ARRANGEMENTS AND METHODS FOR ABRASIVE FLOW MACHINING

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ABSTRACT
A method of treating an interior surface of a workpiece (5); said method comprising providing a workpiece (5) having an interior passage (11) defined at least partly by said interior surface to be treated, said passage (11) having an inlet section and an outlet section; providing in said interior passage (11) at least one deflecting object (6), said deflecting object (6) having an outer surface, whereby a space is formed between said outer surface of said at least one deflecting object (6) and said interior surface of said workpiece (5); providing an abrasive fluid (3) in said space, such that said space is substantially filled with said abrasive fluid (3); and effecting flow of said abrasive medium (3) through said interior passage (11) from said inlet portion to said outlet portion.
ARRANGEMENTS AND METHODS FOR ABRASIVE FLOW MACHINING

FIELD OF THE INVENTION

[0001] The present invention is in the field of abrasive flow machining. More specifically, the present invention relates to new and improved arrangements and methods for treating interior surfaces of workpieces with abrasive fluids.

BACKGROUND OF THE INVENTION

[0002] Abrasive flow machining is a well-known machining process, in which an abrasive medium is extruded through, or past, a workpiece surface, to effect an abrasive surface treatment of the same. The abrasive action in abrasive flow machining may be seen as being analogous to conventional filing, grinding, lapping or honing, in that the extruded abrasive medium passes by a surface of a workpiece, thereby abrading the material forming the surface and thus treating the surface. If suitable non-Newtonian fluids are used, the abrasive fluid may flow through, or past, a workpiece substantially in plug flow. The plug may then be seen as a self-forming file, grinding stone or lap, as it is extruded under pressure through the confined passage, which is restricting its flow. This causes effective surface treatment of the workpiece. Unlike in conventional abrasive techniques, where abrasive particles are held against the workpiece by a solid support, such as the solid support in sanding paper, the media supporting the abrasive particles in abrasive flow machining is plastic. This leads to a very uniform surface treatment.

[0003] WO 2009/105043 discloses an abrasive flow machining apparatus consisting of a structure holding two opposed media chambers and a workpiece inserted therebetween. The media chambers are extruding chambers, which can hydraulically or mechanically extrude the abrasive medium from one chamber through the passage into the other chamber. The surface to be abraded is a bore through the workpiece, and the media chambers are sealed to each end of the bore so that the bore becomes a sealed passageway between the two chambers. The abrasive medium is extruded from one medium chamber to the other in a reciprocating manner.

[0004] U.S. Pat. No. 3,819,343 discloses an abrasive medium for use in abrasive flow machining, which is a semi-solid visco-elastic material permeated with an abrasive grit. The abrasive grit is held in place by the semi-solid visco-elastic material.

[0005] While the conventional abrasive flow machining processes are effective in many applications, the conventional processes are often ineffective, in particular, when the surface to be treated is an interior surface of a passage, which passage is either very long and narrow, or in cases where the passage comprises multiple sections having cross-sectional areas of different magnitude.

[0006] In very long and narrow passages, the required pressure and work needed for moving the viscous abrasive medium through the passage is very high. This puts extra demands on the mechanical stability of the apparatuses used for the purpose, and it increases the energy required for the machining process. Both is undesirable.

[0007] If the passage to be treated includes both, sections having relatively small cross-sectional area and sections having relatively large cross-sectional areas, the fluid velocity in the narrow and wide sections will vary considerably. In narrow sections, the velocity of the fluid will be relatively high, whereas in the wide sections of the passage, the velocity will be relatively low. As a consequence, while the abrasive action will be relatively effective in the narrow sections, the abrasive action in sections having relatively large cross-sectional areas will not be satisfactory.

[0008] There is a need in the art for methods and arrangements for abrasive fluid machining which ameliorate the above mentioned problems.

SUMMARY OF THE INVENTION

[0009] The present invention fulfills this need by providing methods, and corresponding apparatuses, for abrasive flow machining, in which methods an abrasive medium is extruded through a passage, and in which deflection objects are inserted into the passageway, preferably in the passages, or sections thereof, having relatively large cross-sectional area. The deflection elements effect a local reduction of the effective cross-sectional area available for fluid flow. Hence, they increase the velocity of the abrasive medium locally in the vicinity of the deflecting objects. As a result, the effectiveness of the abrasive action at the location of deflection will be increased. Furthermore, since the areas of increased fluid velocity are relatively short (measured in the axial direction), the increase of the overall pressure drop is relatively small. Hence, methods of the invention provide for increased effectiveness of the surface treatment at selected locations within the workpiece, without increasing the required pressure to unacceptable levels.

[0010] If the passage to be treated includes sections of both, relatively wide and relatively narrow cross-sectional area, the deflecting objects can be used to adjust the intensity of the surface treatment in such sections. Deflecting objects can be used to effect a relatively uniform treatment of the surfaces of the wide and narrow sections of the passage in the workpiece, e.g., by locally increasing the flow velocity of the abrasive medium in the wide sections of the passage.

[0011] The present invention thus relates to a method of treating an interior surface of a workpiece;

[0012] said method comprising (i) providing a workpiece having an interior passage defined at least partly by said interior surface to be treated, said passage having an inlet section and an outlet section; (ii) providing in said interior passage at least one deflecting object, said deflecting object having an outer surface, whereby a space is formed between said outer surface of said at least one deflecting object and said interior surface of said workpiece; (iii) providing an abrasive fluid in said space, such that said space is substantially filled with said abrasive fluid; and (iv) effecting flow of said abrasive medium through said interior passage from said inlet portion to said outlet portion.

[0013] In preferred embodiments, the interior space is completely filled with the abrasive fluid.

[0014] The step of effecting flow preferably comprises moving a piston in a cylinder connected to said inlet portion of said interior passage. Thereby abrasive fluid is pumped into said interior passage, and/or there is established a net flow of abrasive fluid through the interior passage.

[0015] Preferably, the at least one deflecting object is mounted on a solid support, such as a rod or a spindle. The deflecting object, however, can also be mounted on a rope or a wire. The wire is preferably flexible. Mounting of the deflecting object on a solid support, such as a rod or is spindle, allows for the spatial position of that deflecting
object in said interior passage to be accurately adjusted. The
cross-sectional area of the rod in a plane normal to the lon
titudinal axis of the passage is preferably substantially smaller
than the cross-sectional area of the deflecting object in a plane
normal to the longitudinal axis of the passage. Preferably, said
cross-sectional area of the rod is at least 5 or 10 times smaller
than said cross-sectional area of the deflecting object. A sub
stantially greater cross-sectional area of the deflecting object,
relative to the cross-sectional area of the road, leads to a local
increase of the velocity of the abrasive medium at and around
the deflecting object.

According to a preferred embodiment of the invention, the rod
is connected to the piston. This arrangement allows for movement of the at least deflecting object at the
same speed and at the same frequency as the piston. This
makes it particularly easy to control the movement and posi
tion of the at least one deflecting object in the interior passage.

In other preferred embodiments, the rod is movable relative to the piston. This allows for the at least one deflecting object to be moved independently from, i.e., at a different speed and frequency as the piston. The deflecting object may also (e.g. additionally) perform a rotating movement in said

In other preferred embodiments of the invention, the at least one deflecting object comprises multiple deflecting objects. In other words, multiple deflecting objects are present. Use of multiple deflecting objects allows, e.g., for accounting for multiple sections of different cross-sectional area in the interior passage, such that the velocity of the abrasive medium can be adjusted in each individual section in a manner that a uniform treatment of the passage’s surface is achieved.

According to one embodiment, the multiple deflecting objects are connected to each other.

For example, the multiple deflecting objects are connected to each other such as to hold the multiple deflecting objects at a fixed distance of each other. This allows for positions of all multiple deflecting objects to be adjusted at the same time.

For this purpose, the multiple deflecting objects may be mounted on one and the same rod. Movement of the multiple deflecting objects in the passage may then be effected by movement of a single rod.

The rod may conveniently be connected to the piston, such that the multiple deflecting objects move in parallel to the piston.

In other preferred embodiments, the multiple deflecting objects are connected to each other such as to allow relative motion, relative to each other. This allows for greater flexibility in determining the longitudinal position and speed of movement of the multiple deflecting objects in the passage.

In preferred methods of the invention, the passage is rotationally symmetric. Alternatively, the interior passage has at least one circular cross-section, preferably in a plane normal to a longitudinal axis of the interior passage.

According to a preferred embodiment, the at least one deflecting object is rotationally symmetric.

If both, the interior passage and the deflecting object, are rotationally symmetric, then an outer contour of the deflecting objects will follow an inner contour of the passage. This leads to substantially uniform velocity of the abrasive medium at the locations of the deflecting objects, when extruded past the deflecting object.

In other preferred embodiments, the interior passage has at least one square cross section, preferably in a plane normal to a longitudinal axis of the interior passage. In such cases, it is preferable that the at least one deflecting object also has at least one square cross section, preferably in a plane normal to a longitudinal axis of the interior passage. This, again, leads to a situation in which an outer contour of the at least one deflecting object follows an inner contour of the passage, and rather uniform treatment of the surface is achieved.

In preferred embodiments of the invention, the at least one deflecting object comprises, or is formed by, or assumes the shape of, a substantially flat structure, preferably oriented normal to a longitudinal axis of said interior passage (when mounted therein).

For example, the at least one deflecting object may comprise a disc-shaped object, or it may comprise a rectangular plate. The disc or the plate may be mounted on a rod.

In particularly preferred embodiments, the at least one deflecting object comprises multiple substantially flat structures, preferably all oriented normal to a longitudinal axis of said passage. The multiple flat structures may all be disc-shaped, or they may all assume the shape of a rectangular plate.

As mentioned previously, an outer contour of said at least one deflecting object may follow an inner contour of said passage. Thereby a gap of approximately constant thickness is formed between the deflecting object and the inner surface of the interior passage, and the abrasive fluid will flow at approximately constant velocity past/around the at least one deflecting object.

Preferably, the abrasive fluid comprises a viscous fluid or a visco-elastic fluid. Preferred fluids are non-Newtonian fluids, in particular dilatant, i.e., shear thickening fluids. Dilatant fluids increase their viscosity as the shear rate or shear stress increases. Such fluids, when extruded through a passage having a constant cross-section, flow substantially in the plug flow like fashion. Plug flow of the abrasive medium through the passage maximizes the shear forces at the surface to be treated, thereby maximizing the effectiveness of the abrasive action.

The abrasive medium further comprises an abrasive grit, i.e., solid particles with abrasive properties. Various abrasive particles can be used. For example the abrasive fluid may contain, e.g., boron carbide, aluminum oxide, calcite, emery (corundum), diamond dust, synthetic diamond dust, novaculite, pumice dust, sand, boron nitride, ceramic particles, ceramic iron oxide, glass powder, steel particles, silicon carbide, and zirconia alumina.

The particles preferably have a median diameter (based on the number of particles) of from 1 μm to 4 mm, preferably from 10 μm to 2 mm, even more preferred from 100 μm to 1 mm. The diameter of a particle is preferably determined from a micro-photograph, namely as the largest individual dimension across the two-dimensional image of said particle in said micro-photograph. An automatic image analysis system, such as the Morphologi G3 System of Malvern Instruments Ltd., England, is preferably used to determine the number-based median diameter of the particles.

As already explained above, the at least one deflecting object is preferably moved in said passage. Thereby the position of the deflecting object(s), and thus the position where effective surface treatment occurs, may be adjusted. Movement of the deflecting object(s) in the passage may also
increase the flow of abrasive fluid, thereby adding to the movement caused by the net flow of abrasive medium through the passage.

[0036] For example, the movement of at least one deflecting object in said passage may comprise movement parallel to a longitudinal axis of said passage, e.g., the movement may include reciprocal movement parallel to a longitudinal axis of said passage.

[0037] In other preferred embodiments, said movement comprises rotational movement about an axis parallel to a longitudinal axis of said passage. This may increase the effectiveness of the surface treatment at the location of the deflecting object by adding a tangential component to the movement of the abrasive fluid across the surface to be treated.

[0038] It is understood by the skilled person that, according to the invention, there is provided a net flow of abrasive fluid through said interior passage from said inlet section to said outlet section.

[0039] Preferred interior surfaces to be treated according to the invention are metal surfaces.

[0040] The present invention also relates to systems, to an apparatus or to an arrangement for treating an interior surface of a workpiece, said workpiece having an interior passage, said interior passage being at least partially defined by said interior surface to be treated, said interior passage having an inlet portion and an outlet portion; the arrangement comprising:

[0041] (i) a first chamber for holding an abrasive fluid; (ii) connecting means for connecting said workpiece to said arrangement in such a manner that a fluid-tight connection is established between said first chamber and said inlet portion of said interior passage; (iii) pressure imposing means for imposing an elevated pressure on said abrasive fluid in said first chamber, if such is present in said first chamber; and (iv) at least one deflecting object mountable in said interior passage, when said workpiece is connected to said arrangement, said deflecting object adapted for deflecting abrasive fluid, when such abrasive fluid is flowing through said interior passage.

[0042] The arrangement may also include the workpiece.

[0043] In a preferred embodiment, said means for imposing a pressure on said abrasive fluid comprises a first cylinder portion and a first piston movably arranged in said first cylinder portion.

[0044] Preferably, said at least one deflecting object is mounted on a rod.

[0045] According to a preferred embodiment, the system, apparatus or arrangement further comprises said arrangement further comprising a second chamber connectable to said workpiece in a manner that a fluid tight connection is established to said outlet portion of said interior passage, said second chamber also comprising means for imposing a pressure on an abrasive fluid when such is present in said second chamber.

[0046] Preferably, said means for imposing a pressure on an abrasive fluid in said second chamber comprises a second cylinder portion and a second piston arranged in said second cylinder portion.

[0047] The first and second pistons are preferably movable in a manner so as to effect reciprocal movement of an abrasive fluid in said interior passage, e.g., past said at least one deflecting object, when such abrasive fluid is present in said first and second chambers and in said interior passage.

[0048] The interior passage may have at least one circular cross-sectional area in a plane normal to a longitudinal axis of said passage.

[0049] In such cases, in particular, it is advantageous that said at least one deflecting object is rotationally symmetric.

[0050] In other embodiments, the interior passage has at least one square cross-sectional area, preferably in a plane normal to a longitudinal axis of said interior passage.

[0051] In these embodiments in particular, it is advantageous that the at least one deflecting object has at least one square cross-sectional area.

[0052] The at least one deflecting object may comprise, or may be formed by, or assume the shape of, a substantially flat structure, preferably oriented normal to a longitudinal axis of said interior passage.

[0053] In preferred embodiments, said substantially flat structure is disc-shaped.

[0054] In other preferred embodiments, said substantially flat structure is a rectangular plate.

[0055] The at least one deflecting object may comprise multiple substantially flat structures oriented normal to a longitudinal axis of said interior passage. These may all be disc-shaped.

[0056] According to the invention, it is generally preferable that an outer contour of said at least one deflecting object follows an inner contour of said interior passage.

BRIEF DESCRIPTION OF THE FIGURES

[0057] FIG. 1 shows a first embodiment of the invention employing a spherical deflecting object.

[0058] FIG. 2 shows a second embodiment of the invention employing a disc shaped deflecting object.

[0059] FIG. 3 shows a third embodiment employing three disc-shaped deflecting objects.

[0060] FIG. 4 shows an embodiment including a deflecting object which is movable independently of a piston.

DETAILED DESCRIPTION OF THE INVENTION

[0061] “Substantially flat”, with reference to a tree-dimensional object extending in the axial and in radial directions, according to the invention, shall be understood as meaning that the object has at least one dimension in the radial direction, which is at least 5, or 10 times greater than the object’s largest dimension in the axial dimension.

[0062] The invention shall now be described with reference to the appended Figures.

[0063] FIG. 1 shows a first embodiment of the invention. Shown is an arrangement for the treatment of an interior surface of a workpiece 5. A cylinder portion 2 and a piston 1 form a first chamber. The first chamber holds and abrasive medium 3. Connected to piston 1 is a rod 4 on which a deflection object 6 is mounted. Deflection object 6, in this embodiment, has spherical shape. Rod 4 keeps deflection object 6 at a fixed distance from piston 1. The first chamber is connected in a fluid-tight manner to workpiece 5. As shown by an arrow on piston 1, the piston is movable downwardly in the vertical direction, so as to impose an increased pressure on abrasive fluid 3 in the first chamber. When piston 1 moves downwardly the first chamber, abrasive fluid 3 is pressed (or extruded) through the internal passage 11 of workpiece 5. In the embodiment shown in FIG. 1, interior passage 11 has an inlet portion at its upper end and an outlet portion at its lower end. The embodiment does not include second chamber con-
nected to the outlet portion of interior passage 11, thus abrasive fluid extruded from the outlet section exits the arrangement and is not used in a cyclic manner. As will be appreciated by the person skilled in the art, in order for the deflection object 6 to be able to follow and irregularly shaped interior passage 11, rod 4 may be of a deformable, e.g., comprising an elastic material. For example, rod 4 may be made of plastic or steel. Rod 4 may also be made of wire or rope.

[0064] FIG. 2 depicts a second embodiment of the invention. In this embodiment, a first chamber is formed from cylindrical portion 2 and corresponding piston 1. The first chamber is filled with abrasive fluid 3. Piston 1 is movable in a vertical direction, in this case to perform a reciprocating movement. Connected to piston 1 is rod 4 to which deflecting object 6 is connected. Movement of piston 1 effects movement of rod 4 and deflecting object 6 at the same speed and frequency. When piston 1 moves upwardly, abrasive fluid 3 is forced into the interior passage, past the moving deflecting object 6, into a second chamber, in this case formed by second cylindrical portion 10 and second piston 9. As will be readily appreciated by the person skilled in the art, the velocity of abrasive fluid 3 in interior passage 11 is increased around the deflecting object 6 relative to the velocity in the remainder of interior passage 11, because around the deflecting object the available for cross-sectional area for fluid flow is particularly small. This leads to a very effective treatment of the inner surface of the workpiece 5 and around deflecting object 6. As is as visualized by double-headed arrows on first and second pistons 1 and 9, both pistons are movable in a reciprocating manner. The reciprocating movement of pistons 1 and 9, in combination with the parallel movement of deflecting object 6 through the interior passage, leads to effective and uniform treatment of the interior surface of workpiece 5.

[0065] FIG. 3 shows a third embodiment of the invention. This embodiment includes first and second fluid chambers, formed by cylindrical portions 2 and 10 with corresponding pistons 1 and 9, respectively. Reciprocal motion of first and second pistons 1 and 9 effects a reciprocating flow of abrasive medium 3 through the interior passage 11. As can be seen from the figure, interior passage 11 has sections of different cross-sectional area. A first section, vertically below a second section, has a larger cross-sectional area than has the second section. In conventional abrasive fluid machining arrangements, this would lead to a less effective machining of the surface in the first section having the larger cross-sectional area. According to the invention, however, multiple deflecting objects 6, 7, 8 may be provided in interior passage 11, thereby effecting a substantially uniform treatment of the surfaces of first and second sections. In the embodiment shown in FIG. 3, three separate deflecting objects 6, 7, 8 are arranged on a single rod 4, thus they move at the same speed and frequency.

[0066] FIG. 4 shows a fourth embodiment of the invention. According to this embodiment, deflecting object 6 is mounted on a rod 4, which rod 4 is movable independently of piston 1. This allows the velocity and frequency of movement of deflecting object 6 to be controlled independently of direction and frequency of piston 1. This is useful, e.g., if the requirements on the smoothness of the surface in the lower part of interior passage 11 are higher than the requirements in the upper part of the passage. In such cases, deflecting object 6 will primarily be positioned in the lower part of passage 11, while at the same time first and second pistons 1 and 9 perform their reciprocating movement, thereby providing for more effective surface treatment in the lower part of the passage 11.

[0067] In FIG. 5 is shown an embodiment in which rod 4 and deflecting object 6 are movable in a rotating fashion about a longitudinal axis of passage 11. Rotational movement of deflecting object 6 in passage 11 adds a tangential component to the otherwise axial movement of the abrasive fluid 3 through passage 11.

[0068] The abrasive fluid may comprise the following components:

<table>
<thead>
<tr>
<th>Component</th>
<th>CAS Number (e.g.)</th>
<th>Wt. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron carbide</td>
<td>74859-21-9</td>
<td>40-70</td>
</tr>
<tr>
<td>Polyborosiloxane polymer</td>
<td>104780-67-8</td>
<td>15-40</td>
</tr>
<tr>
<td>Lubricating grease</td>
<td>74869-21-9</td>
<td>10-30</td>
</tr>
<tr>
<td>Oleic Acid</td>
<td>112-80-1</td>
<td>0.1-2</td>
</tr>
</tbody>
</table>

[0069] The abrasive fluid may comprise abrasive solids selected from the group consisting of: aluminum oxide, silicon carbide, boron carbide, diamond.

[0070] Preferably, at least 80% of the abrasive particles (by number) have a largest diameter of from 0.01 to 2 mm, more preferably 0.02-1 mm, even more preferably 0.05 to 0.5 mm. Most preferably, at least 80% of the abrasive particles have a largest diameter of 0.04-0.1 mm.

[0071] The viscosity of the abrasive medium is preferably 100-1000 Pas, more preferably 300-5000 Pas, most preferably 1500-4000 Pas.

[0072] It is to be understood that the embodiments described hereinabove only serve as illustrative examples. They shall not be construed as limiting the invention to anything different than is defined by the terms of the appended claims.

1. Method of treating an interior surface of a workpiece; said method comprising
   providing a workpiece having an interior passage defined at least partly by said interior surface to be treated, said passage having an inlet section and an outlet section; providing in said interior passage at least one deflecting object, said deflecting object having an outer surface, whereby a space is formed between said outer surface of said at least one deflecting object and said interior surface of said workpiece;
   providing an abrasive fluid in said space, such that said space is substantially filled with said abrasive fluid; and effecting flow of said abrasive medium through said interior passage from said inlet portion to said outlet portion, wherein said at least one deflecting object is moved in said passage, and said movement comprises movement in a direction parallel to a longitudinal axis of said passage.

2. Method of claim 1, wherein said step of effecting flow comprises moving a piston in a cylinder connected to said inlet portion of said interior passage.

3. Method of claim 1, wherein said at least one deflecting object is mounted on a rod.

4. Method of claim 3, wherein said step of effecting flow comprises moving a piston in a cylinder connected to said inlet portion of said interior passage, and wherein said rod is connected to said piston.

5. Method of claim 3, wherein said step of effecting flow comprises moving a piston in a cylinder connected to said
inlet portion of said interior passage, and wherein said rod is movable relative to said piston.

6. Method of claim 1, wherein said at least one deflecting object comprises multiple deflecting objects.

7. Method of claim 6, wherein said multiple deflecting objects are connected, so as to assume a fixed distance to each other.

8. Method of claim 7, wherein said step of effecting flow comprises moving a piston in a cylinder connected to said inlet portion of said interior passage, and wherein said multiple deflecting objects are mounted at a fixed distance to said piston.

9. Method of claim 1, wherein said interior passage has at least one circular cross-sectional area in a plane normal to a longitudinal axis of said passage.

10. Method of claim 9, wherein said at least one deflecting object is rotationally symmetric.

11. Method of claim 1, wherein said interior passage has at least one square cross section in a plane normal to a longitudinal axis of said passage.

12. Method of claim 11, wherein said at least one deflecting object has at least one square cross section.

13. Method of claim 1, wherein said at least one deflecting object is formed by a substantially flat structure oriented, when mounted in said interior passage, normal to a longitudinal axis of said interior passage.

14. Method of claim 13, wherein said substantially flat structure is disc-shaped.

15. Method of claim 13, wherein said substantially flat structure is a rectangular plate.

16. Method of claim 13, wherein said at least one deflecting object comprises multiple substantially flat structures oriented normal to a longitudinal axis of said passage.

17. Method of claim 16, wherein all said multiple flat structures are disc-shaped.

18. Method of claim 1, wherein an outer contour of said at least one deflecting object follows an inner contour of said interior passage.

19. Method of claim 1, wherein said abrasive fluid comprises a shear thickening fluid.

20. Method of claim 1, wherein said abrasive fluid further comprises abrasive particles selected from the group consisting of boron carbide, aluminum oxide, corundum, diamond dust, synthetic diamond dust, novaculite, pumice dust, sand, boron nitride, ceramic particles, ceramic iron oxide, glass powder, steel particles, silicon carbide, and zirconia alumina.

21. Method of claim 1, wherein said movement includes reciprocal movement parallel to a longitudinal axis of said passage.

22. Method of claim 1, wherein said movement comprises rotational movement about an axis parallel to a longitudinal axis of said passage.

23. Method of claim 1, wherein there is provided a net flow of abrasive fluid through said passage from said inlet section to said outlet section.

24. Method of claim 1, wherein said interior surface to be treated is a metal surface.

25. Arrangement for treating an interior surface of a workpiece, said workpiece having an interior passage, said interior passage being at least partially defined by said interior surface to be treated, said interior passage having an inlet portion and an outlet portion; the arrangement comprising:

(i) a first chamber for holding an abrasive fluid;

(ii) connecting means for connecting said workpiece to said arrangement in such a manner that a fluid-tight connection is established between said first chamber and said inlet portion of said interior passage;

(iii) pressure imposing means for imposing an elevated pressure on said abrasive fluid in said first chamber, if such is present in said first chamber; and

(iv) at least one deflecting object mountable in said interior passage, when said workpiece is connected to said arrangement, said deflecting object adapted for deflecting abrasive fluid, when such abrasive fluid is flowing through said interior passage, wherein said deflecting object is mountable in said interior passage such as to allow movement of said deflecting object in said passage parallel to a longitudinal axis of said passage.

26. Arrangement of claim 25, wherein said movement of said deflecting object is reciprocal movement parallel to a longitudinal axis of said passage.

27. Arrangement of claim 25, further comprising said workpiece.

28. The arrangement claim 25, wherein said means for imposing a pressure on said abrasive fluid in said first chamber comprises a first cylinder portion and a first piston movably arranged in said first cylinder portion.

29. The arrangement of claim 28, wherein said at least one deflecting object is mounted on a rod.

30. The arrangement of claim 25, said arrangement further comprising a second chamber connectable to said workpiece in a manner that a fluid tight connection is established to said outlet portion of said interior passage, said second chamber also comprising means for imposing a pressure on an abrasive fluid when such is present in said second chamber.

31. The arrangement of claim 30, wherein said means for imposing a pressure on an abrasive fluid in said second chamber comprises a second cylinder portion and a second piston arranged in said second cylinder portion.

32. The arrangement of claim 31, wherein said first and second pistons are movable in a manner so as to effect reciprocal movement of an abrasive fluid in said interior passage, and past said at least one deflecting object, when such abrasive fluid is present in said first and second chambers and in said interior passage.

33. The arrangement of claim 25, wherein said interior passage has at least one circular cross-sectional area in a plane normal to a longitudinal axis of said passage.

34. The arrangement of claim 33, wherein said at least one deflecting object is rotationally symmetric.

35. The arrangement of claim 25, wherein said interior passage has at least one square cross-sectional area in a plane normal to a longitudinal axis of said interior passage.

36. The arrangement of claim 35, wherein said at least one deflecting object has at least one square cross-sectional area.

37. The arrangement of claim 25, wherein said at least one deflecting object comprises a substantially flat structure oriented normal to a longitudinal axis of said interior passage.

38. The arrangement of claim 37, wherein said substantially flat structure is disc-shaped.

39. The arrangement of claim 37, wherein said substantially flat structure is a rectangular plate.

40. The arrangement of claim 37, wherein said at least one deflecting object comprises multiple substantially flat structures oriented normal to a longitudinal axis of said interior passage.
41. The arrangement of 40, wherein all said multiple flat structures are disc-shaped.

42. The arrangement of claim 25, wherein an outer contour of said at least one deflecting object follows an inner contour of said interior passage.