

PATENT SPECIFICATION

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(54) IMPROVEMENTS RELATING TO FASTENERS

(71) We, GKN SCREWS & FASTENERS LIMITED, a British company of Grove Street, Smethwick, Warley, in the County of Worcester, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to a method of making a self drilling fastener and to a fastener made thereby.

It is an object of the invention to provide a new or improved form of self-drilling fastener and a new or improved method of making such a fastener and of providing a drill point on a fastener blank.

According to the first aspect, the invention provides a method of forming a fastener drill point on a blank having a generally cylindrical end, the drill point comprising a pair of diametrically opposed straight flutes inclined in opposite directions at equal acute angles to the fastener axis and a pair of oppositely inclined planar surfaces intersecting at a fastener tip and having respective cutting edges, formed by the intersection of the surfaces with the flutes, the method comprises impressing the flutes by means of dies having flute-impressing means comprising for each flute two walls adapted to provide the respective flute with a leading and a trailing wall in planes intersecting at an angle substantially greater than 90° and substantially less than 180° to form said flute, the dies being moved relative to each other along a line inclined at an acute angle to both walls of said flute impressing means, the method including a further step of machining flats, being said oppositely inclined surfaces at the free end of the blank, said machining removing material up to the approximate position where the straight flutes most nearly meet across the fastener axis and the machining being performed at an angle controlled by the direction in which the flutes were impressed such that the machined flat surfaces intersect along a line which is directed

perpendicular to the axis and intersecting the angle between the leading and trailing walls of each flute, whereby a lip clearance angle is provided behind the cutting edge of each planar tip surface.

A turning operation may subsequently be performed to remove the extreme edges of the drill flutes to provide a slight land behind the trailing wall of each flute.

During the flute-impressing operation, the blank may be constrained against expansion laterally of the direction of relative movement of the dies.

According to a further aspect of the invention, there is provided a self-drilling fastener comprising a head, a shank including an externally screw threaded part adjacent the head, and a drill point at the end of the shank remote from the head, said drill point including a pair of diametrically opposed straight flutes inclined in opposite directions at equal acute angles to the axis of the shank, the flutes each being defined by a leading wall and a trailing wall in planes intersecting at an angle substantially greater than 90° and substantially less than 180°, the drill point also having a pair of planar faces at its free end, these faces being oppositely disposed with respect to the axis of the shank and equally angularly inclined thereto, said faces intersecting each other on a line of intersection passing through the axis and disposed at the region in which the flutes most nearly approach each other, each face having a respective cutting edge formed by its intersection with the trailing wall of the flute, said line of intersection of the faces also being angularly spaced, as measured about the axis of the shank, in advance of the cutting edge of each face, whereby the slope of the associated face away from the line of intersection provides a lip clearance angle behind said cutting edge.

The leading and trailing walls of each flute may intersect at an angle of approximately 120°.

A pair of further planar surfaces may be

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provided on the drill point, disposed parallel or generally parallel to the axis of the fastener at a part of the drill point which is of greatest diameter.

5 A slight land may be provided behind the trailing wall of each flute.

10 The point formation may taper overall, the smallest diameter being provided at the end thereof adjacent the threaded shank portion of the fastener.

The invention will now be described in more detail by way of example only with reference to the accompanying drawings in which:

15 Figure 1 is a front elevational view of part of a fastener blank after an initial flute forming operation has been performed thereon,

Figure 2 is a view taken along the arrow A in Figure 1,

20 Figure 3 is a sectional view taken along the line B—B of Figure 1,

Figure 4 is a front elevational view of a point formed after a further operation has been performed on the blank,

25 Figure 5 is an underneath plan view of the drill point shown in Figure 4,

Figure 6 is an elevational view taken along the arrow C of Figure 5,

30 Figure 7 is a front elevational view, similar to Figure 4, but of an alternative form of point embodying the invention,

Figure 8 is an underneath plan view of the drill point shown in Figure 7 and similar to the view shown in Figure 5,

35 Figure 9 is a diagrammatic elevational view of a point formation on which a further machining operation has been carried out,

Figure 10 is an underneath plan view of the point formation of Figure 9,

40 Figure 11 is a view on the arrow D of Figure 10,

Figure 12 is a view taken at right angles to the view shown in Figure 9,

45 Figure 13 is an underneath plan view similar to Figure 8 but of a point formation following a further machining operation.

Figure 14 is an underneath plan view similar to Figure 13 but following a turning operation,

50 Figure 15 is a sectional view similar to Figure 3 but illustrating the effect of a turning operation performed on the drill point,

55 Figure 16 illustrates the formation of a modified form of drill point in a forging die, and

Figure 17 is a scrap section on the line B—E of Figure 14.

60 The formation of a drill point according to the invention starts with the formation of a headed blank 10. This may either be provided with an externally threaded shank or be of such a diameter as to permit a thread to be formed thereon. The cylindrical end of the blank 10 which is to have a drill point formed

thereon will be referred to as the "free end portion" 11. 65

A pair of co-operating dies are used in a hot or cold forming operation on the free end portion to form a pair of straight flutes 12 as shown in Figures 1—4 of the drawings. 70

During the forming operation, the free end portion of the shank is squeezed between the co-operating dies which are so shaped that the material of the shank flows to provide a pair of diametrically opposed flutes 12 which are inclined in opposite directions so as to define equal acute angles b with respect to the axis 13 of the shank. The flutes are straight and not helical in formation. 75

The forming operation will be referred to in more detail later. 80

The metal displaced by the formation of the flutes 12 may form a pair of bulges 14 and the forming operation is such that these bulges increase the maximum transverse dimension of the shank, as measured perpendicular to the shank axis, to a value which is somewhat greater than the desired minor diameter of the threaded portion of the shank. When the final drill point is formed by further operations on the free end portion of the fastener, the size of the hole drilled by the drill point will be sufficient to allow penetration of the fastener but will not be so large that a self tapping thread on the shank portion 10 cannot tap its own hole. 85 90 95

Turning now to Figure 2 of the drawings, in which we view the partly formed fastener along one of the flutes 12, it will be seen that the flute is of generally V-shape having a pair of side walls 15 which intersect on a straight line 16. These leading and trailing walls are displaced from each other by an included angle of $2a$. The angles a and b referred to above are shown so as to give the correct "rake angle" to the finished drill point, (in a manner to be described later). 100 105

Because the flutes are straight and oppositely disposed, there is a region indicated by the arrow X in Figure 1 at which the centre line 16 of each flute most nearly approaches the other across the axis of the shank. In this region, the web between the two flutes is thinnest and the position of this cross-over region X needs to be established before proceeding to the next step of the pointing operation. 110 115

In order to form a satisfactory drill point, a machining operation is performed on the free end portion 11 of the blank which is in the condition shown in Figures 1, 2 and 3 of the drawings. Two flat, equally angularly inclined planar faces are formed by machining away or otherwise removing metal from the free end portion 11 of the shank to a point at or adjacent the cross-over region X of the flutes, in order to form a drill point having a chisel shaped extremity and two flutes tapering away therefrom. In the embodiment of Figures 1 to 6, the planar faces intersect 120 125

above the cross-over point in Figures 7, 8, 13 and 14, they intersect below, and in Figures 9—12 they intersect/substantially at the cross-over point.

Thus, the machining or other forming operation is carried out to remove metal below the section line B—B in Figure 1 to produce a preliminary drill point as shown in Figure 4 of the drawings.

The operation is carried out in any suitable manner which will provide two inclined flat faces. For example, a V-section broaching tool can be applied to the end of the fastener in a direction coinciding with the direction of the desired line of intersection of the two flat faces, that is the chisel point of the finished drilling fastener. Alternatively, the faces could be formed by milling or grinding for example, provided that they are substantially flat. The faces define equal angles relative to the fastener axis, and in Figure 6 the complementary angle d is marked, this angle being used later in calculation of the rake angle of the flutes.

Referring to Figures 4, 5 and 6 of the drawings, the planar faces are indicated at 17 and their line of intersection, the chisel point of the fastener, is indicated at 18.

The position of the line of intersection 18 is an important factor in ensuring that the drill point functions correctly. If the fastener is correctly aligned for the formation of the flat faces, 17, the line of intersection 18 will be slightly in advance of each of the cutting edges 19. Thus the cutting edge 19 is in each case spaced behind the line 18 defining the chisel point and so that the metal of the fastener is sloping away from the line 18 to provide a sufficient lip clearance angle behind the cutting edge 19 of each flute for drilling purposes.

Before the machining operation is carried out, it is necessary to orientate the fastener blanks correctly so that a predetermined angle c is defined between the direction of the arrow C (that is, along the line of intersection 18) and the part of the fastener having the widest transverse dimensions taken perpendicular to the axis, to ensure that the chisel point is correctly disposed with respect to the cutting edges 19. If a broaching tool is used to form the point, the tool acts in the direction of the arrow C.

In the preliminary point shown in Figures 1—6 of the drawings, the planar faces 17 intersect just above the cross-over point X of the flutes 12.

Figures 7 and 8 show a preliminary point in every way similar to that previously described except that the planar faces 17a intersect just below the cross-over region X (see Figure 7). This formation means that the cutting edges of the flutes are straight, right up to the chisel point 18a of the fastener and this gives somewhat better cutting properties than the previously described embodiment,

where a slight radius occurs on the cutting edges adjacent the chisel point. This feature can be seen by comparing the slightly radiused central region of the cutting edge 19 of Figure 5, with the completely straight cutting edge 19a of Figure 8.

Further operations are advantageously performed on the preliminary drill point to give good drilling performance and the first such operation is the machining away or otherwise removing of metal from the outwardly bulged portions of the point formation. The effect of this operation is illustrated in Figures 9—11 which also illustrate the inclined planar faces 17b intersecting substantially at the cross-over region X. In this case the cutting edges 19b of the point formation are again slightly radiused at their intersection with the chisel point 18b.

Referring to Figures 9 to 11 of the drawings, a further pair of planar surfaces 20 are provided on the drill point at its widest part, that is the part 14 which is caused to bulge outwardly during the formation of the drill flutes (see Figure 1). These surfaces 20 may be precisely parallel to each other and equally spaced on opposite sides of the fastener axis or may be inclined towards each other at a small angle such that the widest part of the fastener occurs at the place indicated by 21 in the drawings. Alternatively the surfaces 20 may be stepped inwardly behind the place indicated at 21.

The surfaces 20 and the faces 17b formed at the point of the fastener may all be perpendicular to a single imaginary plane, for example as generally indicated at 22 in the drawings and passing through the axis of the fastener. The imaginary plane coincides with the plane of the paper in Figure 11 of the drawings. When this is the case, it is possible to form the faces 17b and surfaces 20 simultaneously, if desired. However, it is not essential that the surfaces 20 are parallel to the line of intersection 18 of the flat faces 17b if these are machined separately.

To prevent undue wear of, or damage to the cutting edges of the drill flutes, a further turning operation may be performed, as illustrated by comparing Figures 13 and 14. This removes the acute angle otherwise left at the flute edges by machining of the planar side surfaces 20. It will be seen that the angle between the turned surface 23 and the cutting edge 19 is greater than 90° and thus the cutting edge is comparatively strong. Preferably, the turning operation does not wholly remove the flat surfaces 20, thereby allowing a clearance behind the flute edges and reducing friction.

If the acute angled edges provided by machining or otherwise forming the flats 20 are left on the fastener, some difficulties may occur in drilling of deep holes in particular, since progressive wear takes place particularly

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on the edges of the trailing walls of the flutes and particularly towards the axial extremity of the point so that an outward taper tends to be formed from the drill point as drilling progresses. A machining operation is performed to remove metal lying outside the circle indicated at 23 in the Figures 14 or 15 of drawings, thereby removing the extreme edges of the flutes producing a slight land behind the trailing wall of the flute in particular.

The same machining operation may be used to provide a reduction in diameter behind the extreme tip of the drill point so as to provide some chip clearance and reduce frictional resistance to turning. This may result in a shoulder being formed at or adjacent the region indicated at 24 in Figures 9 and 11 or may simply provide a straight-forward taper to the forward end of the fastener, the part 21 remaining the broadest part of the drill point.

Instead of, or prior to machining the planar side surfaces 20, the sides of the point formation may be flattened during the flute-forming operation. The dies used in the initial flute forming operation may be similar to the arrangement shown diagrammatically in Figure 16 of the drawings in which the lower die 25 has a pair of flattened laterally opposed surfaces 26 which restrain the metal from flowing outwardly to any great extent at the region 14. This prevents any possibility of rupture occurring around the narrowest region X of the flute formation and also restricts the amount to which the bulges 14 are allowed to be formed. Furthermore, if the dies are shaped with flat surfaces 26, it may not be necessary to carry out a subsequent machining operation to produce the flats 20.

It will be seen from Figure 16 that the dies are moved towards each other in a direction which is at an acute angle to the leading wall and to the trailing wall of the flutes at any given point, in contrast to a previously proposed method of forming flutes in which the dies were moved together in a direction perpendicular to one pair of faces of the flutes being formed.

By the use of dies such as those shown in Figure 16 of the drawings, it is possible to provide any desired rake angle on the leading wall of the flute quite readily.

The geometry of the fastener point can be chosen to give any suitable rake angle and also to give sufficient lip clearance angle behind the cutting edge 19 of the planar tip surface.

The angles a , b , c and d referred to above may be selected and by simple trigonometry it is possible to derive certain intermediate angles p , q which can be used to calculate the values of rake angle and lip clearance angle obtained using the chosen values of a , b , c and d .

Figure 17 is a sectional view on the line B—E of Figure 14 and indicates the position of the rake angle x and lip clearance y . This section is taken in a plane parallel to the axis of the fastener and intersecting the leading wall at an angle of 90° . The rake angle x enables the chippings thrown up by the drill point to be cleared away upwardly from the point and the lip clearance y enables frictional resistance to rotation of the drill point to be kept to a minimum, even if some wear occurs on the extreme cutting edge.

The relationship between the chosen angles a , b , c and d and the derived intermediate angles p and q are as follows:

$$\tan p = \tan a / \cos b$$

$$q = c + p - 90^\circ$$

Having derived the intermediate angles p and q , the rake angle x can be calculated according to the following equation.

$$\tan x = \tan b \cdot \cos p$$

The lip clearance angle y can be calculated from the following relation:

$$\tan y = \tan d \cdot \cos q$$

Thus for example if

$$\left. \begin{array}{l} a=60^\circ \\ b=20^\circ \\ c=70^\circ \\ d=30^\circ \end{array} \right\} \text{ then } \begin{array}{l} x=10^\circ \text{ approximately} \\ y=23^\circ \text{ approximately} \end{array}$$

It will be appreciated that a change in any one of the chosen variables a , b , c or d will give rise to a change in the rake angle and lip clearance angle.

WHAT WE CLAIM IS:—

1. A method of forming a fastener drill point on a blank having a generally cylindrical end, the drill point comprising a pair of diametrically opposed straight flutes inclined in opposite directions at equal acute angles to the fastener axis and a pair of oppositely inclined planar surfaces intersecting at a fastener tip and having respective cutting edges, formed by the intersection of the surfaces with the flutes, the method comprising impressing the flutes by means of dies having flute-impressing means comprising for each flute two walls adapted to provide the respective flute with a leading and a trailing wall in planes intersecting at an angle substantially greater than 90° and substantially less than 180° to form said flute, the dies being moved relative to each other along a line inclined at an acute angle to both walls of said flute-impressing means, the method including a further step of machining flats, being said



on the edges of the trailing walls of the flutes and particularly towards the axial extremity of the point so that an outward taper tends to be formed from the drill point as drilling progresses. A machining operation is performed to remove metal lying outside the circle indicated at 23 in the Figures 14 or 15 of drawings, thereby removing the extreme edges of the flutes producing a slight land behind the trailing wall of the flute in particular.

The same machining operation may be used to provide a reduction in diameter behind the extreme tip of the drill point so as to provide some chip clearance and reduce frictional resistance to turning. This may result in a shoulder being formed at or adjacent the region indicated at 24 in Figures 9 and 11 or may simply provide a straight-forward taper to the forward end of the fastener, the part 21 remaining the broadest part of the drill point.

Instead of, or prior to machining the planar side surfaces 20, the sides of the point formation may be flattened during the flute-forming operation. The dies used in the initial flute forming operation may be similar to the arrangement shown diagrammatically in Figure 16 of the drawings in which the lower die 25 has a pair of flattened laterally opposed surfaces 26 which restrain the metal from flowing outwardly to any great extent at the region 14. This prevents any possibility of rupture occurring around the narrowest region X of the flute formation and also restricts the amount to which the bulges 14 are allowed to be formed. Furthermore, if the dies are shaped with flat surfaces 26, it may not be necessary to carry out a subsequent machining operation to produce the flats 20.

It will be seen from Figure 16 that the dies are moved towards each other in a direction which is at an acute angle to the leading wall and to the trailing wall of the flutes at any given point, in contrast to a previously proposed method of forming flutes in which the dies were moved together in a direction perpendicular to one pair of faces of the flutes being formed.

By the use of dies such as those shown in Figure 16 of the drawings, it is possible to provide any desired rake angle on the leading wall of the flute quite readily.

The geometry of the fastener point can be chosen to give any suitable rake angle and also to give sufficient lip clearance angle behind the cutting edge 19 of the planar tip surface.

The angles a b c and d referred to above may be selected and by simple trigonometry it is possible to derive certain intermediate angles p , q which can be used to calculate the values of rake angle and lip clearance angle obtained using the chosen values of a b c and d .

Figure 17 is a sectional view on the line E—E of Figure 14 and indicates the position of the rake angle x and lip clearance y . This section is taken in a plane parallel to the axis of the fastener and intersecting the leading wall at an angle of 90° . The rake angle x enables the chippings thrown up by the drill point to be cleared away upwardly from the point and the lip clearance y enables frictional resistance to rotation of the drill point to be kept to a minimum, even if some wear occurs on the extreme cutting edge.

The relationship between the chosen angles a b c and d and the derived intermediate angles p and q are as follows:

$$\tan p = \tan a / \cos b$$

$$q = c + p - 90^\circ$$

Having derived the intermediate angles p and q , the rake angle x can be calculated according to the following equation.

$$\tan x = \tan b \cdot \cos p$$

The lip clearance angle y can be calculated from the following relation:

$$\tan y = \tan d \cos q$$

Thus for example if

$$\left. \begin{array}{l} a=60^\circ \\ b=20^\circ \\ c=70^\circ \\ d=30^\circ \end{array} \right\} \text{ then } \begin{array}{l} x=10^\circ \text{ approximately} \\ y=23^\circ \text{ approximately} \end{array}$$

It will be appreciated that a change in any one of the chosen variables a b c or d will give rise to a change in the rake angle and lip clearance angle.

WHAT WE CLAIM IS:—

1. A method of forming a fastener drill point on a blank having a generally cylindrical end, the drill point comprising a pair of diametrically opposed straight flutes inclined in opposite directions at equal acute angles to the fastener axis and a pair of oppositely inclined planar surfaces intersecting at a fastener tip and having respective cutting edges, formed by the intersection of the surfaces with the flutes, the method comprising impressing the flutes by means of dies having flute-impressing means comprising for each flute two walls adapted to provide the respective flute with a leading and a trailing wall in planes intersecting at an angle substantially greater than 90° and substantially less than 180° to form said flute, the dies being moved relative to each other along a line inclined at an acute angle to both walls of said flute-impressing means, the method including a further step of machining flats, being said



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oppositely inclined surfaces at the free end of the blank, said machining removing material up to the approximate position where the straight flutes most nearly meet across the fastener axis and the machining being performed at an angle controlled by the direction in which the flutes were impressed such that the machined flat surfaces intersect along a line which is directed perpendicular to the axis and intersecting the angle between the leading and trailing walls of each flute, whereby a lip clearance angle is provided behind the cutting edge of each planar tip surface.

2. A method according to Claim 1 wherein a turning operation is subsequently performed to remove the extreme edges of the drill flutes to provide a slight land behind the trailing wall of each flute.

3. A method according to Claim 1 or Claim 2 wherein during the flute impressing operation, the blank is constrained against expansion laterally of the direction of relative movement of the dies.

4. A self-drilling fastener comprising a head, a shank including an externally screw threaded part adjacent the head, and a drill point at the end of the shank remote from the head, said drill point including a pair of diametrically opposed straight flutes inclined in opposite directions at equal acute angles to the axis of the shank, the flutes each being defined by a leading wall and a trailing wall in planes intersecting at an angle substantially greater than 90° and substantially less than 180° , the drill point also having a pair of planar faces at its free end, these faces being oppositely disposed with respect to the axis of the shank and equally angularly inclined thereto, said faces intersecting each other on a line of intersection passing through the axis and disposed at the region in which the flutes most nearly approach each other, each face having a respective cutting edge formed by its intersection with the trailing wall of the flute, said line of intersection of the faces also being angularly spaced, as measured about the axis of the shank, in advance of the cutting edge of each face, whereby the slope of the associated face away from the line of intersection provides a lip clearance angle behind said cutting edge.

5. A fastener according to Claim 4 in which

the leading and trailing walls of each flute intersect at an angle of approximately 120° .

6. A fastener according to Claim 4 or Claim 5 in which a pair of further planar surfaces are provided on the drill point, disposed parallel or generally parallel to the axis of the fastener at a part of the drill point which is of greatest diameter.

7. A fastener according to Claim 4, 5 or 6 wherein a slight land is provided behind the trailing wall of each flute.

8. A fastener according to any one of Claims 4 to 7 wherein the point formation tapers overall, the smallest diameter being provided at the end thereof adjacent the threaded shank portion.

9. A fastener having a drill point formed by the method of any one of claims 1 to 3.

10. A method of forming a drill point on a fastener blank according to Claim 1 and substantially as hereinbefore described.

11. A self-drilling fastener substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 6 of the accompanying drawings.

12. A self drilling fastener substantially as hereinbefore described with reference to and as illustrated in Figures 7 and 8 of the accompanying drawings.

13. A self drilling fastener substantially as hereinbefore described with reference to and as illustrated in Figures 9 to 12 of the accompanying drawings.

14. A self-drilling fastener substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 6, or 7 and 8: or 9 to 12: of the accompanying drawings as modified by Figures 14, 15 and 17.

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