

APPARATUS AND METHOD FOR APPLYING A FLUID TO A COMPONENT

5 The present invention relates to an apparatus and method for applying a fluid to a component. The invention is particularly but not exclusively related to an apparatus and method for applying a chemical etchant to a target area of a component.

10 Chemical etching is a commonly used technique for removing one or more surface layers from a metallic component. An acid, base, or other chemical etchant fluid is applied to an area of a component for a period of time and dissolves a surface layer of the component. Various methods may be used to bring the etchant fluid into contact with the component.

15 One known method involves filling a large tank with etchant fluid and immersing a component in the fluid. Masking material may be used to prevent the etchant fluid removing a surface layer from the entirety of the component. Etch tanks may have a negative environmental impact, as well as being inefficient and costly to run. They may also produce large quantities of gas and fluid emissions. Specialist disposal of used and waste product is required, increasing maintenance and running costs. Additional
20 finishing operations are also often required to counteract the effects of the etchant fluid where etching was not required, even when a suitable masking material is used.

25 Another known method of applying etchant fluid to a component is "swab etching", where a liquid etchant is painted on to a surface of a component for a given time. This often results in unsightly and inconvenient "runs" of etchant fluid straying into areas where surface etching was not required. Swab etching is also a comparatively labour intensive method of surface etching, involving close operator contact with hazardous chemicals

Etchant fluids may be heated or subjected to ultraviolet stimulation to increase etch rate. However, in combination with the above methods, these practices involve high capital cost as well as increased labour and etchant response is subject to line of sight and illumination issues

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A particularly difficult problem in surface etching is the removal of material from fine surface features such as are found in laser cut, machined or welded surfaces and the interfaces between such surfaces. Weld contours, particularly in root and toe regions, present difficulties for the manipulation of line of sight based material removal processes. Welds constitute points of material micro structural variation and it is therefore undesirable to unduly thin a weld region or to introduce additional stresses through machining.

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Summary of Invention

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According to the present invention, there is provided apparatus for applying a fluid to a target area of a component, comprising a fluid applicator and means for guiding the fluid applicator along a predetermined path with respect to the component; the fluid applicator comprising a body, an application head mounted on the body and operable in use to be brought into physical contact with the component, and means for controlling the temperature of the fluid to be applied to the component.

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The fluid may be any one of a chemical etchant, scale conditioner, washing fluid and/or neutralising solution. The fluid may be of increased viscosity and may be a paste or gel. The paste may be thixotropic.

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The body may be formed from a deformable material. The body may thus accommodate variations in surface geometry of the component such as convex and concave regions, edge regions and re-entrant features.

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The application head may comprise a brush having a brush head and a plurality of agitators which may be bristles or fins. Advantageously, the agitators of the brush act to scrub a component surface, forcing etchant fluid into fine surface features and also removing unwanted fluid from such features.

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The brush head may comprise an opening, suitable to deposit or collect fluid. The apparatus may further comprise means to apply positive and/or negative pressure at the opening. The brush head may comprise at least two such openings and the apparatus may further comprise means to apply positive pressure at one opening and
10 negative pressure at another opening. The openings may comprise two or more independent sections of a single orifice, thus allowing simultaneous deposition and collection of fluid.

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The apparatus may comprise means for controlling the temperature of the fluid to be applied to the component. It may be desirable for the fluid to be delivered at a raised temperature or at a controlled ambient temperature, according to the particular fluid to be applied.

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The brush may be mounted for rotation about an axis that is substantially parallel to a surface of the body on which it is mounted, a surface of the brush head from which the agitators project being substantially cylindrical. In this manner, the brush may pass over the component surface in a manner similar to that of a vacuum cleaner, the agitators scouring the component surface.

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The plurality of agitators may project from the surface of the brush head in a helical pattern that winds about the brush head. The plurality of agitators may project from the surface of the brush head in at least one chevron pattern, which may be formed about the at least one opening of the brush head.

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The brush may be mounted for rotation about an axis that is substantially normal to a surface of the body on which it is mounted, a surface of the brush head from which the agitators project being substantially planar.

The brush may comprise at least two regions, the regions being operable to rotate in different directions. The regions may be concentric.

The plurality of agitators may project from the planar surface in a spiral configuration.

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The length and stiffness of the agitators may vary across the brush. The brush may comprise regions of different length and/or stiffness agitators.

The brush may be mounted for rotation in both clockwise and anticlockwise directions.

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The agitators of the brush head may comprise bristles or they may comprise fins.

A plurality of brushes may be mounted for rotation on the body of the fluid applicator about parallel axes.

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At least two of the plurality of bushes may comprise different agitator configurations.

The means for guiding may comprise a mechanical manipulation arm on which the fluid applicator may be operable to be mounted.

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The means for guiding may comprise a track, along which the fluid applicator may be operable to be driven. The track may be formed from a deformable material and may be assembled into a frame. The track may comprise a racked surface/rack and pinion arrangement.

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The means for guiding may further comprise means for manipulating the component.

According to another aspect of the present invention, there is provided a method of applying a fluid to a target region of a component using an apparatus of the first aspect of the present invention, comprising connecting a fluid supply to the fluid applicator,

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mounting the fluid applicator on the means for guiding the applicator along a predetermined path, bringing the applicator head into physical contact with the target region of the component, causing the applicator to be guided along the predetermined path while depositing fluid through the applicator from the fluid supply, and controlling
5 the temperature of the fluid to be applied to the component.

The fluid may be any one of a chemical etchant scale conditioner, washing fluid and/or neutralising solution. The fluid may be of increased viscosity and may be a paste or gel. The paste may be thixotropic.

10 The means for guiding may comprise a flexible track and the method may further comprise locating the flexible track about the component, such that the applicator traces the predetermined path along the component when travelling along the track. Locating the flexible track may comprise constructing a frame of the flexible track about
15 the component.

The means for guiding may comprise a mechanical manipulation arm and the method may further comprise programming the mechanical manipulation arm to move the applicator such that the applicator traces the predetermined path along the component.

20 The method may further comprise mounting the component for rotation.

The means for guiding may further comprise means for manipulating the component, the method may further comprise mounting the component on the means for
25 manipulating the component, and the various means for guiding may cooperate to cause the applicator to be guided along the predetermined path.

Depositing fluid through the applicator may comprise applying pressure to the fluid at a fluid opening in the application head. Depositing fluid through the applicator may also
30 comprise causing the application head to rotate.

The method may further comprise collecting fluid under a negative pressure applied at the opening in the application head.

5 The method may further comprise controlling the temperature of the component. The method may further comprise heating and/or cooling the component.

According to another aspect of the present invention, there is provided a chemical etchant comprising titanium dioxide as a thickening agent. The viscosity of the etchant may be above that of the constituent etchants and more specifically between 400 –
10 7500 cP. Viscosity enhancing media may also include inert oxide powders or gels.

According to another aspect of the present invention, there is provided an applicator for depositing a fluid on a component surface, comprising a body, a brush mounted for rotation on the body, the brush comprising a brush head and a plurality of bristles and a
15 fluid passage extending through the brush head and comprising at least one opening that communicates with a bristled surface of the brush head.

The fluid may comprise etchant, detergent containing wash fluid, scale conditioner or neutralising agents.
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The fluid passage may comprise two sub passages, operable to be brought into communication with each other.

Brief Description of the Drawings

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For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the following drawings in which:

30 Figure 1 illustrates a typical weld line in a component;

Figure 2 illustrates a fluid applicator on a component;

Figure 3 shows expanded sectional and side views of a fluid applicator in contact with a component;

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Figure 4a, b and c illustrate a sample application head in the form of a brush deforming on application under variable pressure;

Figure 5 illustrates differences in brush contact area resulting from deformation under variable pressure;

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Figure 6 shows a rectangular bristle configuration;

Figure 7 shows a curved bristle configuration;

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Figure 8 shows a varying bristle configuration;

Figures 9 and 10 show contra-rotating or oscillating brushes;

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Figure 11 illustrates a fluid applicator and brush/ bristle arrangement;

Figure 12 illustrates an advantageous arrangement of brushes on a body of a fluid applicator and resultant etchant flow path;

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Figure 13 is a leading end view of a fluid applicator in position over a component;

Figures 14 and 15 are end views of an example brush showing bristle configurations;

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Figure 16 illustrates an end and sectional view of a brush;

Figure 17 is a side view of a fluid applicator in position on a component;

Figure 18 shows attachment arms;

5 Figure 19 illustrates an application head in the form of a rotating or oscillating brush;

Figure 20 shows a brush arrangement on a fluid applicator;

10 Figure 21 shows a bristle arrangement on a brush;

Figure 22 illustrates a frame constructed around a component;

Figure 23 illustrates a mechanical manipulation arm;

15 Figure 24 shows a treatment arrangement for rotating a component about an axis whilst maintaining applicator position;

Figures 25a-e show a temperature control arrangement; and

20 Figure 26 shows a diagrammatic view of the temperature control arrangement of Figures 25a-e.

Detailed Description of Preferred Embodiments

25 The present invention relates to an apparatus and method for applying a fluid such as a chemical etchant to a target area of a component. The following description uses the example of a weld line as a target feature of a component, an area of which may be appropriate for chemical etching. Figure 1 illustrates a typical weld line 2, such as
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be found on a metallic drum assembled using electron beam welding, around which is a heat affected zone 4. If the drum is produced from titanium, an alpha case layer can occur within the heat affected zone 4. This layer is understood to be an oxygen enriched surface layer of titanium that acts to reduce the fatigue life of the component.

5 It is therefore desirable to remove this alpha case layer using a locally applied chemical etchant including for example Nitric, Hydrofluoric, Hydrochloric or Hydrofluorosilic acids. The etchant is applied over a target area 8 that includes the weld line 2, the heat affected zone 4 and a safety zone 6. It will be appreciated that the present invention is suitable for use with a wide range of surface features, a weld being used merely as a
10 convenient example. The range of application for the invention also includes the entire surface of an aerofoil, blisk or hub including edge and radius/ fillet features.

One aspect of the present invention involves the development of a particularly advantageous chemical etchant for use with the apparatus and method of the invention.

15 Known etchant combinations, such as those employing Hydrofluorosilic acid with Nitric acid or Hydrofluoric acid with Nitric acid are enriched with Titanium Dioxide. TiO_2 acts as a thickening agent, increasing the viscosity of the etchant to that of a paste. Water based gel and other inert oxide powders may also be employed as a thickening agent to achieve the required viscosity, at which the paste will substantially adhere to a
20 component surface, and will not run along the surface. It is a requirement of the etchant paste that it must remove a controlled and uniform layer of between 0.5 and 15.0 μm . Certain applications may require removal of a layer of up to 75.0 μm .

With reference in particular to Figures 2 and 3, an apparatus 5 for applying a fluid to a
25 target area of a component comprises a fluid applicator 10 and means for guiding the fluid applicator along a predetermined path (partially illustrated at 12). The fluid applicator 10 comprises a body 14 and two pairs 16, 18 of application heads in the form of brushes. The brushes are mounted on the body 10 for rotation about parallel axes 20, 22, each of which extends substantially normally to the surface 24 of the body 10 on
30 which the brushes are mounted. In use, the apparatus is brought into proximity with a

component 26, a target area of which is to have etchant fluid applied. Once in position, the means for guiding the fluid applicator 10 causes the applicator to advance towards the component (indicated at arrow 27) such that the brushes are brought into physical contact with a surface 28 of the component 26. Relative motion between the fluid
5 applicator 10 and the component 26 is brought about, as indicated by arrows 29, and the fluid applicator 10 deposits a layer of etchant fluid 30 on the surface 28 of the component 26. The fluid applicator 10 will pass over the surface of the component 26 at least once to deposit etchant fluid 30 and at least once to remove etchant fluid 30. That is to say, the fluid applicator 10 will make at least two passes over the surface of
10 the component 26, at least one of the passes being to apply etchant fluid 30, and at least one of the passes to remove etchant fluid 30. The fluid applicator 10 may also pass over the surface of the component 26 to agitate the etchant fluid 30. Further detail of the process by which etchant fluid is supplied to the fluid applicator and depositing on the surface are discussed below.

15 Figure 3 shows expanded sectional and side views of the fluid applicator 10 in contact with the component 26. Each pair 16, 18 of applicator heads comprises two brushes 32, 34, 36, 38, each of which is mounted for independent rotation. An optional extra pair of application heads 40 is illustrated in the sectional view. Further detail of this and
20 other configuration options for the applicator heads is discussed below. With particular reference to the side view of Figure 3, each brush 32, 34, 36, 38 in each pair 16, 18 of brushes rotates in an opposite direction. Thus the leading pair 16 of brushes 32, 34 rotate inward with respect to each other and the direction of advance, from right to left across Figure 3. It will be understood that each pair 16, 18 of brushes may be replaced
25 by a single brush, positioned along the centre line of the target area, in this case the weld line 3. Each single brush may rotate clockwise or anticlockwise as required.

It will be appreciated that the outer extent of the target area 8 over which the etchant fluid is deposited is defined by the extent of the safety zone 6. It may be desirable to
30 vary the width of the safety zone 6 during application of etchant fluid. Such variation

may be achieved through appropriate brush selection and manipulation of the separation between the fluid applicator 10 and the component 26. Figure 4a illustrates a sample application head in the form of a brush 50, which may be representative of any of brushes 32, 34, 36, 38 described above. The brush 50 comprises a brush head 52 and a plurality of agitators 54. The agitators may be bristles, as illustrated, or may take the form of fins. The following description refers to agitators in the form of bristles 54, but it will be appreciated that the description could equally be applied to agitators 54 in the form of fins. The bristles 54 project from the brush head 52 to define a domed brush periphery, the furthest extent of which is brought into contact with the surface 28 of the component 26 by a comparatively light force F_1 . This light force results in a relatively small contact area A_1 between brush bristles 54 and component 26 at the component surface 28. The bristles 54 of the brush 50 are relatively flexible and may be deformed as illustrated in Figures 4b and 4c. A larger force F_2 may be applied to the brush 50, deforming the longest bristles and bringing more of the domed periphery 56 into contact with the component surface 28, resulting in a larger contact area A_2 . A larger force still F_3 may be applied, as illustrated in Figure 4c, resulting in a further increased contact area A_3 . The difference in contact area that can be achieved is illustrated in Figure 5. The target area over which etchant fluid is applied can thus be varied according to requirements. Deformable bristles having a domed periphery as illustrated may also be particularly applicable for certain geometries of feature within the target etch area. For example, certain weld geometries may be suited to longer, deformable bristles such as those illustrated in Figure 4a.

Figures 6, 7 and 8 illustrate bristle configuration options for brush 50. The plurality of bristles 54 may define a rectangular, planar brush, as illustrated in Figure 6, a domed brush, as illustrated in Figures 4a and 7, or the bristles may define a brush having concentric annular steps, as illustrated in Figure 8. The strength and type of bristle may also vary within the brush head. For example and with reference to Figure 9, the brush 50 may comprise an inner core of short, firm bristles 56, a concentric ring of longer, medium strength bristles 58 and an outer surrounding concentric ring of longer soft

bristles capable of increased deformation. Such variation in bristle length and strength results in a progressive scrubbing effect. Varying the separation between the fluid applicator 10 (and hence brush 50) and the component surface 28 not only alters the deformation of the softer outer bristles but may also determine the thickness of the fluid etchant layer deposited on the surface.

Each of the example brushes 50 illustrated in Figures 6 to 8 is shown rotating in a regular manner in a single direction. However, a single brush 50 may include contra-rotating or oscillating sections, as illustrated in Figures 9 and 10. An inner core 56 of stiff bristles may rotate in a different direction to an intermediate ring 58, which in turn is rotating in a different direction to the radially outer ring 60. Such contra-rotation or oscillation provides increased agitation to the etchant fluid being dispensed, improving the mixing of titanium ions from the substrate into the solution and thus assisting with the surface layer removal process. In addition, contra-rotating or oscillating sections help to ensure that bristles contact all the variable surface geometry and undulating features associated with surface finishes such as welds. No matter what combination of rotational elements is employed for the brushes of the fluid applicator 10, the radially outer ring of the final pair 18 of brushes should rotate inwards with respect to each other and the direction of advance, as illustrated in Figure 11, so as to ensure that etchant fluid is encouraged into the weld line 2.

Figure 12 illustrates an advantageous arrangement of brushes on a body of a fluid applicator 10 comprising eight separate brushes. At the leading edge 70 of the fluid applicator 10 is a first stage brush 72 rotating in an anticlockwise direction. The first stage brush 72 is a comparatively small brush with firm bristles, of the type illustrated in Figures 6 or 7. This brush covers the immediate weld pool 2 and the heat affected zone 4 with the firm bristles employed to scrub the zone while chemical reaction occurs, mechanically assisting the etching process. Etchant fluid is fed through the centre of the brush 72 and the rotation of the brush 72 feeds the etchant fluid outwards under centrifugal forces. Behind the first stage brush 72 is a pair of second stage brushes 74,

76. These are larger brushes comprising firm, medium and soft bristles, as illustrated in Figures 8 and 9, and may include contra-rotating or oscillating sections. The second stage brushes 74, 76 scrub the heat affected zone 4 and spread etchant fluid over the area to be treated. Etchant fluid is fed through the centre of the brushes 74, 76 and the rotation of the brushes 74, 76 feeds the etchant fluid outwards under centrifugal forces. The majority of the etchant fluid is deposited along the central line of the target area 8 as a result of the internal rotation of the second stage brushes 74, 76. Behind the second stage brushes 74, 76 is a third stage brush 78. The third stage brush 80 is also a comparatively small brush with firm bristles, of the type illustrated in Figures 6 or 7. This brush also covers the immediate weld pool 2 and the heat affected zone 4 with the firm bristles employed to scrub the zone while chemical reaction occurs, mechanically assisting the etching process. Etchant fluid is fed through the centre of the brush 78 and the rotation of the brush 80 feeds the etchant fluid outwards under centrifugal forces. Behind the third stage brush 78 is a pair of fourth stage brushes 80, 82. These are larger brushes comprising firm, medium and soft bristles, as illustrated in Figures 8 and 9, and may include contra-rotating sections. No etchant fluid is fed through the fourth stage brushes 80, 82, these brushes scrub and spread previously deposited etchant fluid over the area to be treated. At least the outermost rings of the fourth stage brushes rotate outwards with respect to each other and the direction of advance, so as to concentrate deposition of etchant fluid away from the centre areas and even the distribution. Finally, behind the fourth stages brushes 80, 82 is a pair of fifth stage brushes 84, 86. These are medium sized brushes of the type illustrated in Figures 8 and 9, and comprise firm, medium and soft bristles. No etchant fluid is fed through the fifth stage brushes 84, 86. These brushes spread and agitate the previously deposited etchant fluid, concentrating it from the outer regions to the central region. The brushes do not in fact contact the surface of the component but are raised slightly, thus leaving a thin layer of etchant fluid where the bristles do not make contact (illustrated as area 90 on the Figure). The separation between the fifth stage brushes 84, 86 is increased with respect to the earlier stage pairs so that the brushes extend slightly beyond the target area 8, collecting etchant fluid that has been spread by the fourth stage brushes

80, 82. The fifth stage brushes also act to agitate etchant fluid over the outer reaches of the target area, helping to produce equal etchant effects over the entire area. The combined effect of the five stages of brushes is to leave a fully agitated thin layer of etchant fluid over the entire target area 8, with a thicker deposited layer in the central region of the weld 2 and heat affected zone 4.

Figure 13 is a leading end view of the fluid applicator 10, described above with reference to Figure 12, in position over the component 26. The central first stage brush 72 can be seen partially obscuring the second stage brushes 74, 76. The variable stiffness bristles of the second stage brushes 74, 76 deform whilst rotating to scrub and adapt to the variable surface of the component while at the same time agitating the deposited etchant fluid to ensure thorough mixing.

Etchant fluid is deposited via the application head brushes as mentioned above. A central opening in the brush head allows fluid etchant to be deposited, while the rotating action of the brush encourages spread of the fluid over the entire contact area. Positive pressure may be applied to fluid at the opening to encourage deposition. Once the surface of the component has been etched to the required depth, it is necessary to remove the fluid and to clean the component surface. The same central opening may be used to collect spent etchant fluid, assisted by negative pressure or a vacuum applied at the opening. Positive or negative pressure may be applied at the opening of a fluid conduit that is in communication with the opening and also with a fluid reserve and other external mechanisms. A water feed may be incorporated to assist with the collection/cleaning of the component surface. Deposition/spreading and collection of fluid etchant may be assisted by the bristle configuration of the brushes. Figures 14 and 15 are end views of an example brush 100, which may be representative of any of the fluid applicator brushes described above. The brush 100 comprises bristles 102 that are arranged to form a spiral, graduating outwards from the central opening 104. During deposition, when positive pressure is applied at the central opening, the brush rotates in a clockwise direction, as illustrated by arrow A in Figure 14 and Figure 15a.

The spiral configuration of the bristles assists the natural spreading motion of the clockwise rotation and encourages even distribution of the deposited fluid. When it is necessary to recover used etchant fluid, the brush 100 is rotated in an anti clockwise direction, as illustrated by arrow B in Figure 14 and Figure 15b. The anti clockwise rotation of the spiral causes the outer most regions of the spiral to act as a scoop, collecting up the etchant fluid and conveying it into the spiral, towards the central opening where negative pressure is applied to suck the gathered fluid into the fluid conduit (not shown). The bristles of the brush 100 may be of variable stiffness as discussed above but in a preferred example, the spiral arrangement bristles are all of a medium stiffness and uniform length. Such an arrangement assists in maintaining the spiral configuration, and thus improves the efficiency of the distribution/collection action of the bristles.

It has been discussed above that agitation of the etchant fluid while on the component surface assists with mixing and ensuring efficient material removal. Agitation ensures that a layer of depleted etchant fluid and evolved gaseous product from the etching reaction does not build up immediately adjacent to the component surface. One desirable way of agitating and ensuring efficient surface removal is to cycle etchant fluid during the etch process. Continually depositing and collecting fluid ensures that the fluid remains well mixed and spent fluid is not allowed to accumulate. In addition, deposited fluid may be collected and reheated or cooled before being redeposited, thus ensuring the fluid retains optimal efficiency within predefined specification limits within the range 10-90°C. This also ensures that a previously discussed wash stage may act to pre-heat the component to aid in temperature control of the fluid once deposited. Recycling fluid in this way ensures that the minimum amount of fluid is used to achieve the required depth of material removal, providing both economic and environmental advantages. Figure 16 illustrates an end and sectional view of a brush that may be employed to circulate etchant fluid, as well as depositing and/or collecting as necessary. The brush 110 has a central opening that is divided into two independent sections for deposition and removal of fluid. It will be appreciated that while these

sections may be in communication with each other at some external location, to allow for the cycling of etchant fluid, at the opening location they are independent, to allow positive pressure to be applied at the fluid outlet and negative pressure to be applied at the fluid inlet. With reference to Figure 16, fluid etchant is fed out of the brush head
5 through the outlet indicated at location 1 on the Figure. Relatively firm bristles provide a path from the brush head to the component surface and centrifugal force encourages outward spreading of the etchant fluid once on the component surface. Radially outwards of feed location 1 is a first clearing zone indicated at location 2. There is no fluid feed in this area. The first clearing zone 2 receives fluid from the feed location 1
10 via centrifugal forces and relies upon such forces to spread the fluid as the brush rotates. The bristles in the first clearing zone 2 are softer than those in the feed location 1 to allow spreading of fluid and scrubbing of complex surfaces. Radially outwards of the first clearing zone 2 is a second clearing zone 3. There is also no feed in the second clearing zone 3, this area receives etchant from the first clearing zone 2
15 via centrifugal forces and relies on these forces to spread fluid as the brush 110 rotates. The bristles in the second clearing area 3 are slightly firmer than those in the first clearing area, to ensure that only a controlled amount of etchant is passed into the radially outer removal zone 4. The removal zone 4 also has no fluid feed but receives fluid spread from the second clearing zone under centrifugal forces. The removal zone
20 is bounded by a thick wall of fine, firm bristles that allow fluid in removal zone 4 to be evacuated under reduced pressure that is applied via the removal section of the central opening.

Figure 17 is a side view of a fluid applicator 10 having a body 14 in position on a
25 component 26 and partially illustrating a means for guiding the fluid applicator, indicated at 12. The body 14, on which application heads in the form of brushes are mounted, is made of a deformable material, for example a polymeric material and may be of different sizes or shapes depending on the component and/ or the geometry of the area to be treated. The deformable material allows the body to adapt to different component
30 surface geometries. The means for guiding the fluid applicator 10 may have several

attachment arms 120, 122, 124 by which it is connected to the body 14 of the fluid applicator 10. Each of these attachment arms may be independently moveable or extendable to manipulate the body 14 of the fluid applicator 10 such that the application heads are maintained in precisely the desired spatial relationship with the component surface, no matter what the component surface geometry may be. For example, if the component surface has a distinct concave curve, the outer attachment arms 120, 124 may be retracted, forcing the body to deform into a convex shape to match the surface of the component. Any other surface geometry may be similarly accommodated by appropriate manipulation of the deformable body, ensuring that the application heads are maintained in physical contact with the component surface to deposit, agitate and collect fluid etchant as required.

Further detail of the attachment arms and means for guiding 12 is illustrated in Figure 18, where it can be seen that each of the attachment arms may be independently extended, retracted and rotated or pivoted to manipulate the body 14 in the position and shape required. In addition, the post 126 on which the attachment arms are supported may also rotate, and the attachment arms may be translated along the post. Further detail of the different embodiments of the means for guiding the fluid applicator 10 is discussed below with respect to Figures 22 to 24.

Figures 19 to 21 illustrate an alternative embodiment of application head in the form of a brush 200. The brush 200 is mounted in a fluid applicator 10 as described above. The brush 200 is designed to be mounted for rotation about an axis that runs substantially parallel to a mounting surface of the body 14 of the fluid applicator, substantially in the manner of a vacuum cleaner. The brush 200 comprises a brush head 202 having a substantially cylindrical outer surface on which is mounted a plurality of bristles 204. In one embodiment, illustrated in Figure 19, the plurality of bristles 204 is arranged to form a helix, winding about the brush head 202. A plurality of openings 206 open onto the bristled surface of the brush head 202. These openings 206 perform

the same function as the central openings discussed above with respect to the first described embodiment of application head. The openings 206 permit deposition and collection of etchant fluid that may be provided to (as indicated at arrow 208) and/or removed from (as indicated at arrow 210) the brush 200.

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Figure 20 illustrates how several of the brushes 200 may be mounted for rotation on a body 14 of a fluid applicator 10. Alternating helical bristle configurations ensure even spread and distribution of a deposited layer of etchant fluid over the target area 8 of the component 26. During deposition, some or all of the openings may deposit fluid. Any
10 bristles located adjacent an opening that is not depositing fluid assist the process by agitating already deposited fluid. During removal, all or some of the bristles may be cause to rotate in the opposite direction, channelling spent fluid towards the openings that receive fluid under negative pressure. The arrangement of the plurality of bristles 204 may be altered to specifically assist with fluid deposition and removal. Figure 21
15 illustrates an alternative arrangement in which the plurality of bristles 204 are arranged in a series of chevrons, each chevron centred upon an opening in the brush head surface. During deposition, indicated by arrow A and the left hand part of Figure 21, the brush head rotates such that the chevrons of bristles act to spread the deposited fluid across the surface of the component, as indicated by arrow B. During collection, as
20 indicated by arrow C and the right hand part of Figure 21, the brush head rotates such that the chevrons of bristles act to scoop up etchant fluid and direct it into the path of the openings that can collect the fluid under the application of negative pressure, as illustrated by arrows D.

25 A first embodiment of the means for guiding the fluid applicator 10 is illustrated in Figure 22. According to this embodiment, the means for guiding comprises a flexible track 300 that is assembled into a frame 310 around the component 26 to be etched. The track 300 may be flexible or may be of rigid material and construction. The track 300 is assembled into the frame 310 by a series of clamps 302 that secure the track in
30 place and prevent movement. Pads 304 may be employed to prevent the clamps 302

and/or track 300 coming into contact with the component 26 and perhaps damaging the component surface. The track 300 carries a rack or other means by which the fluid applicator may be secured on and moved along the track 300 in the desired direction. The fluid applicator 10 is mounted on the track such that the application heads can
5 contact the component surface over the target area to deliver, agitate and finally collect etchant fluid. A single track may support multiple heads to reduce treatment time. The precise location of the track may be determined using for example the CAD drawings of the component. The target area to be treated, for example a weld on an aerofoil component, can be precisely identified on the drawings or CAD software. A path for the
10 fluid applicator that will result in treatment of the target area may then be determined. The appropriate location for the track may then be calculated from the predetermined path and the known geometry of the fluid applicator 10 and the track location may be fixed and the frame constructed.

15 Figure 23 illustrates another embodiment of the means for guiding the fluid applicator along a predetermined path. According to this embodiment, the means for guiding is a computer controlled mechanical manipulation arm 400. The mechanical manipulation arm is preferably a multi axis arm that allows fine control and manipulation of the location and orientation of the fluid applicator. The spatial coordinates of the target
20 area 8 may be provided to the control unit which determines a path along which the fluid applicator must travel in order to treat the target area and causes the manipulation arm to position and move the fluid applicator accordingly. A simpler manipulation arm may be employed in combination with manipulation of the component to be treated, as illustrated in Figure 24. The component, for example a drum may be mounted for
25 rotation on a platform about a fixed axis, reducing the amount of translation required of the means for guiding the fluid applicator in order to enable the fluid applicator to contact any point on the surface of the component 26. For example the fluid applicator may trace a spiral over the component, or may trace a series of discrete circles using an oscillatory pattern, or set concentric path.

The use of CAD software to determine a predetermined path for the fluid applicator to follow, and then to instruct a manipulation arm or direct the construction of a frame allows a high degree of accuracy to be achieved while minimising operator contact with etchant media. In each case, the predetermined path may involve several discrete sections, over which the fluid applicator may need to pass but which should not have etchant media applied. The flow of etchant fluid to the fluid applicator may be stopped as the fluid applicator passes over such regions. In addition, or in the alternative, the fluid applicator may be offset from the component surface as it passes over such sections.

It will be appreciated that it may be desirable to vary the offset of the fluid applicator from the component surface during treatment so as to vary the thickness of the deposited layer of etchant fluid. For example, the fluid applicator may be in close physical contact with the component surface during deposition, slightly further away during manipulation/agitation of the etchant fluid so as to merely mix the etchant rather than remove it from the surface, and then in close contact again for etchant removal. The actual process cycle may be more complicated than has so far been described. For example, a full process cycle may include the following steps:

- i) Wash – a first pass of the target area is conducted to thoroughly scrub the target area
- ii) Scale condition – a viscous scale conditioner is applied using the fluid applicator to prepare the surface
- iii) Wash – a third pass is conducted to remove the scale conditioner and clear the surface
- iv) Etch – a layer of etchant fluid is applied as described above
- v) Agitate – several passes may be made cycling and agitating the etchant paste to ensure even and thorough removal of the required thickness of surface layer
- vi) Wash – a penultimate pass is made to remove the etchant and clear the surface
- vii) Dry and Clean – a final pass is made to scrub the surface and remove any last loose material an air-knife approach may be used.

It will be appreciated that the bristle requirements for the different process stages may be different. For example firmer bristles are required for depositing layers of fluid while longer, softer bristles may be preferred for agitation and cleaning. The various requirements may be accommodated in a single applicator by employing several
5 different brushes on a single applicator and by employing variable bristle types on individual brush heads, as described above. It may also be desirable to employ specific brushes within the applicator for specific tasks. For example it may be desirable to use different brushes for the application and removal of the scale conditioner to those employed for application, agitation and removal of the etchant fluid. Different brushes,
10 tailored to the specific process stage requirements, can be mounted on a carousel and moved between operating and holding positions as required. A water feed may be incorporated to assist with the wash process stages as required.

It will be understood that variations can be made to the specific embodiments of
15 apparatus described above without departing from the scope of appended claims. For example, additional agitation or temperature control may be provided by steam or gas jets delivered either from the applicator body or through the application heads of the fluid applicator. Additional agitators may also be provided in the form of flutes, ribs or supplementary bristles. Such agitators may be mounted on the application heads or
20 may be mounted on separately on the body. Heating or cooling may be provided via the circulatory control unit, body or application heads to increase or decrease the temperature of the scale conditioning, wash or etchant fluid. It will be understood that heating etchant fluid may increase the rate at which surface material is removed , although this may result in an increased health and safety concern. Depth probes
25 and/or a surface scanner/analyser may also be incorporated into the fluid applicator, with the potential for incorporation of electrolytic fluid monitoring and control.

The temperature of the component may be controlled. The temperature of the component may be controlled by cooling and/or heating the component directly or by
30 cooling and/or heating the atmosphere in which the component is held throughout the

process. Figure 25a-e and Figure 26 present a means for temperature control of the component 26, comprising an enclosure 500 for housing the component 26 during the method of the present invention. A door/shutter 510 is lifted from a rest position (Figure 25a) by an actuation means 520 and the component 26 is moved inside the enclosure 500 (Figure 25b). The actuation means 520 then lowers the door/shutter 510 such that the component 26 is contained within the enclosure 500 (Figure 25c). Once inside the enclosure 500, the method of the present invention is worked, with the temperature of the atmosphere inside the enclosure and the temperature of the component 26 being monitored and controlled to within predetermined and desirable limits. Once the method of the present invention is complete, the door/shutter 510 is lifted from the closed rest position (Figure 25d) by the actuation means 520 and the component 26 is moved outside of the enclosure 500 (Figure 25e). A micro switch fitted to the door/shutter 510 is operable to monitor the position of the door/shutter 510 and thus prevent deployment of the application head 10 and chemicals while the door/shutter 510 is open.

Figure 26 shows the component 26 when located within the enclosure 500 during the method of the present invention. Thermocouples 530 are arranged around the enclosure to measure the temperature of the atmosphere within the enclosure 500. Additional thermocouples 532 are attached to multiple locations on the surface of the component 26 to thereby measure the temperature of the component 26. Thermocouples 534 are also attached to an output duct of an atmospheric heater/cooler 536. Thermocouples 538, 540 are additionally attached to the input and output respectively of a heater/cooler chemical reservoir 542 used to contain the chemicals used in the method of the present invention. The thermocouples 530, 532, 534, 538, 540 are input to the heater/flow control unit 544. In dependence upon the input from the thermocouples 530, the heater/flow control 544 unit makes adjustments to the atmospheric heater 536 to maintain the atmospheric temperature to within a desired temperature range. In dependence upon the input from thermocouples 532, 534, 538 and 540 the heater/flow control unit 544 makes adjustments to the heater/cooler chemical reservoir 542 to maintain the temperature of the chemicals

being applied to the component 26 via the application device 10 to within a desired temperature range. Following application via the application device 10, a fluid flow control device 546 recirculates the fluid into the heater/cooler chemical reservoir 542 or channels the fluid into a series of fluid specific reservoirs 548. From the fluid specific
5 reservoirs 548, fluids may then be pumped into heater/cooler chemical reservoir 542 via the fluid flow control device 546 and then recirculated and reheated as required. Alternatively fluids may be channelled from the fluid specific reservoirs 548 into waste disposal tanks 560. Following conclusion of the chemical process, a wash fluid shall cleanse and neutralise the system, with fluid passing directly through the fluid flow
10 control device 546 and fluid specific reservoirs 548 into the waste disposal tanks 560.

The component may be maintained at a temperature of about 293K by the temperature control means for scale conditioning part of the process. The component may be maintained at about 363K by the temperature control means for the cleaning and
15 etching parts of the process.

It will be further understood that while various aspects of the present invention have been described in combination, such combinations are not intended to be limiting in scope. Any aspect of the present invention may be employed in combination with any
20 other aspect of the present invention above described.

The present invention has been described with particular reference to the surface processing of a weld line. However, the present invention is applicable to any circumstance in which surface treatment of a target area of a component is required.
25 The manoeuvrability and versatility of the apparatus of the present invention renders it particularly suited to the treatment of curved components such as aerofoils for gas turbine engines. The adaptability and fine control provided by the apparatus of the present invention enables accurate treatment of convex and concave surface areas including edge and tip surfaces and re-entrant features such as weld crowns and
30 underbeads. It will be appreciated, however, that the apparatus of the present

invention can be employed for the treatment of any kind of component. Such treatment is not limited to the particular application of etchant fluid described, but may also include non destructive testing applications and cleaning as well as surface preparation, diffusion bonding and chemical milling. The apparatus is suitable for use with metallic
5 as well as glass and other material components.

It will be appreciated that the present invention provides an efficient and environmentally sound apparatus and method for applying an etchant or other fluid to a component surface. Fine control is provided to enable exact distribution of fluid and
10 hence accurate surface material removal by etchant media. The apparatus is extremely versatile and adaptable to a wide range of component shapes and sizes. Accurate treatment of target surface areas by the apparatus retains component thickness and reduces chemical usage. The apparatus is self contained, not requiring the use of sealant or masking material. The invention also contains scope for
15 miniaturisation, use on bimetallic components or assemblies and use on assemblies containing non-metallics such as seals, foams, rubbers and hard polymers.

To avoid unnecessary duplication of effort and repetition in the text, certain features are described in relation to only one or several aspects or embodiments of the invention.
20 However, it is to be understood that, where it is technically possible, features described in relation to any aspect or embodiment of the invention may also be used with any other aspect or embodiment of the invention.

CLAIMS

- 1 Apparatus for applying a fluid to a target area of a component, comprising
5
a fluid applicator; and means for guiding the fluid applicator along a
predetermined path with respect to the component ; the fluid applicator
comprising:
- 10 a body;
- an application head mounted on the body and operable in use to be brought into
physical contact with the component;
- 15 wherein the application head comprises an opening;
- and means to apply positive pressure at the opening; and
- means to apply negative pressure at the opening or at an additional fluid opening
20 in the application head.
- 2 Apparatus as claimed in claim 1, wherein the fluid is any one of a chemical
etchant, scale conditioner, washing fluid and/or neutralising solution.
- 25 3 Apparatus as claimed in any one of claims 1 or 2, wherein the body is formed
from a deformable material.
- 4 Apparatus as claimed in any one of the preceding claims, wherein the
application head comprises a brush having a brush head and a plurality of
30 agitators.

5 Apparatus as claimed in claim 4, wherein the brush is mounted for rotation about an axis that is substantially parallel to a surface of the body on which it is mounted, a surface of the brush head from which the agitators project being substantially cylindrical.

5

6 Apparatus as claimed in claim 5, wherein the plurality of agitators projects from the surface of the brush head in a helical pattern that winds about the brush head.

10 7 Apparatus as claimed in claim 5, wherein the plurality of agitators projects from the surface of the brush head in at least one chevron pattern.

8 Apparatus as claimed in claim 4, wherein the brush is mounted for rotation about an axis that is substantially normal to a surface of the body on which it is mounted, a surface of the brush head from which the agitators project being substantially planar.

15

9 Apparatus as claimed in claim 8, wherein the plurality of agitators projects from the surface of the brush head in a spiral configuration.

20

10 Apparatus as claimed in any one of claims 4 to 9, wherein the agitators comprise bristles.

11 Apparatus as claimed in any one of claims 4 to 9, wherein the agitators comprise fins.

25

12 Apparatus as claimed in any one of the preceding claims, further comprising means for controlling the temperature of the fluid to be applied to the component.

30

- 13 Apparatus as claimed in any one of claims 5 to 12, comprising a plurality of brushes mounted for rotation on the body of the fluid applicator about parallel axes.
- 5 14 Apparatus as claimed in claim 13, wherein at least two of the plurality of brushes comprise different agitator configurations.
- 15 Apparatus as claimed in any one of the preceding claims, wherein the means for guiding comprises a mechanical manipulation arm on which the fluid applicator is operable to be mounted.
10
- 16 Apparatus as claimed in any one of claims 1 to 14, wherein the means for guiding comprises a track, along which the fluid applicator is operable to be driven.
15
- 17 Apparatus as claimed in any one of the preceding claims, wherein the means for guiding further comprises means for manipulating the component.
- 18 A method of applying a fluid to a target region of a component using an apparatus as claimed in any one of claims 1 to 17, comprising:
20
- connecting a fluid supply to the fluid applicator;
- mounting the fluid applicator on the means for guiding the applicator along a predetermined path;
25
- bringing the applicator head into physical contact with the target region of the component,
- 30 causing the applicator to be guided along the predetermined path while depositing fluid through the applicator from the fluid supply, and

wherein depositing fluid through the applicator comprises applying pressure to the fluid at a fluid opening in the application head; and

5 the method further comprises collecting fluid under a negative pressure applied at the fluid opening or at an additional fluid opening in the application head.

19 A method as claimed in claim 18, wherein the fluid is any one of a chemical etchant, scale conditioner, washing fluid and/or neutralising solution.

10 20 A method as claimed in any one of claims 18 or 19, wherein the means for guiding comprises a track, the method further comprising locating the track about the component, such that the applicator traces the predetermined path along the component when travelling along the track.

15 21 A method as claimed in any one of claims 18 or 19, wherein the means for guiding comprises a mechanical manipulation arm, the method further comprising programming the mechanical manipulation arm to move the applicator such that the applicator traces the predetermined path along the component.

20 22 A method as claimed in any one of claims 18 to 21, wherein the means for guiding further comprises means for manipulating the component, the method further comprises mounting the component on the means for manipulating the component, and wherein the various means for guiding cooperate to cause the applicator to be guided along the predetermined path.

25 23 A method as claimed in claim 23, wherein depositing fluid through the applicator further comprises causing the application head of the applicator to rotate.

- 24 A method as claimed in any one of claims 19 to 24, the method further comprising controlling the temperature of the component.
- 5 25 Apparatus substantially as described herein, with reference to and as shown in the accompanying drawings.
- 26 A method substantially as described herein, with reference to and as shown in the accompanying drawings.