section similar to Figs. 5A to 5C but with curved primary
relief surfaces;

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Fig. 7 is a cross section similar to Figs. 5A to 5C but with curved rake surfaces;

Fig. 8 is a side view of a milling cutter in accordance with the present invention; and

5 **Fig. 9** is a perspective view of a portion of the cutter body of the milling cutter in accordance with the present invention, with a cutting insert removed from an insert pocket.

DETAILED DESCRIPTION OF THE INVENTION

10 Attention is first drawn to Figs. 1 to 7, showing a cutting insert **10** in accordance with the present invention there. The cutting insert **10** is indexable, and is preferably manufactured by form-pressing or by injection molding and sintering carbide powders. The cutting insert **10** comprises two identical opposing end surfaces **12** of a generally rectangular shape in an end view of the
15 cutting insert **10**. Each end surface **12** has 180° rotational symmetry about a first axis **A1** passing through the two end surfaces **12**.

A peripheral side surface **14** extends between the two opposing end surfaces **12** and comprises two opposed identical minor side surfaces **16**, two opposed identical major side surfaces **18** of a generally parallelogrammatic
20 shape, and corner side surfaces **20** located between adjacent minor and major side surfaces **16**, **18**. The two identical opposing major side surfaces **18** each have 180° rotational symmetry about a second axis **A2** which is perpendicular to the first axis **A1** and passes through the opposing major side surfaces **18**. Similarly, the two identical opposing minor side surfaces **16** each have 180°
25 rotational symmetry about a third axis **A3** passing through the opposing minor side surfaces **16**. The third axis **A3** is perpendicular to the first axis **A1** and to the second axis **A2**. A minor plane **P1** of the cutting insert **10** is defined by the first axis **A1** and the second axis **A2**, and a median plane **M** of the cutting insert **10** is defined by the second axis **A2** and the third axis **A3**. The cutting insert **10**

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is provided with a through bore **22** extending between, and opening out to, the major side surfaces **18**. The bore has a bore axis **B** that coincides with the second axis **A2**. The through bore **22** is for receiving a clamping screw **24** in order to secure the cutting insert **10** to a milling cutter **26** as will be described below with
5 reference to Figs. 8 and 9.

Each end surface **12** has four corners, two diagonally opposed raised corners **28** and two diagonally opposed lowered corners **30**. The raised corners **28** of each end surface **12** lie in an end surface plane **P**. The median plane **M** is parallel to, and lies midway between, the end surface planes **P**. The lowered
10 corners **30** are closer to the median plane **M** than the raised corners **28**. Each corner side surface **20** extends between a given raised corner **28** of one of the two opposing end surfaces **12** and a given lowered corner **30** of the other of one of the two opposing end surfaces **12**.

A peripheral edge **32** is formed at the intersection of each end surface
15 **12** and the peripheral side surface **14**. For each end surface **12**, the peripheral edge **32** comprises two major cutting edges **34**, formed by the intersection of the major side surfaces **18** with the end surface **12**; two minor cutting edges **36**, formed by the intersection of the minor side surfaces **16** with the end surface **12**; and four corner edges **38**, two raised corner edges **40** and two lowered corner
20 edges **42**, formed by the intersection of the corner side surfaces **20** with the end surface **12**. The raised corner edges **40** are corner cutting edges. If desired, the lowered corner edges **42** may also be corner cutting edges. In the embodiment shown in the figures, each major cutting edge **34** extends between a given raised corner edge **40** and given lowered corner edge **42**. Similarly, each minor cutting
25 edge **36** extends between a given raised corner edge **40** and given lowered corner edge **42**. If desired, the minor cutting edges **36** are straight.

A major dimension **D1** of the cutting insert **10** is defined between the end surface planes **P**, and a minor dimension **D2** of the cutting insert **10** is defined between the major side surfaces **18** of the cutting insert **10** (see Fig. 2).

The cutting insert **10** of the present invention is preferably a tangential cutting insert **10**. That is, the major dimension **D1** is preferably greater than the minor dimension **D2**.

Rake surfaces **44** are formed in each end face adjacent the major and
5 minor cutting edges **34**, **36** and the corner cutting edges **40** (**42**). The rake surfaces **44** extend from the major and minor cutting edges **34**, **36** and from the corner cutting edges **40** (**42**) in an inward direction of the cutting insert **10** to an inner end surface **46**. If desired, the inner end surface **46** of each end surface **12** is flat and the inner end surfaces **46** of each end surface **12** are parallel to each
10 other. Preferably, in an end-view of the cutting insert **10**, the inner end surfaces **46** have the form of a distorted parallelogram (see Fig. 3). During a metal cutting operation, chips cut from a workpiece flow from the part of the cutting edge that is in contact with the workpiece, along the rake surface **44** towards the inner end surface **46** and in general continue to flow along at least part of the inner end
15 surface **46**. Therefore, the rake surface **44** and the inner end surface **46** form a chip surface **48** of the cutting insert **10**. The fact that the through bore **22** extends between the major side surfaces **18** and not between the insert end faces, as in many types of double-sided inserts is advantageous in that the chip surface is completely independent of the through bore **22**. Therefore, the minor dimension
20 **D2** of the cutting insert **10** may be designed to be much smaller than it can in non-tangential cutting inserts in which the through bore **22** extends between and opens out to the chip surfaces, thereby limiting the extent to which the minor dimension **D2** can be reduced. Therefore, advantageously, the cutting insert **10** of the present invention can be used in smaller diameter milling cutters than can
25 non-tangential cutting inserts.

Each major side surface **18** comprises a primary relief surface **50** adjacent each major cutting edge **34** extending from the major cutting edge **34** towards the median plane **M**. In each cross section of the cutting insert **10** taken in a plane generally perpendicular to the major side surfaces **18** (or, equivalently,

in a plane parallel to the minor plane **P1** of the cutting insert **10**) a line **L** (**LA**, **LB**, **LC**) tangent to the primary relief surface **50** at the major cutting edge **34** is inclined to the median plane **M** of the cutting insert **10** at an acute interior angle α (αA , αB , αC). The interior angle α may be constant or may vary continuously
5 along the major cutting edge **34**. The variation of the interior angle α can be in accordance to any desired definition, for example it can vary along the major cutting edge **34** in such a way so as to define a helically twisting primary relief surface **50**. The cross sections of the primary relief surfaces **50** may be straight, as shown in Figs. 5A to 5C, or they may be convexly curved as shown in Fig. 6.
10 The cross sections of the rake surfaces **44** may be straight as shown in Figs. 5A to 5C, or they may be concavely curved as shown in Fig. 7.

In Figs. 5A to 5C the cross section of the cutting insert **10** taken in a plane generally perpendicular to the major side surfaces **18** intersects each primary relief surface **50** in a straight line. Consequently, the lines **L** (**LA**, **LB**,
15 **LC**) tangent to the primary relief surfaces **50** at the major cutting edges **34** coincide with the straight lines formed by the intersection of the plane generally perpendicular to the major side surfaces **18** and the primary relief surfaces **50**. If the primary relief surfaces **50** are convexly curved as shown in Fig. 6, then the interior angle α is measure between a line tangent to the primary relief surface **50**
20 at the major cutting edge **34**.

Attention is now drawn to Fig. 8, showing a milling cutter **26** with an axis of rotation **R**, having a cutter body **54** provided with a plurality of insert pockets **56**. In each insert pocket **56** a cutting insert **10** in accordance with the present invention is clamped by means of a clamping screw **24**. The insert
25 pocket **56** comprises adjacent side and rear walls **58**, **60** generally transverse to a base **62**. The side wall **58** is provided with an axial location surface **64** and the rear wall **60** is provided with two protruding tangential location surfaces **66** located on either side of a central recessed region **68** of the rear wall **60**. The base **62** of the insert pocket **56** is provided with a threaded bore **70** for receiving the clamping

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screw **24** in order to secure the cutting insert **10** in the insert pocket **56**. When the cutting insert **10** is secured in the insert pocket **56**, a given major side surface **18** will abut the base **62** of the insert pocket **56**, the two tangential location surfaces **66** abut a given inner end surface **46** and the axial location surface **64**
5 abuts a given minor side surface **16** of the cutting insert **10**.

The cutting insert **10**, in accordance with the present invention is preferably made of carbide powders and pressed or injection-molded into its final shape and then sintered. The major side surfaces **18** of the cutting insert **10** may be ground to increase the accuracy of the positioning of the cutting insert **10** in
10 the insert pocket **56**. Likewise, the minor side surfaces **16** may be ground, in order to increase the accuracy of the positioning of the cutting insert **10** in the insert pocket **56**. However, the primary relief surfaces **50** are not necessarily ground.

Although the present invention has been described to a certain degree
15 of particularity, it should be understood that various alterations and modifications could be made without departing from the spirit or scope of the invention as hereinafter claimed.

CLAIMS:

1. A double-sided cutting insert (10), for use in a milling cutter, comprising:
 - two identical opposing end surfaces (12) and a peripheral side surface (14)
 - 5 extending therebetween, the peripheral side surface (14) comprising two opposing identical major side surfaces (18);
 - four spaced apart major cutting edges (34), each major cutting edge (34) formed at the intersection of each major side surface (18) with each end surface (12); and
 - 10 a primary relief surface (50) adjacent each major cutting edge (34), wherein in each cross section of the cutting insert (10) taken in a plane generally perpendicular to the major side surfaces (18), a line (L, LA, LB, LC) tangent to each primary relief surface (50) extending from the major cutting edge (34) adjacent each primary relief surface (50) is inclined to a median plane (M) of the
 - 15 cutting insert (10) at an acute interior angle (α , α_A , α_B , α_C).
2. The cutting insert (10) according to claim 1, wherein in each cross section of the cutting insert (10) taken in a plane generally perpendicular to the major side surfaces (18) the cross section of each primary relief surface (50) is a straight line.
- 20 3. The cutting insert (10) according to claim 1, wherein in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces (18) the cross section of each primary relief surface (50) is a convex curve.
4. The cutting insert (10) according to claim 1, wherein each end surface
- 25 (12) comprises a rake surface (44) adjacent each major cutting edge (34), the rake surface (44) extending from the major cutting edges (34) in a generally inward direction of the cutting insert (10 to an inner end surface (46).
5. The cutting insert (10) according to claim 4, wherein in each cross section of the cutting insert (10) taken in a plane generally perpendicular to the

major side surfaces (18) the cross section of each rake surface (44) is a straight line.

6. The cutting insert (10) according to claim 4, wherein in each cross section of the cutting insert (10) taken in a plane generally perpendicular to the
5 major side surfaces (18) the cross section of each rake surface (44) is a concave curve.

7. The cutting insert (10) according to claim 1, wherein the peripheral side surface (16) further comprises two opposing identical minor side surfaces (16), with a minor cutting edge (36) formed at the intersection of each minor side
10 surface (16) with each end surface (12).

8. The cutting insert (10) according to claim 1, wherein the major side surfaces (18) are of a generally parallelogrammatic shape.

9. The cutting insert (10) according to claim 4, wherein the inner end surface (46) of each end surface (12) is flat and the inner end surfaces (46) of
15 each end surface (12) are parallel to each other.

10. The cutting insert (10) according to claim 4, wherein each end surface (12) has four corners (28, 30), two diagonally opposed lowered corners (30) and two diagonally opposed raised corners (28), the lowered corners (30) being closer to the median plane (M) than the raised corners (28).

20 11. The cutting insert (10) according to claim 10, wherein each end surface (12) comprises two raised corner edges (40) and two lowered corner edges (44), formed by the intersection of corner side surfaces (20) with each end surface (12), the raised corner edges (40) being corner cutting edges.

12. The cutting insert (10) according to claim 11, wherein the lowered
25 corner edges (42) are corner cutting edges.

13. The cutting insert (10) according to claim 11, wherein each major cutting edge (34) extends between a given raised corner edge (40) and given lowered corner edge (42).

14. The cutting insert (10) according to claim 11, wherein each minor

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cutting edge (36) extends between a given raised corner edge (40) and given lowered corner edge (42).

15. The cutting insert (10) according to claim 14, wherein the minor cutting edges (36) are straight.

5 16. The cutting insert (10) according to claim 1, wherein a through bore (22) extends between, and opens out to, the major side surfaces (16).

17. A milling cutter (52) comprising:

at least one cutting insert (10) in accordance with any one of claims 1 to 16;
and

10 a cutter body (54) having at least one insert pocket (56) in which the at least one cutting insert (10) is retained, the at least one insert pocket (56) comprising adjacent side and rear walls (58, 60) generally transverse to a base (62); the base (62) being provided with a threaded bore (70) for receiving a clamping screw (24) for securing the cutting insert (10) in the insert pocket (56), the side wall (58)
15 being provided with an axial location surface (64) that abuts a given minor side surface (16) of the at least one cutting insert (10); the rear wall (60) being provided with two protruding tangential location surfaces (66), located on either side of a central recessed region (68) of the rear wall (60), that abut a given inner end surface (46) of the at least one cutting insert (10).