

CUTTING TOOL AND CUTTING INSERT THEREFOR

FIELD OF THE INVENTION

The present invention relates to a cutting tool and particularly to a milling cutting tool capable of performing face milling operations at a high feed rate and a long tool shank. The invention also discloses an indexable cutting insert for use
5 with the cutting tool.

BACKGROUND OF THE INVENTION

Japanese Publication No. 2000202703 A to Masaharu discloses a boring tool having two identical nearly parallelogrammatic plate form tips. Each tip has a pair
10 of first cutting edges 15 and a pair of second cutting edges 16 arranged in a rotational symmetry and connected via a nose part 17. The first cutting edge 15 having a circular arcing cutting edge 15a at the side of the nose part 17 and a rectilinear cutting edge 15b merging with the cutting edge 15a via a first bending part 15. The second cutting edge 16 having two rectilinear cutting edges 16a and
15 16b merging via a second bending part 16c.

Each of the tips used in '703 is disposed differently with respect to the tool since each of the cutting edges has different characteristics. Since the cutting edges are arranged in 180° rotational symmetry, each tip can be indexed only two times at

its pocket. Furthermore, if the tips used in '703 are used to perform ramp-down milling they are not properly supported against radially outwardly directed cutting forces that tend to withdraw each tip out of its pocket.

Japanese Publication No. 2000-005921 to Yoshimitsu shows, in Fig. 4 thereof, a three-corner cutting insert. Each of the three cutting edges comprises a small curved cutting edge portion 7 and a large straight cutting edge portion 8. The cutting insert of '921 does not have a cutting edge specifically designed for performing ramp-down milling. Furthermore, the cutting insert is not properly supported against radially outwardly directed cutting forces that tend to withdraw the cutting insert out of its pocket during a ramp-down milling operation.

Another kind of tool, having means for preventing rotation of the cutting insert around the axis of the clamping screw, is shown in European Patent No. EP 0 091 408 B1 to Bylund. In '408 there is disclosed a cutting insert 12 having three convex cutting edges 16, 17 and 18. Each of the cutting edges is connected, at a rear end thereof, to an auxiliary cutting edge 32, which extends transversely to the cutting edge and forms an obtuse angle therewith. The auxiliary cutting edge 32 is intended to cut the workpiece during reversed relative movement between the insert and the workpiece. The cutting edges of the cutting insert 12 are not peripherally continuous around the top face of the cutting insert. Instead, they are separated by an intermediate peripheral space 24, 25 and 26. The cutting insert 12 is not provided with a cutting edge for performing ramp-down milling operations and is not especially supported against radially outwardly directed cutting forces that tend to withdraw the cutting insert out of its pocket. For preventing rotation of the cutting insert, the cutting insert is provided with a supporting surface 27 that is directed substantially towards the center of the cutting insert. The supporting surface 27 abuts against an abutment surface 28 on the tool body that fits into the intermediate peripheral surface.

A disadvantage of the tool of '408 is that in order to prevent rotation of the cutting insert, the cutting edges are formed with recesses which complicate and weaken the cutting insert.

It is an object of the present invention to provide a cutting tool and a cutting
5 insert therefor that significantly reduce or overcome the aforementioned disadvantages.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a cutting tool
10 (10) having a longitudinal axis (A), the cutting tool comprises a tool body (12), having at least one mounting leg (14) formed at a front end (16) thereof, the at least one mounting leg (14) having an insert pocket (18) with a cutting insert (20) retained therein;

the insert pocket comprises a base wall (24) and first and second rear sidewall
15 sections (40, 42) transversely directed to the base wall (24), a generally circular recess (28) extends downwardly from the base wall (24), the recess has a lower wall (30) bounded by a peripheral wall (32) extending uprightly from the lower wall (30) to the base wall (24),

the cutting insert comprises an upper surface (60), a lower surface (62) and a
20 side surface (64) extending therebetween, the upper and side surfaces (60, 64) intersecting at a cutting edge (66), a cylindrical protrusion (82) having a cylindrical peripheral surface (84) extends downwardly from the lower surface (62) to a bottom surface (86) of the protrusion (82);

wherein the cutting insert (20) is retained in the insert pocket (18) with first,
25 second and third abutment surfaces (52, 56, 58) of the insert pocket (18) abutting the cutting insert (20), where the first abutment surface (52) is located on the first rear sidewall section (40) and it abuts a first support surface (52') located on the side surface (64) of the cutting insert, the second abutment surface (56) is located on the second rear sidewall section (42) and it abuts a second support surface (56') located

on the side surface (64) of the cutting insert, and the third abutment surface (58) is located on the peripheral wall (32) of the recess (28) and it abuts a third support surface (58') located on the cylindrical peripheral surface (84) of the protrusion (82) of the cutting insert (20).

5 In accordance with a preferred embodiment of the present invention, the cutting edge (66) comprises at least three cutting edge portions (68) that are separated from each other by corner cutting edges (70) and each cutting edge portion comprises a first cutting edge (72) that extends between a second cutting edge (74) and an adjacent corner cutting edge (70).

10 Preferably, the first cutting edge (72) is convex.

 If desired, the second cutting edge (74) is straight.

 Further in accordance with a preferred embodiment of the present invention, the side surface (64) comprises side surface sections with a first side surface section (76) adjacent the first cutting edge (72), a second side surface
15 section (78) adjacent the second cutting edge (74) and a side surface corner section (80) adjacent the corner cutting edge (70), each of the side surface sections extending from its associated cutting edge towards the lower surface (62).

 In accordance with a preferred embodiment, the first and second rear sidewall sections (40, 42) are separated by a first recessed region (44).

20 Further in accordance with a preferred embodiment, the first support surface (52') and the second support surface (56') are located on either side of a common side surface corner section (80).

 Typically, a portion of the common side surface corner section (80) is located in the first recessed region (44).

25 Preferably, the peripheral wall (32) of the recess (28) comprises a major portion (34) having a major radius R1, and a minor portion (36) having a minor radius R2.

 Further preferably, the minor radius R2 is smaller than the major radius R1.

Still further preferably, the angular extent of the minor portion (36) is smaller than the angular extent of the major portion (34).

In accordance with a preferred embodiment, a threaded bore (38) extends downwardly from the lower wall (30) of the recess (28).

5 Typically, a through bore (88), having an insert axis (B), extends between the upper surface (60) of the cutting insert (20) and the bottom surface (86) of the protrusion (82).

Further typically, a retaining screw (22) is located in the through bore (88) and threadingly engages the threaded bore (38).

10 In accordance with a specific embodiment of the present invention, first cutting edge (72) subtends a first angle (α) of 70° with the insert axis (B).

Further in accordance with a specific embodiment of the present invention, the second cutting edge (74) subtends a second angle (β) of 35° with the insert axis.

Typically, the first cutting edge (72) forms an obtuse interior third angle (γ)
15 with the adjacent second cutting edge (74).

In accordance with a specific embodiment of the present invention, the third angle is 153° .

Also in accordance with the present invention there is provided a cutting insert (20), comprising an upper surface (60), a lower surface (62) and a side surface
20 (64) extending therebetween, the upper and side surfaces (60, 64) intersecting at a cutting edge (66), a cylindrical protrusion (82) having a cylindrical peripheral surface (84) extends downwardly from the lower surface (62) to a bottom surface (86) of the protrusion (82), the cutting insert having an insert axis (B) passing through the upper and bottom surfaces (60, 86);

25 the cutting edge (66) comprises at least three cutting edge portions (68) that are separated from each other by corner cutting edges (70) and each cutting edge portion comprises a first convex cutting edge (72) that extends between a second cutting edge (74) and an adjacent corner cutting edge (70).

If desired, the second cutting edge (74) is straight.

In accordance with a specific embodiment of the present invention, first cutting edge (72) subtends a first angle (α) of 70° with the insert axis (B).

Further in accordance with a specific embodiment of the present invention, the second cutting edge (74) subtends a second angle (β) of 35° with the insert axis (B).

Typically, the first cutting edge (72) forms therewith an obtuse interior third angle (γ) with the adjacent second cutting edge (74).

In accordance with a specific embodiment of the present invention, the third angle is 153° .

Typically, a through bore (88), having as axis the insert axis (B), extends between the upper surface (60) of the cutting insert (20) and the bottom surface (86) of the protrusion (82).

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention and to show how the same may be carried out in practice, reference will now be made to the accompanying drawings, in which:

Fig. 1 is a perspective view of a cutting tool according to the present invention;

Fig. 2 is a bottom perspective view of a cutting insert shown in Fig. 1;

Fig. 3 is a partial exploded view of the cutting tool of Fig. 1 showing one of the cutting inserts removed from its pocket;

Fig. 4 is a partial view of the cutting tool of Fig. 1 showing a top view of one of the cutting inserts retained in its pocket;

Fig. 5 is the same view as Fig. 4 with the position of the cutting insert shown in dashed lines so that the insert pocket can be seen in a top view; and

Fig. 6 is a cross-sectional view taken along line VI-VI in Fig. 4 with the retaining screw removed.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Attention is drawn to the drawings. A cutting tool **10** comprises a tool body **12** having a plurality of mounting legs **14** formed at a front end **16** of the tool body **12**. Each mounting leg **14** has an insert pocket **18** in which a cutting insert **20** is retained by means of a retaining screw **22**. The cutting tool **10** has a rear end **23** opposite the front end **16** with an axis of rotation **A** passing through the front and rear ends **16**, **23** defining a front to rear direction.

The insert pocket comprises a base wall **24** and a sidewall **26** that is transversely directed to the base wall **24**. A generally circular recess **28** extends downwardly from the base wall **24**. The recess **28** has a lower wall **30** bounded by a peripheral wall **32** extending uprightly from the lower wall **30** to the base wall **24**. The peripheral wall **32** of the recess **28** preferably comprises two circular portions of differing radii, but having the same center. The peripheral wall **32** comprises a major portion **34** having a major radius **R1**, and a minor portion **36** having a minor radius **R2**. The minor radius **R2** is smaller than the major radius **R1**. According to a specific application of the present invention, the minor radius **R2** is 0.25 mm smaller than the major radius **R1**. The angular extent of the minor portion **36** is smaller than the angular extent of the major portion **34**. In accordance with a specific application, the minor portion **36** of the peripheral wall **32** has an angular extent ϕ of approximately 40°. A threaded bore **38**, having a pocket axis **C**, for receiving the retaining screw **22**, extends downwardly from the lower wall **30** of the recess **28**. The centers of the two circles on which the major and minor portions **34**, **36** lie coincide with the axis **C**.

The sidewall **26** comprises three sidewall sections, two rear sidewall sections, a first rear sidewall section **40** and a second rear sidewall section **42** separated by a first recessed region **44** and a side sidewall section **46**. The first rear sidewall section **40** is adjacent the side sidewall section **46** and separated from it by a second recessed region **48**. The first rear sidewall section **40** has a region **50** adjacent the first recessed region **44**, at least a portion of which constitutes a first abutment

surface **52** for abutting the cutting insert **20**. Similarly, the second rear sidewall section **42** has a region **54** adjacent the first recessed region **44**, at least a portion of which constitutes a second abutment surface **56** for abutting the cutting insert **20**. Also, at least a portion of the minor portion **36** constitutes a third abutment surface **58** for abutting the cutting insert **20**. As will be explained in greater detail below, the first, second and third abutment surfaces are designed to retain the cutting insert **20** in the insert pocket **18** in a well defined and secure manner.

Attention is drawn to Fig. 5. It will be noted that the minor portion **36**, and therefore the third abutment surface **58**, is located adjacent the side sidewall **46** towards the front of the insert pocket **18**. In terms of an analog clock, the minor portion is located approximately between 7 and 8 O' clock. It will be appreciated that the precise location of the minor portion **36** is a question of design and distribution of forces. In practice, the illustrated location of the minor portion **36** is a preferred location. However, it can also be located at other locations between the preferred location up to approximately adjacent the second recessed region **48**.

The cutting insert **20** comprises an upper surface **60**, a lower surface **62** and a side surface **64** that extends between the upper and lower surfaces **60**, **62**. The upper surface **60** and the side surface **64** intersect at a cutting edge **66** comprising three cutting edge portions **68** separated from each other by corner cutting edges **70**. Each of the three cutting edge portions comprises a convex first cutting edge **72** that extends between a straight second cutting edge **74** and an adjacent corner cutting edge **70**. The side surface **64** is divided into sections corresponding to the various cutting edges. Accordingly, the side surface **64** has a first side surface section **76** adjacent the first cutting edge **72**, a second side surface section **78** adjacent the second cutting edge **74** and side surface corner section **80** adjacent corner cutting edge **70**. A cylindrical protrusion **82** having a cylindrical peripheral surface **84** extends downwardly from the lower surface **62** to a bottom surface **86** of the protrusion **82**. The peripheral surface **84** is perpendicular to the lower surface **62**. A centrally located through bore **88**, having an insert axis **B**, extends between the

upper surface **60** and the bottom surface **86**. The protrusion **82** has a protrusion radius **R3**. The protrusion radius **R3** is smaller than the major radius **R1** and approximately equal to the minor radius **R2**.

The three cutting edge portions **68** are rotationally symmetrically arranged with respect to the insert axis **B**. The first cutting edge **72** is substantially larger than the second cutting edge **74**. According to a preferred embodiment of the present invention, the first cutting edge **72** subtends a first angle α of 70° at the insert axis **B** and the second cutting edge **74** subtends a second angle β of 35° at the insert axis **B**. The first and second cutting edges **72**, **74** of a given cutting edge portion **68** make an obtuse interior third angle δ of 153° between each other. The cutting insert **20** is indexable and has three indexing positions.

In order to secure the cutting insert **20** in the insert pocket **18**, the protrusion **82** is inserted into the recess **28** until the lower surface **62** of the cutting insert abuts the base wall **24** of the insert pocket, with a portion of a given side surface corner section **80** located in the first recessed region **44**. The retaining screw **22** is then placed in the through bore **88** of the cutting insert and threadingly engaged with the threaded bore **38** and tightened for securely retaining the cutting insert in the insert pocket **18**. When the cutting insert **20** is securely retained in the insert pocket **18** the first and second abutment surfaces **52**, **56** abut the first and second side surface sections **76**, **78** located on either side of the given side surface corner **80**, being common to the first and second side surface sections **76**, **78**, at first and second support surfaces **52'**, **56'**, respectively and the third abutment surface **58** abuts the cylindrical peripheral surface **84** of the protrusion **82** at a third support surface **58'**.

The pocket axis **C** of the threaded bore **38** is slightly offset with respect to the insert axis **B**. This offset, i.e., eccentricity, is provided so that when the retaining screw **22** is tightened, abutment forces are exerted by the abutment surfaces **52**, **56**, **58** on the cutting insert providing a pre-tensioning of the cutting insert **20** in order to obtain a well defined location of the cutting insert **20** in the insert pocket **18**. Since the third abutment surface **58** lies on a surface which is concentric with the pocket

axis **C** the abutment force applied by it on the protrusion **82** of the cutting insert is directed towards the insert axis **B** and therefore cannot contribute to the rotation of the cutting insert about the insert axis **B**. The location and direction of each of the first and second abutment surfaces **52**, **56** are designed so that the under working
5 conditions net abutment force applied by these abutments surfaces to the side surface **64** of the insert does not give rise to rotation of the cutting insert about the insert axis **B**. In other words, the lines of action of the abutment forces of the first and second abutment surfaces **52**, **56** operate in opposite senses about the insert axis **B** and cancel out. Hence, the present invention guarantees unique and stable
10 location of the cutting insert **20** in the insert pocket **18**.

The cutting tool **10** is particularly suitable for performing face milling by the first cutting edge **72** and ramp-down milling operations by the second cutting edge **74**. Since the first cutting edge **72** is convex and has a relatively large radius of curvature, the cutting insert **20** can cut at a relatively high feed speed at a small
15 depth of cut. The cutting forces acting on the cutting insert in such a case are directed substantially axially, therefore, it is possible to cut with a tool having a relatively long overhang without exceeding the allowed radial forces that tend to bend the tool and cause vibrations.

Although the present invention has been described to a certain degree of
20 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 cutting tool (10), having a longitudinal axis (A), the cutting tool comprises a tool body (12), having at least one mounting leg (14) formed at a front end (16) thereof, the at least one mounting leg (14) having an insert pocket (18) with a
5 cutting insert (20) retained therein;

the insert pocket comprises a base wall (24) and first and second rear sidewall sections (40, 42) transversely directed to the base wall (24), a generally circular recess (28) extends downwardly from the base wall (24), the recess has a lower wall (30) bounded by a peripheral wall (32) extending uprightly from the lower wall (30) to the
10 base wall (24),

the cutting insert comprises an upper surface (60), a lower surface (62) and a side surface (64) extending therebetween, the upper and side surfaces (60, 64) intersecting at a cutting edge (66), a cylindrical protrusion (82) having a cylindrical peripheral surface (84) extends downwardly from the lower surface (62) to a bottom
15 surface (86) of the protrusion (82);

wherein the cutting insert (20) is retained in the insert pocket (18) with first, second and third abutment surfaces (52, 56, 58) of the insert pocket (18) abutting the cutting insert (20), where the first abutment surface (52) is located on the first rear sidewall section (40) and it abuts a first support surface (52') located on the side
20 surface (64) of the cutting insert, the second abutment surface (56) is located on the second rear sidewall section (42) and it abuts a second support surface (56') located on the side surface (64) of the cutting insert, and the third abutment surface (58) is located on the peripheral wall (32) of the recess (28) and it abuts a third support surface (58') located on the cylindrical peripheral surface (84) of the protrusion (82)
25 of the cutting insert (20).

2. The cutting tool according to claim 1, wherein the cutting edge (66) comprises at least three cutting edge portions (68) that are separated from each other by corner cutting edges (70) and each cutting edge portion comprises a first cutting

edge (72) that extends between a second cutting edge (74) and an adjacent corner cutting edge (70).

3. The cutting tool according to claim 2, wherein the first cutting edge (72) is convex.

5 4. The cutting tool according to claim 3, wherein the second cutting edge (74) is straight.

5. The cutting tool according to claim 2, wherein the side surface (64) comprises side surface sections with a first side surface section (76) adjacent the first cutting edge (72), a second side surface section (78) adjacent the second cutting edge (74) and a side surface corner section (80) adjacent the corner cutting edge (70), each of the side surface sections extending from its associated cutting edge towards the lower surface (62).

6. The cutting tool according to claim 5, wherein the first and second rear sidewall sections (40, 42) are separated by a first recessed region (44).

15 7. The cutting tool according to claim 6, wherein the first support surface (52') and the second support surface (56') are located on either side of a common side surface corner section (80).

8. The cutting tool according to claim 7, wherein a portion of the common side surface corner section (80) is located in the first recessed region (44).

20 9. The cutting tool according to claim 4, wherein the peripheral wall (32) of the recess (28) comprises a major portion (34) having a major radius R1, and a minor portion (36) having a minor radius R2.

10. The cutting tool according to claim 9, wherein the minor radius R2 is smaller than the major radius R1.

25 11. The cutting tool according to claim 10, wherein the angular extent of the minor portion (36) is smaller than the angular extent of the major portion (34).

12. The cutting tool according to claim 11, wherein a threaded bore (38) extends downwardly from the lower wall (30) of the recess (28).

13. The cutting tool according to claim 12, wherein a through bore (88), having an insert axis (B), extends between the upper surface (60) of the cutting insert (20) and the bottom surface (86) of the protrusion (82).

14. The cutting tool according to claim 13, wherein a retaining screw (22) is
5 located in the through bore (88) and threadingly engages the threaded bore (38).

15. The cutting tool according to claim 13, wherein first cutting edge (72) subtends a first angle (α) of 70° with the insert axis (B).

16. The cutting tool according to claim 15, wherein the second cutting edge (74) subtends a second angle (β) of 35° with the insert axis.

10 17. The cutting tool according to claim 16, wherein the first cutting edge (72) forms an obtuse interior third angle (γ) with the adjacent second cutting edge (74).

18. The cutting tool according to claim 17, wherein the third angle is 153° .

19. A cutting insert (20), comprising an upper surface (60), a lower surface (62) and a side surface (64) extending therebetween, the upper and side surfaces (60,
15 64) intersecting at a cutting edge (66), a cylindrical protrusion (82) having a cylindrical peripheral surface (84) extends downwardly from the lower surface (62) to a bottom surface (86) of the protrusion (82), the cutting insert having an insert axis (B) passing through the upper and bottom surfaces (60, 86);

the cutting edge (66) comprises at least three cutting edge portions (68) that are
20 separated from each other by corner cutting edges (70) and each cutting edge portion comprises a first convex cutting edge (72) that extends between a second cutting edge (74) and an adjacent corner cutting edge (70).

20. The cutting insert according to claim 19, wherein the second cutting edge (74) is straight.

25 21. The cutting insert according to claim 20, wherein first cutting edge (72) subtends a first angle (α) of 70° with the insert axis (B).

22. The cutting insert according to claim 21, wherein the second cutting edge (74) subtends a second angle (β) of 35° with the insert axis (B).

23. The cutting insert according to claim 22, wherein the first cutting edge (72) forms therewith an obtuse interior third angle (γ) with the adjacent second cutting edge (74).

24. The cutting insert according to claim 23, wherein the third angle is 153° .

5 25. The cutting insert according to claim 24, wherein a through bore (88), having as axis the insert axis (B), extends between the upper surface (60) of the cutting insert (20) and the bottom surface (86) of the protrusion (82).