

TOOL JOINT

FIELD OF THE INVENTION

The present invention relates to a tool joint employing threaded coupling to be used in particular in cutting tool assemblies employing different heads that are used on a single tool holder.

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BACKGROUND OF THE INVENTION

Tool joints with male and female members employing threaded coupling are known in the art. Such a male member usually comprises an external thread portion that matches a corresponding internal thread portion in the female member. An example of such a tool joint coupling mechanism is disclosed in US Patent No. 5,114,286. As shown in '286, a male coupler (11) is axially aligned with a female coupler (13). The male coupler (11) has a helical male thread (21) which is sized and shaped to match a corresponding helical female thread (23) in the female coupler (13). A disadvantage of the coupling mechanism of the kind described is shown schematically in Fig. 1 (and shown clearly in Figs. 1 and 5 of '286). It involves the fact that forward to the forward most thread crest **14** of the male member **12** there is formed a narrow neck portion **16** which weakens the forward end of the male member. The term "narrow neck portion" refers, herein, to a section of the male member having a diameter equal to the root diameter of the thread.

Another problem involved with such tool joints relates to the fact that the forward most thread crest, and, also the rear most thread crest, are incomplete, having narrowing runout portions at their open ends. This is clearly shown, for example, in Fig. 2 of US Patent No. 1,407,335 to Reynolds. Such narrow end
5 portions are too weak to transfer axial loads between the male and female members.

A solution to the problem is disclosed in US Patent No. 4,735,537 to Rath, which teaches how to reduce the narrow neck portion. In the threaded portion of the male member of '537, the inner end portion of the thread has its full dimension almost to the point where it terminates. This enables the transition section to be
10 made shorter.

It is the object of the present invention to provide a tool joint with male and female members having matching threads in which the threads in both the male member and the female member do not have the conventional runout of incomplete cross-section, thereby providing a shorter and stronger tool joint.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a tool joint having an axis A and comprising a male member and a female member;

the male member having an axis B and comprising:

20 a male body portion; and
a male coupling portion projecting rearwardly from the male body portion, the male coupling portion having an unthreaded forward portion adjacent the male body portion and a rear threaded portion terminating at a rear end;

the threaded portion of the male coupling portion having a thread
25 terminating in a forward end part adjacent the forward portion of the male coupling portion and in a rear end part adjacent the rear end of the rear portion of the male coupling portion, the thread having an intermediate section of uniform depth between the forward and rear end parts;

the forward end part of the thread of the male coupling portion being a thread root having a variable depth gradually decreasing from a depth equal to the uniform depth of the thread to no depth;

the rear end part of the thread of the male coupling portion being a thread crest having a variable height gradually decreasing from a height equal to the uniform depth of the thread to no height;

the female member having an axis C and comprising:

a female body portion; and

a female coupling portion comprising a bore for accepting the male coupling portion, the bore extending rearwardly from a front surface of the female member towards the female body portion, the bore having an unthreaded forward portion adjacent the front surface and a rear threaded portion terminating adjacent the female body portion;

the threaded portion of the female coupling portion having a thread terminating in a forward end part adjacent the unthreaded forward portion of the female coupling portion and in a rear end part adjacent the female body portion, the thread of the female coupling portion having an intermediate section between the forward and rear end parts, the thread of the female coupling portion having a depth equal to the uniform depth;

the forward end part of the thread of the female coupling portion being a thread crest having a variable height gradually decreasing from a height equal to the uniform depth to no height;

the rear end part of the thread of the female coupling portion being a thread root having a variable depth decreasing from a depth equal to the uniform depth of the thread to no depth;

wherein, upon threaded coupling of the male and female members to form a tool joint connection, the threaded portion of the male member engages the threaded portion of the female member;

the forward end part of the thread of the male coupling portion and the forward end part of the thread of the female coupling portion have a gap between them of a first angular extent; and

the rear end part of the thread of the male coupling portion and the rear end
5 part of the thread of the female coupling portion have a gap between them of a second angular extent.

In accordance with a preferred embodiment of the present invention, the male body portion further comprises a rearwardly facing annular shoulder adjacent the unthreaded forward portion of the male coupling member and the front surface of the
10 female member is a forwardly facing annular shoulder; and

wherein, upon threaded coupling of the male and female members to form a tool joint connection, the annular shoulder of the male body portion abuts the annular shoulder of the female body portion.

Further in accordance with a preferred embodiment of the present
15 invention, the unthreaded forward portion of the male coupling portion is frustoconical in shape, rearwardly tapering towards the rear threaded portion of the male coupling portion and the unthreaded forward portion of the bore of the female coupling portion is frustoconical in shape, rearwardly tapering towards the female body portion; and

20 wherein, upon threaded coupling of the male and female members to form a tool joint connection, the unthreaded forward portion of the male coupling portion abuts the unthreaded forward portion of the female coupling portion.

Typically, the first angular extent is in the range of 20° to 90°.

Preferably, the first angular extent is 70°.

25 Typically, the second angular extent is in the range of 20° to 90°.

Preferably, the second angular extent is 70°.

In accordance with the present invention, the forward and rear end parts of the male and female threaded portions each have an angular extent in the range of 5° to 30°.

Preferably, the forward and rear end parts of the male and female threaded portions each have an angular extent of 15° .

Typically, the male member is made of cemented carbide and the female member is made of steel.

5 In accordance with the present invention, during the threaded coupling of the male and female members the unthreaded forward portion of the male coupling member abuts the unthreaded forward portion of the female coupling member before the annular shoulder of the male body portion abuts the annular shoulder of the female body portion.

10 Preferably, when the unthreaded forward portion of the male coupling portion comes into initial contact with the unthreaded forward portion of the female coupling portion the annular shoulder of the male body portion is spaced a distance L from the annular shoulder of the female body portion.

Typically, the distance L lies in the range of 0.1 to 0.6 mm.

15 In accordance with a preferred embodiment of the present invention, the distance L equals to 0.3 mm.

In accordance with a preferred embodiment of the present invention, the annular shoulder of the male body portion and the annular shoulder of the female body portion are perpendicular to the axis A.

20 Typically, the annular shoulder of the male body portion and the annular shoulder of the female body portion are ground.

Further typically, the unthreaded forward portion of the male coupling portion and the unthreaded forward portion of the female coupling portion are ground.

Still further typically, the thread portion of the male member is ground.

25 Preferably, the unthreaded forward portion of the male coupling portion taper at an angle α_1 with respect to the axis B, the unthreaded forward portion of the female coupling portion taper at an angle α_2 with respect to the axis C, the angle α_1 being equal to the angle α_2 .

Typically, the angles α_1 and α_2 are in the range of 2.5° to 3.5° .

Further typically, the angles α_1 and α_2 are 3° .

Optionally, the angle α_1 is greater than the angle α_2 by 0.25° .

In accordance with a preferred embodiment, the thread portion of the male member and the thread portion of the female member are a single lead threads.

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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:

10 **Fig. 1** is a side view of a male member of a prior art coupling mechanism;

Fig. 2 is a perspective view of a cutting tool employing a tool joint according to the present invention;

Fig. 3 is an exploded view of the cutting tool of Fig. 2;

15 **Fig. 4** is a perspective view of the male member of Fig. 3 showing the forward end part of the thread;

Fig. 5 is a perspective view of the male member of Fig. 3 showing the rear end part of the thread;

Fig. 6 is a partial perspective view of the female member of Fig. 3 showing the forward end part of the thread;

20 **Fig. 7** is a partial perspective view of the female member of Fig. 3 showing the rear end part of the thread;

25 **Fig. 8** is a cross-sectional view taken in a plane passing through the axis A of the male and the female members when the unthreaded forward portion of the male coupling portion comes into initial contact with the unthreaded forward portion of the female coupling portion;

Fig. 9 is a cross-sectional view of the tool joint of Fig. 2 taken in a plane passing through the axis A;

Fig. 10 is a partial side view of a male member with a thread according to prior art;

Fig. 11 is a partial side view of a male member with a thread according to the present invention;

Fig. 12 is a rear view of the male member shown in Fig. 3;

Fig. 13 is a front view of the female member shown in Fig. 3;

5 **Fig. 14** is a cross-sectional view of the male member engaged with the female member taken in a plane XIV-XIV in Fig. 9; and

Fig. 15 is a cross-sectional view of the male member engaged with the female member taken in a plane XV-XV in Fig. 9.

10 DETAILED DESCRIPTION OF THE INVENTION

Attention is drawn to Figs. 2 to 11. As shown, a tool joint **20** having a longitudinal axis **A** comprises a male member **22** and a female member **24**. According to a specific application of the present invention, the tool joint **20** constitutes a cutting tool assembly where the male member **22** is made of cemented
15 carbide and constitutes a cutting head and the female member **24** is made of tool steel and constitutes a holding shank.

The male member **22** has a longitudinal axis **B**, a body portion **26** and a coupling portion **28** projecting rearwardly from the rear end **30** of the body portion **26**. The structure of the body portion **26** is not described since it is not an essential
20 feature of the present invention and it can be of any desired shape. The rear end **30** of the body portion **26** comprises a rearwardly facing annular shoulder surface **32**. The rearwardly facing annular shoulder **32** has rotational symmetry about the axis **B**, and is perpendicular thereto.

The coupling portion **28** has an unthreaded forward portion **36**, adjacent the
25 male body portion **26**, and a rear threaded portion **38** terminating at a rear end **39**. The unthreaded forward portion **36** of the male coupling portion comprises a frustoconical surface **40** that is rearwardly tapering towards the rear threaded portion **38** and is slanted at an angle α_1 with respect to the axis **B**. The angle α_1 is

typically in the range of 2.5° to 3.5° . According to a preferred embodiment of the present invention, the angle α_1 is 3° .

The rear threaded portion **38** of the coupling portion **28** has a thread **46** terminating in a forward end part **41** adjacent the forward portion **36** of the male coupling portion **28** and in a rear end part **43** adjacent the rear end **39** of the rear portion **38** of the male coupling portion **28**. The thread **46** has an intermediate section **45** of uniform depth between the forward end part **41** and the rear end part **43**. Similarly, the intermediate section **45** has a uniform height **h**, which is equal to the uniform depth and which is defined as the radial difference between the crest and the root of the thread. The thread **46** has a lead angle α measured with respect to a plane perpendicular to the axis **B**. Typically, the lead angle is in the range of 4° to 5° . The thread **46** has a trapeze cross-sectional shape with rounded edges. In order to avoid a narrow neck portion adjacent the forward portion **36** of the male coupling portion **28** thereby weakening the male member **22**, the forward end part **41** of the thread **46** is, as best seen in Figs. 4 and 5, a thread root **48** having a variable depth gradually decreasing from a depth equal to the uniform depth of the thread to no depth. Similarly, the rear end part **43** of the thread **46** is a thread crest **50** having a variable height gradually decreasing from a height equal to the uniform depth of the thread to no height.

A further thread property of relevance to the present invention is thread thickness **T**. The thread thickness **T** is defined herein as the maximum thickness of a crest measured along a line making an angle α with the axis **B**.

Fig. 10 shows a prior art thread on a male body **80**. The thickness of the thread is constant up to a point **P1** where the thread reaches the rear end **82** of the male body **80**. From the point defined **P1**, the thickness **T** of the thread gradually decreases till it becomes zero at the point **P2**. The portion **88** of the thread between points **P1** and **P2**, having a height **h** along a major part thereof, cannot be regarded

as an effective thread and since it is an incomplete thread it cannot adequately transfer load as can the complete thread. The portion **88** usually has an angular extent θ (not shown) as viewed in an end view of the thread that, for commonly used lead angles, is in the range of 120° to 270° . Concerning the terms “effective
5 thread”, “incomplete thread” and “complete thread”, reference is made to “Machinery’s Handbook 25 twenty fifth edition”, 1996, Industrial Press Inc., New York, pp. 1631-1634.

Despite the fact that the portion **88** cannot transfer load as the rest of the complete thread, and, therefore, it is unnecessary, it still has a height **h** along a
10 major part thereof. This means, that when the male body **80** is engaged within a corresponding female body (not shown), a proper female thread must be left for receiving the portion **88**. Such a female thread, that does not transfer load is also unnecessary and weakens the female body.

In order to overcome the aforementioned disadvantages, the thread in
15 accordance with the present invention is, as shown in Fig. 11, produced without the portion **88**. From the point **P1**, on the crest **50**, the thread gradually decreases to the point **P3** through an intermediate portion **92**. The point **90** is distanced from the axis **B** the same distance as the root **48** does. Usually, the intermediate portion **92** has an angular extent θ_1 of less than 30° , and typically having the value of 15° .
20 According to a preferred embodiment of the present invention the male member is made of cemented carbide and the thread is produced by grinding. The angular extent θ_1 of the intermediate portion **92** is determined by the radius of the grinding wheel used.

The principle described above, with the respective changes that have to be
25 made, is applied to both ends of the threads in the male and female members of the invention.

According to a preferred embodiment of the present invention, the rearwardly facing annular shoulder **32**, the frustoconical surface **40** and the thread **46** are ground.

The female member **24** has a longitudinal axis **C**, a side peripheral surface **58** and a front surface **60** connected to the side peripheral surface **58**. The front surface **60** has a ring shaped axially directed abutment surface **62** that has rotational symmetry about the axis **C** and is perpendicular thereto.

A bore **64** extends rearwardly from the front surface **60**. The bore **64** constitutes a coupling portion **59** of the female member and is forward to a female body portion **61**. The bore **64** has a forward portion **66** and a rear portion **68**. The forward portion **66** comprises a frustoconical surface **70** rearwardly tapering towards the female body portion **61** and slanted at an angle α_2 with respect to the axis **C**. The angle α_2 is in the range of 2.5° to 3.5° . According to the present invention, the angle α_2 is preferably 3° . The rear portion **68** has a thread **72**. The thread **72** has a trapeze cross-sectional shape with rounded-edges that mates with the thread **46** of the male member. The thread **72** terminating in a forward end part **63** adjacent the forward portion **66** of the female coupling portion **59** and in a rear end part **65** adjacent the female body portion **61**. The thread **72** has an intermediate section **67** of uniform depth between the forward end part **63** and the rear end part **65**. The thread **72** has a lead angle α the same as the lead angle of the thread **46** of the male member. As best seen in Figs. 6 and 7, the forward end part **63** of the thread **72** is a thread crest **74** having a variable height gradually decreasing from a height equal to the uniform depth of the thread to no height. The rear end part **65** of the thread **72** is a thread root **76** having a variable depth gradually decreasing from a depth equal to the uniform depth of the thread to no depth.

In order to assemble the tool joint the male member **22** is mounted in the female member **24** and rotated relative thereto with the male thread **46** engaging the

female thread **72**. The male thread **46** and the female thread **72** freely turn until the frustoconical surface **40** comes into initial contact with the frustoconical surface **70**. In this position, the rearwardly facing annular shoulder surface **32** is spaced a distance **L** from the abutment surface **62** (see Fig. 8). The length **L** is typically in the range of 0.1 mm to 0.6 mm. According to a preferred embodiment of the present invention, the length **L** equals 0.3 mm.

According to one embodiment of the present invention, the slant angle α_1 of the frustoconical surface **40** is equal to the slant angle α_2 of the frustoconical surface **70**. Thus, it is ensured that both frustoconical surfaces **40** and **70** come into full contact with each other. According to another embodiment of the present invention, the slant angle α_1 of the frustoconical surface **40** is greater than the slant angle α_2 of the frustoconical surface **70** by 0.25° . In accordance with this embodiment it is ensured that the initial contact between both frustoconical surfaces **40** and **70** is made at their front portions thereby increasing the rigidity of the tool joint in the forward connection portion between the male member **22** and the female member **24** near the shoulder surface **32** and the abutment surface **62**.

Following the initial contact between the frustoconical surfaces, the male member **22** is forcibly tightened against the female member **24** till the distance **L** is reduced to zero and the annular shoulder **32** of the male member abuts the abutment surface **62** of the female member. By bringing into abutment the two surfaces **32** and **62**, the frustoconical surface **40** of the male member causes a small radially outwardly deformation of the frustoconical surface **70** of the female member. The deformation is enabled due to the relative thinness of the wall of the female member in the region of the frustoconical surface **70**.

When the male member is fully engaged with the female member, the axes **A**, **B** and **C** overlap, the forward end part **41** of the thread of the male coupling portion and the forward end part **63** of the thread of the female coupling portion

have a gap **94** between them of a first angular extent $\theta 2$. Also, the rear end part **43** of the thread of the male coupling portion and the rear end part **65** of the thread of the female coupling portion have a gap **95** between them of a second angular extent $\theta 3$. The design of the threads ensures that the angular extent $\theta 2$ and the angular extent $\theta 3$ are both less than 90° , hence ensuring a strong and rigid engagement without having a relatively weak cross-section. Typically, the first and the second angular extents are in the range of 20° to 90° . Preferably, the first and the second angular extents are 70° .

The abutment between the surfaces **32** and **62** ensures rigidity in the periphery of the contact area between the male and female members. The abutment between the frustoconical surfaces **40** and **70** ensures concentricity between the male and the female members, and, furthermore, it carries a substantial part of the torque applied by the female member to the male member during a cutting operation. The special design of the full engagement between the threads of the male member and the female member eliminates relatively weak cross-sections thus increasing the entire strength of the tool joint.

The tool joint in accordance with the present invention is used for cutting tools having a cutting head diameter in the range of 6 to 20 mm. If desired, for increasing the rigidity of the cutting tool, the side peripheral surface of the body portion of the female member tapers forwardly at an acute angle β with respect to the axis **C**, the angle β being typically in the range of 0° to 5° . When it is desired, for example, to machine walls of deep pockets, the side peripheral surface **58** of the female member is made cylindrical having a diameter smaller than the diameter of the periphery **34** of the body portion of the male member, thereby, the machining depth is not limited by the holding shank.

It is understood that the tool joint of the cutting tool assembly described above is not restricted to a cutting head and a holding shank. For example, the tool

joint can be used as an extension of any two mating parts constituting male and female members.

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

CLAIMS:

1. A tool joint (20) having an axis A and comprising a male member (22) and a female member (24);

the male member having an axis B and comprising:

5 a male body portion (26); and

a male coupling portion (28) projecting rearwardly from the male body portion, the male coupling portion having an unthreaded forward portion (36) adjacent the male body portion and a rear threaded portion (38) terminating at a rear end (39);

10 the threaded portion of the male coupling portion having a thread (46) terminating in a forward end part (41) adjacent the forward portion of the male coupling portion and in a rear end part (43) adjacent the rear end of the rear portion of the male coupling portion, the thread having an intermediate section (45) of uniform depth between the forward and rear end parts (41, 43);

15 the forward end part (41) of the thread of the male coupling portion being a thread root (48) having a variable depth gradually decreasing from a depth equal to the uniform depth of the thread to no depth;

the rear end part (43) of the thread of the male coupling portion being a thread crest (50) having a variable height gradually decreasing from a height equal to the uniform depth of the thread to no height;

20 the female member having an axis C and comprising:

a female body portion (61); and

25 a female coupling portion (59) comprising a bore (64) for accepting the male coupling portion, the bore extending rearwardly from a front surface (60) of the female member towards the female body portion, the bore having an unthreaded forward portion (66) adjacent the front surface and a rear threaded portion (68) terminating adjacent the female body portion;

the threaded portion of the female coupling portion having a thread (72) terminating in a forward end part (63) adjacent the unthreaded forward portion of the female coupling portion and in a rear end part (65) adjacent the female body

portion, the thread of the female coupling portion having an intermediate section (67) between the forward and rear end parts, the thread of the female coupling portion having a depth equal to the uniform depth;

the forward end part (63) of the thread of the female coupling portion
5 being a thread crest (74) having a variable height gradually decreasing from a height equal to the uniform depth to no height;

the rear end part (65) of the thread of the female coupling portion being a thread root (76) having a variable depth decreasing from a depth equal to the uniform depth of the thread to no depth;

10 wherein, upon threaded coupling of the male and female members to form a tool joint connection, the threaded portion (38) of the male member engages the threaded portion (68) of the female member;

the forward end part (41) of the thread of the male coupling portion and the forward end part (63) of the thread of the female coupling portion have a gap (94)
15 between them of a first angular extent (θ_2); and

the rear end part (43) of the thread of the male coupling portion and the rear end part (65) of the thread of the female coupling portion have a gap (95) between them of a second angular extent (θ_3).

2. A tool joint according to claim 1, wherein the male body portion further
20 comprises a rearwardly facing annular shoulder (32) adjacent the unthreaded forward portion of the male coupling member and the front surface (60) of the female member is a forwardly facing annular shoulder; and

wherein, upon threaded coupling of the male and female members to form a tool joint connection, the annular shoulder of the male body portion abuts the annular
25 shoulder of the female body portion.

3. A tool joint according to claim 1, wherein the unthreaded forward portion (36) of the male coupling portion is frustoconical in shape, rearwardly tapering towards the rear threaded portion of the male coupling portion and the unthreaded forward portion

(66) of the bore of the female coupling portion is frustoconical in shape, rearwardly tapering towards the female body portion; and

wherein, upon threaded coupling of the male and female members to form a tool joint connection, the unthreaded forward portion of the male coupling portion abuts the unthreaded forward portion of the female coupling portion.

4. A tool joint according to claim 1, wherein the first angular extent is in the range of 20° to 90°.

5. A tool joint according to claim 4, wherein the first angular extent is 70°.

6. A tool joint according to claim 1, wherein the second angular extent is in the range of 20° to 90°.

7. A tool joint according to claim 6, wherein the second angular extent is 70°.

8. A tool joint according to claim 1, wherein the forward and rear end parts (41, 63; 43, 65) of the male and female threaded portions each have an angular extent in the range of 5° to 30°.

9. A tool joint according to claim 8, wherein the forward and rear end parts of the male and female threaded portions each have an angular extent of 15°.

10. A tool joint according to claim 1, wherein the male member is made of cemented carbide and the female member is made of steel.

11. A tool joint according to claim 2, wherein during the threaded coupling of the male and female members the unthreaded forward portion of the male coupling member abuts the unthreaded forward portion of the female coupling member before the annular shoulder of the male body portion abuts the annular shoulder of the female body portion.

12. A tool joint according to claim 11, wherein when the unthreaded forward portion of the male coupling portion comes into initial contact with the unthreaded forward portion of the female coupling portion the annular shoulder of the male body portion is spaced a distance L from the annular shoulder of the female body portion.

13. A tool joint according to claim 12, wherein the distance L lies in the range of 0.1 to 0.6 mm.

14. A tool joint according to claim 13, wherein the distance L equals to 0.3 mm.
15. A tool joint according to claim 2, wherein the annular shoulder of the male body portion and the annular shoulder of the female body portion are perpendicular to the axis A.
- 5 16. A tool joint according to claim 2, wherein the annular shoulder of the male body portion and the annular shoulder of the female body portion are ground.
17. A tool joint according to claim 2, wherein the unthreaded forward portion of the male coupling portion and the unthreaded forward portion of the female coupling portion are ground.
- 10 18. A tool joint according to claim 1, wherein the thread portion of the male member is ground.
19. A tool joint according to claim 3, wherein the unthreaded forward portion of the male coupling portion taper at an angle α_1 with respect to the axis B, the unthreaded forward portion of the female coupling portion taper at an angle α_2 with respect to the
- 15 axis C, the angle α_1 being equal to the angle α_2 .
20. A tool joint according to claim 19, wherein the angles α_1 and α_2 are in the range of 2.5° to 3.5° .
21. A tool joint according to claim 20, wherein the angles α_1 and α_2 are 3° .
22. A tool joint according to claim 19, wherein the angle α_1 is greater than the angle
- 20 α_2 by 0.25° .
23. A tool joint according to claim 1, wherein the thread portion of the male member and the thread portion of the female member are a single lead threads.