

HIGH PRESSURE LIQUID ABRASIVE DE-BURRING SYSTEM AND PROCESS FOR SAME

FIELD OF THE INVENTION

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The present invention, relates to a system and process for performing de-burring and polishing work using abrasive media on work pieces with high pressure liquid flow.

BACKGROUND

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The invention relates to machining and particularly to the field of traditional machining processes and equipment employing the techniques of and compositions for abrasive flow machining, grinding, de-burring, radiussing, leveling and polishing of work pieces. Such processes are traditionally employed in the working of castings, forged parts, machined parts, and the like, which are made of metal.

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PRIOR ART

Parts made of metallic or non-metallic materials (hereinafter referred as "work pieces") when produced by traditional manufacturing methods such as lathe turning, drilling and so on usually cause burrs to form. Such burrs are a small matter in case of parts not requiring high precision, but the burrs must be removed in case of parts requiring high precision because the burrs adversely affect the performance of the pieces.

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Abrasive flow machining has gained wide acceptance for a number of applications as the machining and finishing technique of choice. Such techniques are particularly adapted, for example, to working interior passages in work pieces, for light grinding, de-burring, radiussing leveling and polishing of complex surfaces. More complex workings include three-dimensioned surfaces where surface detail requires working, and in repetitive working of multiple work pieces of complex form and shape.

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There are three main groups of conventional machines in the market:-

Vibration bowl;

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Centrifugal flow type; and

Barrel type

An example of vibration bowl approach to abrasive machining is US Patent No. 5486135 for "Vibratory Tumbling machine vessel for burnishing or cleansing metal, plastic" (Jerry Arpaio). An example of Centrifugal type approach to abrasive machining is U S Patent No. 4385472 (Gunther W Balz). An example of Barrel type approach to abrasive machining is US 4949510 (Kobayashi, et al.)

Irrespective of the type of conventional machines used, the work pieces are placed inside a work space together with media. In the vibration bowl approach, the vibrations of work pieces and media would cause the media to rub against the work pieces, thereby smoothing the rough parts. In the centrifugal type approach, the centrifugal action would cause the work pieces and media to rub against each other, thereby smoothing the rough parts. The barrel type approach uses rotational force to cause the work pieces and media to rub against each other, thereby smoothing the rough parts.

PROBLEMS IN THE ART

The machines and inventions of the prior art uses media to rub against the metal pieces to de-burr, polish and finish the work pieces. Such operations have several disadvantages.

First and foremost, the mode of operation in the prior art machines uses vibration or mechanical spinning action to move media and work pieces. Liquid is not used to generate motion to move the media and work pieces. Due to the "de-burring" action, the chips and particles removed by abrasive action from the work pieces would eventually clog the outlets and inlets. Liquid is thus used for cleaning and lubricating functions. Therefore there is a requirement to clean the media and work pieces after one or two cycle of processing, resulting in two or more rinses.

In some prior art machines, the operations can only run for a few hours before the heat generated by the vibration becomes unbearable for the operators. To achieve a mirror like finish, a typical operation for de-burring, polishing and finishing using machines of the prior art would take 12 to 16 hours. The process of the prior art takes a long time and is therefore not productive, due to the deficiencies of the existing art.

The machines of the prior art uses vibration and spinning force to generate motion, such motion generating horizontal motion and downward force, as illustrated by Fig 1 In de-burring, the horizontal motion is required but if the downward force is too great, the force will generally bend the burr before it is ground off by the media. This problem of bending burr is well known in the surface treatment industry and referred to as "folding burr". For many years this problem of "bending burr" could not be solved by the machines of the prior art. It also takes a very long time to remove the "folding burr" and in many cases, the size and shape of the final work pieces are affected. Fig. 2 is an illustration of the abrasive forces of a medium on the surface of a work piece which results in an "orange skin effect" on a work piece in which the polished shining surface is not smooth. The finished work pieces will also have "micro cracks" which eventually result in having liquid and impurities trapped in the crevices and which eventually leads to corrosion of the work pieces.

Current de-burring systems are often not allowed to operate in many areas since these systems discharge substantial amounts of waste into the environment.

These deficiencies of the prior art would also contribute substantially to the cost and inefficiency of the process and equipment and, is a limiting factor determining the rate of production.

In addition, the inventor found current de-burring systems unable to meet industry's requirements for ferrous and non-ferrous work pieces which are getting smaller and thinner and often of complicated shapes.

Finally, there is also a need for improved surface finishing which current de-burring systems are unable to meet.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide an improved de-burring system which makes use of high pressure liquid flow and the different densities of the media and work pieces to generate horizontal force and an upward gravity neutralization force to carry out

the de-burring process, and in so doing, solve the problem of "folding burr" faced by prior art.

5 It is another object of the present invention to provide an improved de-burring system which is environmental friendly and reduces the costs of liquid by recycling the liquid and at the same time, remove the sludge by filtration thereby enabling continuous operations.

10 It is another object of the present invention to provide an improved de-burring process which solve the problem of "folding burr" medium which performs abrasive work on each work piece predominantly by elastic deformation.

15 It is still another object of the present invention to provide an improved de-burring process which offers improved productivity with improved efficiency, reduced operation procedure, reduced down time, reduced pollution and improved water conservation.

It is yet another object of the present invention to provide an improved de-burring process with the lowest HPA (Hard Particle Analysis) meeting the requirements of computer hard disk drive manufacturers and pharmaceutical industries.

20 These and still other objects, which are made apparent in the following disclosure and description of the invention, are attained in the present invention.

SUMMARY OF THE INVENTION

25 A first object of the invention is a high pressure liquid system to de-burr and polish work pieces, using a plurality of different types of abrasive media at progressive stages to de-burr and polish the work pieces in a processing tank, said processing tank having a bottom and a top, with outlets near the top of the processing tank, the system having:-

30 two or more pressure chambers fitted to two or more rims forming a base plate at the bottom of the processing tank;

35 ejecting means in each rim, by which liquid is forced out at high pressure from the pressure chambers;

wherein the work pieces and the abrasive media are placed at the bottom of the processing tank and liquid at high pressure is forced through the ejecting means so that the liquid under high pressure firstly lifts the work pieces and abrasive media and also creates a horizontal centripetal force and an upward force from the bottom of the processing tank to the top of the processing tank, and then downwards towards the centre of the processing tank in a spiral motion, to grind the burrs and polish the surfaces of the work pieces, causing chips and particles to be removed from the work pieces and to float to the surface of the liquid, near the top of the processing tank, which together with the liquid flow out from the outlets of the processing tank.

Preferably the pressure chamber for a high pressure liquid system to de-burr and polish work pieces has an inlet pipe for liquid to be pumped in and the pressure chamber is joined to the bottom of the processing tank by the rim.

Preferably, the rim has a plurality of orifices.

Preferably the base plate consists of two or more rims and a seal, said seal sealing the inner circumference of the first rim and the outer circumference of the second rim to prevent pressure leak between the first pressure chamber and the second pressure chamber.

Preferably the ejecting means consist of a plurality of ducts leading to a plurality of orifices for the liquid to be ejected under high pressure.

Preferably the high pressure liquid system to de-burr and polish work pieces has additionally,

two or more high pressure pumps to force the liquid through the plurality of ducts leading to the orifices;

a filtration system with filtration pump;

a receiving tank;

a system of pipes to bring the liquid through the receiving tank, filtration system, pressure chambers and into the processing tank before going through the same cycle.

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Advantageously the high pressure liquid system has a receiving tank which encloses the processing tank and pressure chambers, so that liquid flowing out from the outlets of the processing tank are received and transferred by the system of pipes to a filtration system and pumped by the filtration pump back to the pressure chambers and then ejected at high pressure through the nozzles and orifices into the processing tank, by the two or more high pressure pumps.

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Preferably, the plurality of ducts leading to the orifices in the base plate for a high pressure system is set at an angle from 25° to 50° to the vertical.

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Preferably, the receiver tank has a bypass inlet for removal of liquid to adjust the speed of rotation of the media and work pieces in the processing tank.

Advantageously the high pressure liquid system has additionally a cooling system to cool the liquid.

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Preferably the high pressure liquid system has a programmable controller which controls the timing, speed of rotation of the mixture of media and work pieces, pressure in the pressure chamber and the duration of each cycle depending on the type of work piece and the finishing required for the work pieces.

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Alternatively, the processing tank is tubular in configuration.

A second object of the invention is a high pressure abrasive process using the high pressure flow system of the invention, the process comprising the following steps:-

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placing a plurality of work pieces and an abrasive media at the bottom of the processing tank, and

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forcing liquid at high pressure through ejecting means, in each rim from the base plate at the bottom of the processing tank,

so that the liquid under high pressure firstly lifts the work pieces and abrasive media from the bottom of the processing tank, said liquid at high pressure creating:-

a horizontal centripetal force; and

an upward force from the bottom of the processing tank to the top of the processing tank, and said force coming then downwards towards the centre of the processing tank in a spiral motion,

to grind the burrs and polish the surfaces of the work pieces, causing chips and particles to be removed from the work pieces and to float to the surface of the liquid, and together with the liquid near the top of the processing tank, flow out from the outlets of the processing tank.

Preferably, the step of forcing the liquid out is carried out by ejecting means, under high pressure through two or more pressure chambers fitted to the processing tank.

Preferably, the step of forcing the liquid at high pressure is carried out by ejecting means which consist of a plurality of ducts leading to a plurality of orifices in the rim which forms the base plate of the processing tank.

Advantageously, the step of forcing the liquid at high pressure is carried out by ejecting means which consists of a plurality of ducts, the ducts set at an angle from 25° to 50° to the vertical.

More advantageously the process includes a filtration step wherein the liquid with the chips and particles flows out from the outlets near the top of the processing tank to a receiving tank and said liquid is cleaned by passing through a filtration system, to remove the chips and particles, wherein the cleaned liquid is returned through an inlet pipe into each pressure chamber.

More advantageously in the process, includes a step of cooling the liquid by a cooling system so that the liquid is maintained at an appropriate temperature for de-burring and polishing the work pieces.

- 5 A third object of the invention is a high pressure liquid process using different types of abrasive media at progressive stages of de-burring and polishing the work pieces, further including the following steps:-

10 removing the media after completion of the stage, leaving the work pieces in the bottom of the processing tank;

introducing another type of abrasive media at the bottom of the processing tank according to the de-burring and polishing requirements for the work pieces, and

15 forcing liquid at high pressure through ejecting means, from the base plate at the bottom of the processing tank,

20 so that the liquid under high pressure firstly lifts the work pieces and abrasive media from the bottom of the processing tank, said liquid at high pressure creating:-

a horizontal centripetal forces; and

25 an upward force from the bottom of the processing tank to the top of the processing tank, and said force coming then downwards towards the centre of the processing tank in a spiral motion,

30 removing the chips and particles through continuous filtration and cooling of the liquid before sending the liquid back to the pressure chambers, to repeat the process until the work pieces have met the specified requirements for de-burring and polishing.

BRIEF DESCRIPTION OF THE DRAWINGS

35 FIG. 1 shows the de-burring action of the media using the machines of the prior art on the surface of a work piece.

FIG. 2 is an illustration of the abrasive forces of a medium on the surface of a work piece which results in bending burr or "orange skin effect" on a work piece when using the machines of the prior art.

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Fig. 3 shows the main components of a system using the inventive process.

Fig. 4 shows the flow of liquids in the system using the inventive process.

10 Fig. 5 is a detailed drawing of the pressure chambers connected to the base plate of the processing tank.

Fig. 6 shows a top view of the base plate and a cross section of a portion of the base plate taken at section A – A.

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Fig. 7 is a flow diagram showing the various stages in the High pressure flow process.

Fig. 8 shows the flow of liquids at the commencement of the inventive process.

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Fig. 9 shows the horizontal centripetal forces generated by the liquid ejected through multiple nozzles and movement of media and work pieces as these are driven around the processing tank.

25 Fig. 10 shows the vertical forces depicted in the flow pattern of liquid, media and work pieces when viewing the cross section of the processing tank.

Fig. 11 shows the view from the top of the processing tank showing the flow pattern of liquid, media and work pieces.

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Fig. 12 is an illustration of the abrasive forces of a medium on the surface of a work piece during the inventive process.

35 Fig 13 shows the flow of liquids at the end of the High Pressure Liquid Abrasive De-burring and Polishing process.

DETAILED DESCRIPTION

The present invention performs work on surfaces of work pieces to effect light grinding, de-burring, radiussing, leveling and polishing of work pieces particularly where surface detail requires such working for many work pieces at the same time.

In machining terms, light grinding refers to machining operations on a work piece which correct errors of form. De-burring refers to such operations performed to remove flaws. Radiussing refers to operations which effect a softening or dulling of sharp edges of the work piece, by "rounding over" of the edge. Leveling refers to a reduction in waviness of a work piece surface by the machining operations. The term polishing refers to a reduction in roughness of work piece surfaces.

In the prior art, the use of abrasive media or abrasive particles is well known and would not be described herein. By use of such media having varying properties, extremely fine grinding, polishing and de-burring effects are produced on work pieces.

For purposes of understanding the following description of the operation of the High Pressure Flow process and system using such process, the term "de-burring and polishing" is used herein to refer to the various abrasive treatments and processes described for treating work pieces, after general machining, in order for the work pieces to attain a finished surface meeting the requirements of industry.

Fig. 1 to Fig. 6 describes the various parts of a system used for this inventive process.

Fig 1 and Fig. 2 shows the de-burring action of the media using the machines of the prior art on the surface of a work piece. The machines of the prior art uses either vibration or spinning action to generate motion. The motion would move the media over the work pieces, with a horizontal force. At the same time, gravitational force will force the media downwards against the surface of the work pieces. If the downward force is too great, the downward force will bend the burr before it is being grind off as shown in Fig. 2.

Fig. 3 shows the main components of a typical system using the inventive process, including a processing tank (10), a receiving tank (20), two main pumps (15,16), filtration system (50) and pump (52) and a cooling system (54). The base of the processing tank (10) is connected to two pressure chambers (11,12), all of which fits
5 into the receiving tank (20). The de-burring and polishing process takes place within the processing tank (10).

Fig. 4 shows the flows of liquid in an embodiment of the invention using the high pressure liquid to de-burr and polish work pieces (40). The embodiment described
10 herein is a processing tank (10) with two pressure chambers (11,12).

Liquid for use in the high pressure abrasion process is pumped from two main pumps (15,16) through two inflow pipes (13,14) into two pressure chambers (11,12) joined to the base plate (30) of the processing tank (10), which also forms the bottom
15 of the processing tank (10). Liquid overflowing in the processing tank (10) will flow down from the upper sides of the processing tank (10) and also from several outlets near the top of the processing tank (10), into a receiving tank (20). For the purpose of describing the inventive process herein, the term "liquid" is used which can be water or a mixture of water and chemicals.

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The liquid flowing into the receiving tank (20) will contain particles and chips generated during the de-burring and polishing action of the abrasive media (42) on the work pieces (40). The sludge is collected in the receiving tank (20) and eventually removed by opening valve (26). Liquid in the receiving tank (20) is then pumped
25 through a filtration system (50), which filters and remove all remaining particles, from the liquid. Much heat is generated by the pressure applied and also due to friction generated by the abrasive action between media (42) and work pieces (40), media (42) and media (42) and work pieces (40) and work pieces (40). Therefore the system of this invention would also have a cooling system (54). By using this cooling
30 system (54), the temperature of the processing tank (10) can be maintained at around 40° C, which is acceptable to an operator working on the system using this inventive process. If a lower temperature is required, a chiller can be added onto the system.

After filtration, the clean liquid is then pumped at high pressure and returned to the pressure chambers (11,12). The pumps (15,16) of the pressure chambers (11,12) will then force out the liquid at high pressure, into the processing tank (10), through the ducts (33) leading to the orifices (32) in the base plate (30) at the bottom of the
5 processing tank (10).

The system of receiver tank (20), filtration system (50) and pumps (52) are necessary for liquid to be recycled for treatment before being used again in the High Pressure Liquid Flow process. The liquid treatment eliminates the requirement to
10 stop the de burring process in order for the whole bath of liquid to be changed after one or two cycles in the de-burring process.

Fig. 5 is a detailed drawing of the pressure chambers (11,12) joined to the processing tank (10) with the rims (34,36) which form the base plate (30) of the
15 processing tank (10). Two pressure chambers (11,12), a first pressure chamber (11) and a second pressure chamber (12) are fitted into the processing tank (10), below the base plate (30). Additional pressure chambers would be required for processing tanks (10) of bigger capacity. The base of the processing tank (10) and the pressure chambers (11,12) are enclosed by the receiving tank (20), said receiving
20 tank (20) to receive outflow of liquid from the processing tank (10). A first inlet pipe (13) leads to the first pressure chamber (11) and a second inlet pipe (14) leads to the second pressure chamber (12). The two pressure chambers (11,12) receive liquid pumped at high pressure through the two inlet pipes (13,14), the high pressure coming from two separate high pressure pumps (15,16). A bypass inlet (22) allows
25 for removal of liquid through opening valve (24) to reduce the rotational speed of media (42) and work pieces (40) if required.

Fig. 6 shows a top view of the base plate (30) and a cross section of a portion of the base plate (30) taken at section A – A. In the embodiment having a processing
30 tank (10) with two pressure chambers (11,12). The bottom of the processing tank (10) is joined to two rims (34,36), a first rim (34) and a second rim (36), which forms a base plate (30). The two rims (34,36) fit the dimensions of the top of the first and second pressure chambers (11,12). In between the inner circumference of the first rim (34) and the outer circumference of the second rim (36), is a seal (38).

The seal (38) functions to prevent pressure leak between the first pressure chamber (11) and the second pressure chamber (12).

5 The drawing of the cross section A-A in the base plate (30) shows the ducts (33) in the base plate (30) leading out of the pressure chambers (11,12) into the orifices (32) of the base plate (30). These ducts (33) are set at various angles. The angles of these ducts (33) range from 25° to 50°. This is because the size of the orifice (32), the angle of the ducts (33) and distribution of the orifices (32) in the base plate (30) determine the forces generated for lifting the media (42) and work pieces (40) in
10 the liquid for the abrasive action. The number of orifices (32) is also based on the pump head installed for the system of this inventive process.

Fig. 7 to Fig. 13 describes the various stages of the inventive process.

15 Fig. 7 is a flow diagram showing the various stages in the inventive process. Typically, the various stages require media (42) of different materials, for each stage of the de-burring, polishing and finishing work. At each stage the media (42) used is removed while new media (42) required for the next stage is loaded, with the work pieces (40) remaining in the processing tank (10). To carry out the de-burring
20 process continuously, the typical system would include a programmable controller with which several types of finishing can be programmed to complete the entire process e.g. rough de-burr followed by fine de-burr and polishing in one setting.

Fig. 8 shows the flow of liquids at the commencement of the inventive process.
25 Liquid is pumped via two main pumps (15,16), through two separate inlet pipes (13,14), a first inlet pipe (13) leading into a first pressure chamber (11) and a second inlet pipe (14) leading into a second pressure chamber (12). The pressure in the first chamber (11) may reach a head of 70 meter or 7 bar which is necessary when using heavy media (42) such as steel balls to do the polishing work.
30 The second pressure chamber (12) has lower pressure as its main function is to assist in the generation of spiral motion. More pressure chambers can be added for bigger capacity processing tanks (10). A bypass inlet (22) allows for adjustment of the rotation speed of the media (42) and work pieces (40) in the processing tank (10) for a temporary period of time or throughout the process.

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Fig. 9 shows the horizontal centripetal forces generated by the liquid forced out under high pressure through the plurality of orifices (32) and movement of media (42) and work pieces (40) as these are driven around the processing tank (10). Fig. 10 shows the vertical forces (also described as "upward gravity neutralization force") depicted in the flow pattern of liquid, media (42) and work pieces (40), when viewing the cross section of the processing tank (10). Fig. 11 shows the view from the top of the processing tank (10) showing the flow pattern of liquid, media (42) and work pieces (40).

10 The forces generated by liquid forced out under high pressure through the plurality of orifices (32) causes two forms of movement of media (42), work pieces (40) and liquids:-

a horizontal centripetal force;

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an upward force from the bottom of the processing tank (10) to the top of the processing tank (10), and then downwards to the centre of the processing tank (10)

20 as the media (42) and work pieces (40) are moved around the processing tank (10). The horizontal centripetal force will push the media (42) and work pieces (40) in a spiral motion around the processing tank (10). This horizontal force is necessary for grinding of the burr or polishing of the surface of the work piece (40). As known in the art, there is also a gravitational force affecting the media (42) and which causes the "folding burr" in work pieces (40). The high pressure ejection of liquid from the plurality of orifices (32) at the base plate (30) of the processing tank (10) now creates the upward gravity neutralization force on the media (42) which counters the gravitational force on the media (42) against the surface of the work pieces (40), thus preventing the creation of "folding burrs".

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The high head liquid generated by the two pumps (15,16) also creates a layer of cushion zone at the bottom of the processing tank (10). Abrasive action therefore takes place at the top of the cushion zone. Abrasion of the base plate (30) and orifices (32) would thus be avoided. Also the liquid flow direction, viewed from the side of the processing tank (10), is upwards to the higher zone before coming down

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towards the centre of the processing tank (10), adding to the spiral movement due to the horizontal centripetal force. In this manner, chips and particles removed from the work pieces (40) are brought up to the higher zone. From the higher zone which is near the top of the processing tank (10), the liquid, the chips and particles will flow down from outlets (8) near the top of the processing tank (10). Also due to the high pressure inflow through the ducts (33) leading to the orifices (32), the chips and particles would never be able to enter the orifices (32), creating blockages.

Fig 12 is an illustration of the abrasive forces on a medium on the surface of a work piece (40) under High Pressure liquid flow as both media (42) and work pieces (40) moved around the processing tank (10). The ejection of the liquid will push the media (42) in a circular motion around the processing tank (10) resulting in a horizontal centripetal force on the media (42). This horizontal centripetal force is necessary for grinding of the burr or polishing of the surface of the work piece (40). As known in the art, there is also a gravitational force affecting the media (42) which causes the "folding burrs". The upward gravity neutralization force on the media (42) will nullify the gravitational force on the media (42) against the surface of the work pieces (40).

The system for this de-burring process also include a programmable controller with which several types of finishing can be obtained for the entire process e.g. rough de-burr followed by fine de-burr and polishing in one cycle.

A description of the stages of the High Pressure Liquid flow to de-burr and polish work pieces (40) is described herein with reference to Fig. 7 to Fig. 13 .

The media (42) and work pieces (40) are placed inside a processing tank (10) through an opening for placement of media (42) and work pieces (40).

Media (42) is selected depending on the kind of finishing required for that stage of de-burring and polishing the work pieces (40). Once the media (42) is placed into the processing tank (10), the work pieces (40) are also placed inside the processing tank (10).

Liquid (which can be water or a mixture of water and chemicals) is then forced at very high pressure through the ducts (33) in the orifices (32) in the rims (34,36) which form the base plate (30) in the bottom of the processing tank (10). In all cases, the liquid selected is based on the relative densities of the media (42) and work pieces (40).

The system is switched on and liquid is pumped into the processing tank (10) through the first and second inlet pipes (13,14) into the first and second pressure chambers (11,12). The liquid is then forced out under high pressure through the ducts (33) leading out to the orifices (32) in the rims (34, 36) which form the base plate (30) of the processing tank (10). The inflow of liquid will firstly generate a lifting effect on the media (42) and work pieces (40). The media (42) and work pieces (40) then starts to rotate in a spiral motion and the media (42) and work pieces (40) will then be lifted up from the bottom of the processing tank (10).

The High Pressure Flow of liquid within the processing tank (10) generates two forces on the media (42):-

a horizontal centripetal force created in a horizontal plane which pushes the media (42) along in a horizontal direction and grinds the burr or polish the surface of the work pieces (40)

an upward force created by the bottom to top movement of liquid, which neutralizes the gravitational force exerted on the media (42)

The liquid ejected under high pressure from the pressure chambers (11,12), goes through the ducts (33) leading out to the orifices (32) in the rims (34, 36), the liquid coming out at an angle. The angles of the ducts (33) are varied, ranging from 25° to 50°. The orifices (32) are distributed all over in the rims (34, 36) forming the base plate (30). Each rim (34, 36) is joined to the top of the pressure chambers (11,12) and forms the base plate (30) which is at the bottom of the processing tank (10). In between the inner circumference of the first rim (34) and the outer circumference of the second rim (36), is a seal (38). The seal (38) functions to prevent pressure leak between the first pressure chamber (11) and the second pressure chamber (12).

Since the media (42) and work pieces (40) are directly on top of the base plate (30) of the processing tank (10), the force of the liquid will drive the media (42) and work pieces (40) around the processing tank (10). The media (42) and work pieces (40) will thus rotate around the processing tank (10) in a spiral manner. Due to different
5 densities of media (42) and work pieces (40), the media (42) and work pieces (40) will have different flow speeds. As the work pieces (40) and the media (42) are swirling around the processing tank (10), the media (42) and the work pieces (40) will come into contact with each other, thus rubbing against each other. This rubbing action will perform the de-burring or polishing action.

10 In conventional systems and processes, the gravitational force will cause the bending burrs. In the present invention, the high pressure flow from the bottom of the chamber (11,12) will contribute an upward force which counters the gravitational force imposed on the media (42) against the surface of the work pieces (40).

15 Due to the high pressure flow, and constant force of liquid into the processing tank (10), slug and particles which come off the work pieces (40) are prevented from being deposited into micro cracks on the surface of the work pieces (40), unlike the conventional systems and processes. The result is lower impurity in these work
20 pieces (40) resulting in improved coating reliability of the finished work pieces (40), reducing the risk of plating, bubble or corrosion in these finished work pieces (40).

The liquid and particles and chips removed from the work pieces (40) and used media (42) will flow from a plurality of outlets (8) near the top of the processing
25 tank (10) and downwards into the receiving tank (20). In the receiving tank (20), the sludge is collected and eventually removed. The waste liquid is then pumped into a filtration system (50) to remove all impurities. The liquid which is now cleaned is then pumped back into the processing tank (10), going through the first inlet pipe (13) and second inlet pipe (14) back into the first and second pressure chambers
30 (11,12). From the pressure chambers (11,12), the liquid is once again forced out through the ducts (33) which are set at various angles, leading out to the orifices (32) into the bottom of the processing tank (10) to generate the two forces on the media (42) and work pieces (40).

By using the formula of

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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heat will generated due to pressure being applied and due to friction arising from abrasive action between the media (42) and the work pieces (40), media (42) and media (42) and work pieces (40) and work pieces (40). A cooling system (54) is therefore required. With the inclusion of a cooling system (54), the operating
10 temperature can be maintained at around 40° which is in the acceptable range for an operator to work on the system utilizing this inventive process. If the work pieces (40) are materials which require lower temperatures, chillers can be installed for such work pieces (40).

15 A system of receiver tank (20), filtration system (50) and pumps (52) are necessary for liquid to be recycled for treatment before being used again in the High Pressure Liquid Flow system and process. The filtration system (50) eliminates the requirement to stop the de-burring process for the whole bath of liquid to be changed after one or two cycles in the de-burring process.

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The de-burring and polishing process of this invention can continue until the level of surface treatment required is achieved. This might necessarily require change of media (42) and running the de-burring process with the changed media (42). However, there is no requirement to change the liquid. Once the selected media
25 (42) is loaded, the de-burring process will continue until the level of finishing required is achieved. Nonetheless, the entire process can still be shorter than the process of the prior art. Once the level of finishing has been achieved, the work pieces (40) would be unloaded and the work pieces (40) would be quite clean, necessitating minor rinsing.

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The programme and duration for de-burring depends on the type of finishing required for the work piece (40). Preferably, the de-burring treatment is controlled by a programmable controller so as to reduce manpower required to supervise the de-burring process.

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The invented process is capable of use on work pieces (40) of any material which can be worked by abrasive effect of media (42) against the surfaces of the work pieces (40) for light grinding, de-burring, radiussing, leveling and polishing of work piece (40) surfaces. Most commonly the invention will be employed with metal work pieces (40),
5 including, for example, steels, including mild steel, tool steels, stainless steels, and the like, aluminum, aluminum-magnesium alloys, beryllium copper alloys, titanium, and many others. It is possible that the system can be used on ceramics, cerements, and other machinable composites, glass, semi-conductor materials, and the like.

10 The process of the present invention also offers the lowest HPA (Hard Particle Analysis) of 8,000 and lower. The operations of the present invention can therefore extend to those industries which require components with the lowest HPA (Hard Particle Analysis) meeting the requirements of computer hard disk drive manufacturers and pharmaceutical industries.

15 Due to the high pressure flow of the invention, deposition of particles in micro cracks in the work pieces (40) are prevented. The finished work pieces (40) from this inventive process have surfaces which can be coated, cast, stamped, machined or milled, bobbed, forged or formed by non-traditional machining techniques, such as
20 electrical discharge machining, chemical or electrochemical milling. Due to absence of impurities in the micro cracks, after coating reliability is improved since there would be absence of bubbles or corrosion after the coating.

OTHER EMBODIMENTS

25 While an embodiment of the system using the inventive process has been given herein, other embodiments are possible. Two pressure chambers had been described herein. Additional chambers may be required for bigger capacity systems or bigger capacity processing tanks. Additional chambers would require corresponding number of rims
30 forming the base plate.

The angle of the ducts and number of the orifices will vary depending on the efficiency of the pumps. The layout and distribution of the orifices on the base plate can also be changed.

There could be more than one processing tank. It is also envisaged that the processing tank be tubular in shape or cylindrical in shape.

The description of the processing tank, base plate, pressure chamber, receiving tank, filtration system, cooling system and pumps have been given for purpose of illustration herein. The embodiments are merely preferred examples and not to be construed as limiting the scope of the inventive process. It is therefore envisaged similar devices could be used for the same purposes with or without modifications for the inventive process to work in such environments.

Having described preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the claims.

ADVANTAGEOUS EFFECTS OF THE INVENTION

The use of forcing liquid at high pressure flow from the bottom of the processing tank and the different densities of the media and work pieces generates a horizontal force and an upward gravity neutralisation force to carry out the de-burring and polishing, and in so doing, solve the problem of "folding burr" faced by prior art.

This process is also environmental friendly and reduces the costs of water by recycling the water based liquid and at the same time, remove the sludge by filtration thereby enabling continuous operations.

The High Pressure liquid abrasive system of de-burring offers improves productivity with improved efficiency, reduces operation procedure, reduces down time, reduces pollution and improves water conservation.

The High Pressure Liquid abrasive system of de-burring offers the lowest HPA (Hard Particle Analysis) being able to reduce HPA to 8,000 and below, and with reduced impurities, the surface of the work pieces have greater after coating reliability and lower plating, bubble and corrosion.

CLAIMS

1. A high pressure liquid system to de-burr and polish work pieces (40), using a plurality of different types of abrasive media (42) at progressive stages in de-burring and polishing the work pieces (40) in a processing tank (10), said processing tank (10) having a bottom and a top, with outlets (8) near the top of the processing tank (10), the system having:-

two or more pressure chambers (11,12) fitted to two or more rims (34, 36) forming a base plate (30) at the bottom of the processing tank (10);

ejecting means in each rim (34, 36), by which liquid is forced out at high pressure from the pressure chambers (11,12);

characterized in that the work pieces (40) and the abrasive media (40) are placed at the bottom of the processing tank (10) and liquid at high pressure is forced through the ejecting means so that the liquid under high pressure firstly lifts the work pieces (40) and abrasive media (42) and also creates a horizontal centripetal force and an upward force from the bottom of the processing tank (10) to the top of the processing tank (10), and then downwards towards the centre of the processing tank (10) in a spiral motion, to grind the burrs and polish the surfaces of the work pieces (40), causing chips and particles to be removed from the work pieces (40) and to float to the surface of the liquid, near the top of the processing tank (10), and which together with the liquid flow out from the outlets (8) of the processing tank (10).

2. The pressure chamber (11,12) for a high pressure liquid system to de-burr and polish work pieces (40), as claimed in Claim 1, the pressure chamber (11, 12) having an inlet pipe (13) for liquid to be pumped in and said pressure chamber joined to the bottom of the processing tank (10) by the rim (34, 36).

3. A rim (34, 36) for a high pressure chamber of a high pressure liquid system, as claimed in Claim 1 wherein the rim (34, 36) has a plurality of orifices (32).

4. A base plate (30) for a high pressure chamber of a high pressure liquid system, consisting of two or more rims (34,36) and a seal (38), said seal (38) sealing the inner circumference of the first rim (34) and the outer circumference of the second rim (36).

5

5. The ejecting means for a high pressure liquid system to de-burr and polish work pieces (40), as claimed in Claim 1, wherein ejecting means consist of a plurality of ducts (33) leading to a plurality of orifices (32) for the liquid to be ejected under high pressure.

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6. A high pressure liquid system to de-burr and polish work pieces (32), as claimed in Claim 1 having additionally,

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two or more high pressure pumps (15,16) to force the liquid through the plurality of ducts (33) leading to the orifices (32);

a filtration system (50) with filtration pump (52);

a receiving tank (20);

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a system of pipes to bring the liquid through the receiving tank (20), filtration system (50), pressure chambers (11,12) and into the processing tank (10) before going through the same cycle.

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7. A system for de-burring and polishing work pieces (40) with a plurality of different types of abrasive media (42) in a processing tank (10), as claimed in Claim 1, wherein a receiving tank (20) encloses the processing tank (10) and pressure chambers (11,12), so that liquid flowing out from the outlets (8) of the processing tank (10) are received and transferred by the system of pipes to a filtration system (50) and pumped by the filtration pump (52) back to the pressure chambers (11,12) and then ejected at high pressure through the ducts (33) leading to the orifices (32) into the processing tank (10), by the two or more high pressure pumps (15,16).

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8. A plurality of ducts (33) leading to the orifices (32) in the base plate (30) for a high pressure system for a de-burring and polishing process as claimed in Claim 5,

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said ducts (33) leading to the orifices (32) set at an angle from 25° to 50° to the vertical.

9. The receiver tank (20) for a de-burring and polishing system, as claimed in Claim 6, the receiver tank (20) having a by pass inlet (22) for removal of liquid to adjust the speed of rotation of the media (42) and work pieces (40) in the processing tank (10).

10. A high pressure liquid system to de-burr and polish work pieces (40) as claimed in Claim 6, the system having additionally a cooling system (54) to cool the liquid.

11. A high pressure liquid system to de-burr and polish work pieces (40), as claimed in Claim 6, the system having additionally a programmable controller which controls the timing, speed of rotation of the mixture of media (42) and work pieces (40), pressure in the pressure chamber (11,12) and the duration of each cycle depending on the type of work piece (40) and the finishing required for the work pieces (40).

12. A processing tank (10) for use in a de-burring and polishing process as claimed in Claim 1 or Claim 6, wherein the processing tank (10) is tubular in configuration.

13. An abrasive process to de-burr and polish a plurality of work pieces (40) using a high pressure flow system as claimed in Claim 1, the process comprising the following steps:-

placing a plurality of work pieces (40) and an abrasive media (42) at the bottom of the processing tank (10), and

forcing liquid at high pressure through the ejecting means in each rim (34, 36) forming the base plate (30) at the bottom of the processing tank (10),

so that the liquid under high pressure firstly lifts the work pieces (40) and abrasive media (42) from the bottom of the processing tank (10), said liquid at high pressure creating:-

5 a horizontal centripetal force; and

an upward force from the bottom of the processing tank (10) to the top of the processing tank (10), and said force coming then downwards towards the centre of the processing tank (10) in a spiral motion,

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to grind the burrs and polish the surfaces of the work pieces (40), causing chips and particles to be removed from the work pieces (40) and to float to the surface of the liquid, and together with the liquid near the top of the processing tank (10), flow out from the outlets of the processing tank (10).

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14. A process as claimed in Claim 13, wherein the step of forcing the liquid at high pressure is carried out by ejecting means using high pressure created by two or more pressure chambers (11,12) fitted to the processing tank (10).

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15. A process as claimed in Claim 13, wherein the step of forcing the liquid at high pressure is carried out by ejecting means, which consists of a plurality of ducts (33) leading to a plurality of orifices (32) in the rim (34, 36) which forms the base plate (30) of the processing tank (10).

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16. A process as claimed in Claim 13, wherein the step of forcing the liquid at high pressure is carried out by ejecting means, which consists of a plurality of ducts (33) set at an angle from 25° to 50° to the vertical.

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17. A process as claimed in Claim 13, including a filtration step wherein the liquid with the chips and particles flows out from the outlets (8) near the top of the processing tank (10) to a receiving tank (20) and said liquid is cleaned by passing through a filtration system (50) to remove the chips and particles, wherein the cleaned liquid is returned through an inlet pipe (13,14) into each pressure chamber (11,12).

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18. A process as claimed in Claim 13, including a cooling step wherein the liquid is cooled by a cooling system (54) so that the liquid is maintained at an appropriate temperature for de-burring and polishing the work pieces (40).

5 19. A process as claimed in Claim 13, using different types of abrasive media (42) at progressive stages of de-burring and polishing the work pieces (42), further including the following steps:-

10 removing the media (42) after completion of the stage; leaving the work pieces (40) in the bottom of the processing tank (10);

introducing another type of abrasive media (42) at the bottom of the processing tank (10) according to the de-burring and polishing requirements for the work pieces (40), and

15 forcing liquid at high pressure through ejecting means, from the rim (34, 36) forming the base plate (30) at the bottom of the processing tank (10),

20 so that the liquid under high pressure firstly lifts the work pieces (40) and the another type of abrasive media (42) from the bottom of the processing tank (10), said liquid at high pressure creating:-

a horizontal centripetal force; and

25 an upward force from the bottom of the processing tank (10) to the top of the processing tank (10), and said force coming then downwards towards the centre of the processing tank (10) in a spiral motion,

30 removing the chips and particles through continuous filtration and cooling of the liquid before sending the liquid back to the pressure chambers (11, 12), to repeat the process until the work pieces (40) meet the specified requirements for de-burring and polishing.

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