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(54) **SURFACE REFINING AND CLEANING METHOD FOR METAL PARTS OR THE LIKE AND DEVICE THEREFOR**

OBERFLÄCHENVEREDELUNGS UND -REINIGUNGSVERFAHREN UND VORRICHTUNG FÜR METALLTEILE ODER DERGLEICHEN

PROCEDE DE NETTOYAGE ET D'AFFINAGE DE SURFACE POUR DES PIECES METALLIQUES OU SIMILAIRES ET DISPOSITIF PREVU AVEC CE PROCEDE

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Description

Field of Art:

[0001] This invention relates to a method of refining (peening) metal part surfaces, such as for gears, springs, and molds, and to a device in which such method is implemented. More specifically, it relates to a metal part surface modification and cleaning method and the device using this method which is especially suitable for the machining industry where shot peening is typically used to improve metal part surfaces (e.g., to form compressive residual stresses, enhance fatigue strength, harden the workpiece) and for use in fields where parts need to be cleaned.

Background of the Art:

[0002] Conventionally, shot peening has been used to improve a variety of metal part surfaces to form compressive residual stresses, enhance fatigue strength, harden the workpiece, etc.

[0003] More recently, to impede stress corrosion cracking and protect materials in critical applications, such as a nuclear reactor vessel, against such cracking, there is also a technique available to suppress the residual stresses on the surface of a workpiece using cavitation generated by injecting water into water via a nozzle comprising two or more throats.

[0004] This technique to improve metal part surfaces, however, has been disclosed as if it utilized the collapsing impact force of cavitation. Nevertheless, it has been used practically while being confused with a "general water jet", which has a "cavitating jet" that is injected into the air.

[0005] In other words, the use of the "general water jet" has assumed that the surface peening level (introduced residual stress value, improved fatigue strength level, surface hardening grade, etc.) is dependent upon the pressure of the water injected. On such an assumption, an expensive high-pressure pump is employed to increase the pump discharge pressure. Nevertheless, satisfactory treatment capability has remained unattainable from the viewpoint of surface treatment. Furthermore, there have been some other problems awaiting solution. The factors which may govern a cavitation collapsing impact force in the surface modification process are not yet fully understood. And neither the collapsing impact force of the cavitation bubble nor the cavitation jet's surface treatment effect have been effectively utilized.

[0006] The inventor of the disclosure specified herein has therefore proceeded with studies on the collapsing impact force of the cavitation bubble and on the cavitating jet's surface modification phenomenon. As a result, it has been verified that the collapsing impact force of the cavitation bubble and the cavitating jet's surface modification effect (improving residual stresses, hardening the workpiece and enhancing fatigue strength) are dependent upon not only the pressure of the pressurized water but also on the pressure of the water tank in which the workpiece is placed, that for the ratio of pressurized water pressure to water tank pressure an optimum value exists, that the cavitation collapsing impact force increases and decreases according to the temperature of the fluid, and that the cavitation collapsing impact force could be increased if the conditions referred to above were satisfied.

[0007] The present invention has been made, based on such knowledge referred to above. The workpiece to be treated is located in a tank filled with a fluid, such as water or oil. And the workpiece is treated by injecting a cavitating jet. To increase the cavitating jet's treatment capability, moreover, the tank in which the workpiece is located is pressurized and controlled by pressurization in a short time. Thus, the present invention provides a method and its device for peening and cleaning metal part or other surfaces, permitting a metal part to be improved on the surface.

[0008] Furthermore, to inject a cavitating jet onto the workpiece to be treated, a freely movable pressurizing vessel is provided for the present invention to comprise a method and device for peening and cleaning the surfaces of metal and other parts which are capable of treating the surface of a large-sized structure.

[0009] A pressurizing section is formed in a pipe to inject a cavitation jet. Thus, the present invention provides a method and device for peening and cleaning the surfaces of metal and other parts, which would allow the internal surface of the pipe to be treated and cleaned while moving the section along the internal surface of the pipe.

[0010] And the present invention, at least in its preferred embodiments, aims to use the above-mentioned cleaning method and device to resolve the problems mentioned above.

[0011] JP 07 328857 discloses a surface cleaning device with a first vessel placed on a part to be treated, a nozzle to inject a pressurised fluid into the first vessel and a nozzle to inject a cavitating fluid into the pressurised fluid to apply a peening effect to the surface of the part.

Disclosure of the Invention:

[0012] From a first aspect the present invention provides a metal part and other surface modification and cleaning method, comprising: placing the part to be treated within a first vessel, which is filled with a pressurised fluid, said first vessel being placed within a second vessel, which is filled with a fluid, and applying a peening effect to the surface of the part by generating cavitation by injecting a pressurized fluid from a nozzle distant from said part on the surface so that the collapsing impact force of the cavitation bubble may be used to strengthen and clean the surface of the treated part.

[0013] From a second aspect the present invention provides a metal part and other surface modification de-

vice composed of a first vessel, which in use accommodates the part to be treated in a pressurised fluid, a lid hermetically enclosing the first vessel, a second vessel, which in use accommodates said first vessel, a nozzle to inject a pressurized fluid jet into the pressurized fluid within the first vessel, a flow rate control valve to control the jet pressure from said nozzle and a pressure control valve to control the fluid pressure in the first vessel.

[0014] The problem-resolving means employed in the present invention also include in preferred embodiments of the invention:

[0015] A metal part and other surface modification and cleaning method, in which the part to be treated is placed within a first vessel which is filled with a fluid, which flows in the first vessel located at a distance from the surface of said part and flows from the first vessel, with this fluid's flow rates controlled to pressurize the first vessel to increase the collapsing impact force of the cavitation bubble, which is in turn used to apply a peening effect to the surface of the part to strengthen and clean the surface of the treated part.

[0016] A metal part and other surface modification and cleaning method, in which a first vessel is pressurized by controlling the flow rates of both fluids flowing in and out of said first vessel to increase the collapsing impact force of the cavitation bubble and strengthen and clean the treated part by applying a peening effect under such impact force.

[0017] A metal part and other surface modification and cleaning method, in which a substance with different acoustic impedance is inserted between said first and second vessels.

[0018] A metal part and other surface modification and cleaning method, in which the temperature of the fluid in said first vessel is controlled by controlling the temperature of the fluid that fills the space between said first and second vessels.

[0019] A metal part and other surface modification and cleaning method, in which the cavitating jet to be injected into a first vessel is sent to the cooling means from the first vessel and returned to a cavitating jet pump after being cooled by said cooling means.

[0020] A metal part and other surface modification device composed of a first vessel capable of accommodating the part to be treated, a lid that hermetically encloses the first vessel, a second vessel capable of accommodating said first vessel, a nozzle to inject a pressurized fluid into the pressurized fluid, a flow control valve to control the jet pressure from said nozzle and a pressure control valve to control the fluid pressure in the first vessel.

[0021] A metal part and other surface modification device provided with two or more said nozzles, with said second vessel configured to have a larger depth than the height of the first vessel.

[0022] A metal part and other surface modification device, in which a substance with different acoustic impedance is arranged between said first and second vessels.

[0023] A metal part and other surface modification device whose lid on said first vessel is closed with a specified force.

[0024] A metal part and other surface modification device provided with a means of heating or cooling the fluid in said second vessel.

[0025] A metal part and other surface modification device, in which said part to be treated is loaded on a carriage to carry it.

[0026] A metal part and other surface modification and cleaning method, in which the part to be treated is installed in a first vessel, which is filled with a fluid, which is in turn flowed into said first vessel to pressurize said first vessel in the interior, with the collapsing impact force of the cavitation bubble increased by injecting the pressurized fluid to generate cavitation in said first vessel which is pressurized so that said impact force is used to strengthen and clean the surface of the treated part by applying a peening effect to the part.

[0027] A metal part and other surface modification and cleaning device composed of said first vessel, a nozzle to pour a pressurized fluid into first vessel, and a nozzle to inject a cavitating jet into the pressurized fluid in the first vessel.

[0028] A metal part and other surface modification and cleaning device configured to control the pressure of the fluid in said first vessel by a fluid pressure regulator means such as a valve or the like.

[0029] A metal part and other surface modification and cleaning device provided with a means of cooling the cavitating jet fluid to be poured into the first vessel.

[0030] A metal part and other surface modification and cleaning device, in which a pressurized fluid is poured into said first vessel to effectively surround the cavitating jet fluid.

[0031] A metal part and other surface modification and cleaning device, in which either the first member or the second member is provided with a fluid pressure regulator means to regulate the fluid pressure in the fluid-pressurizing chamber.

A Brief Description of the Figures:

[0032]

Figure 1 is a block diagram of the surface modification device involved in a first embodiment of the present invention.

Figure 2 shows the pressurization data relating to the present invention.

Figure 3 is a block diagram of the surface modification device involved in a second embodiment of the present invention.

Figure 4 shows the compressive residual stresses that have arisen from treating a steel using the present invention.

Figure 5 shows the compressive residual stresses that have arisen from treating a carburized gear material using the present invention.

Figure 6 depicts an example of workpiece hardening.

[0033] Based on the figures, the embodiment forms of the present invention are described in detail below.

[0034] Figure 1 is a block diagram of the metal part and other surface modification device involved in the first embodiment.

[0035] In Figure 1, 1 is the first vessel, which permits a workpiece to be delivered and enter with ease, being configured to be hermetically sealable by means of a Lid 2, to reform the surface of the workpiece.

[0036] A second vessel 3 which is capable of accommodating same first vessel 1, and is formed to have a larger depth than the height of the first vessel so that it can form appropriate Space S in the periphery of the first vessel.

[0037] 4 is the nozzle to inject a cavitation jet into the first vessel 1.

[0038] 5 is the conduit to supply the nozzle with a high-pressure fluid from the first vessel 1.

[0039] 6 is a control valve to regulate the high-pressure fluid flow rate.

[0040] 7 is a conduit, through which the fluid is drained from the first vessel 1.

[0041] 8 is a pressure control valve located in said conduit to regulate the pressure in the first vessel 1.

[0042] The first vessel 1 may be provided with two or more nozzles. It is preferable, moreover, that Flow Control Valve 6 is located in a branched Conduit 5a rather than directly in Conduit 5 to couple a High-pressure Pump P and the Nozzle 4.

[0043] Workpiece W is placed within the hermetically sealable the first vessel 1 which is filled with a fluid, such as water or oil, allowing the workpiece to be delivered and enter, with the space between the first vessel 1 and the second vessel 3 being filled with a fluid, such as water or oil.

[0044] Said Flow Control Valve 6, Pressure Control valve 8 and Pump P are coupled with an electronic control device which is not illustrated. And they are controlled to attain an optimum pressure, based on a signal from a pressure/temperature sensor which is not illustrated.

Specific Action (operation) in Said Embodiment Forms:

[0045] After being placed within the first vessel 1, Workpiece W is hermetically sealed with Lid 2 capable of being peened and closed. High-pressure water is injected from Nozzle 4 to generate Cavitation 9 around the jet so to hit the cavitation bubbles against Workpiece W. The collapsing impact force of the cavitation bubbles acts upon the surface of the workpiece, thereby bringing about a workpiece-hardening effect to the surface of the workpiece, an improvement of residual stresses and an enhancement of fatigue strength.

[0046] To increase the collapsing impact force of Cavitation Bubble 9, Flow Control Valve 6 is used to control the flow rate of the pressurized fluid flowing into the first vessel 1 from Nozzle 4 or Pressure Control valve 8 is used to control the flow rate of the fluid flowing from the first vessel to control the pressure of the fluid pressurized in first vessel.

[0047] If the first vessel 1 has any portion in gaseous phase, moreover, pressurization will require a certain time because the gaseous-phase portion is compressed with the pressurized water. In this embodiment form, therefore, the second vessel 2 has its depth increased so that the first vessel 1 can be pressurized in a shorter time. And the pressure of the fluid filled in the second vessel 3 is used to keep a specified pressure applied to the first vessel. This permits the first vessel 1 to be pressurized in a shorter time while allowing the gaseous phrase portion in the first vessel to be reduced to the minimum possible in a short time.

[0048] As referred to above, the present invention is capable of minimizing the gaseous phase portion in the first vessel 1 to be pressurized. Consequently, it is possible to reduce the time required to pressurize the first vessel 1.

[0049] In a case in which the first vessel 1 has an optimum fluid pressure of 5 atmospheres, for example, it is assumed that the first vessel contains approximately 12 litres of air. Then, approximately 1 minute is required to pressurize the vessel by means of a high-pressure pump having a capacity of 10 liters per minute. Consequently, the time equivalent to the actual working time (several seconds thru several minutes, which could be reduced, depending upon the arrangement of the nozzle), would be wasted. With the present invention, the first vessel 1 is immersed beforehand in the fluid filling the second vessel. The air in the first vessel 1, therefore, can be reduced to one-tenth or less while enabling a reduction of treatment time to one-tenth or less. Furthermore, in proportion to the depth of the first vessel 1, a specified pressure is kept applied to the first vessel. In the above-mentioned case, for example, it is possible to reduce the pressurizing time by 100% because the pressurization would take zero time when the second vessel 3 has a water depth of 50 meters even if approximately 12 litres of air is stored in the first vessel 1.

[0050] In comparison with the case where the first vessel is not pressurized as referred to above, the present embodiment form allows for a successful achievement of desirable effects, such as a significant improvement of residual stresses, an enhancement of fatigue strength, a capability of inserting compressive residual stresses into the deep portion from the workpiece surface, higher efficiency (shorter time requirement), than the case without pressurization, together with the capability of hardening the surface of the workpiece.

[0051] Figure 3 shows the pressurization data. In the figure, A shows the case with pressurization and B without pressurization while X stands for the depth at which residual stresses may be improved. Compared with the case without pressurization, the depth in which compressive residual stresses penetrate the surface of the work-

piece is increased twice thru 10 times or more with pressurization while the treatment time requirement is decreased by half thru one-tenth. (This value is attainable when the jet has a discharge pressure of 20 MPa, with a nozzle bore ranging from 0.4 to 0.8 millimeters. The larger the nozzle and the greater the discharge pressure, the more conspicuously effective the pressurization will be.)

[0052] The collapsing impact force of the cavitation bubble is also dependent upon the fluid temperature. With the second vessel 3 located in the periphery of the first vessel 1, and with a fluid temperature control unit added to the second vessel 3, the fluid in the first vessel can be kept at a constant temperature and controlled to a range of 30°C through 60°C, within which the cavitation bubbles come to have an optimum collapsing impact force. Unless the second vessel 3 is provided, the first vessel 1 will have a temperature rise, thereby damping the collapsing impact force of cavitation bubbles. At the same time, there are such hazardous possibilities that leakage may take place in the high-pressure pump, piping and/or the first vessel 1, or may turn liable to break.

[0053] With water applied, cavitation foams have a collapsing impact force maximized at a temperature of 50°C, intermediate between the boiling and melting points. In practical use, it would be hazardous if a high-pressure pump or piping had a high temperature (80°C or more) at which their resistance to pressure would show an extreme drop. In this sense, the first vessel 1 should preferably have a fluid temperature fall within a range of 30°C thru 60°C.

[0054] Installing the second vessel 3 allows for a reduction of the cavitation noise that takes place within the first vessel 1. Inserting a substance with different acoustic impedance the first vessel 1 and the second vessel will enhance the sound-proof (silencing) effect.

[0055] With the second vessel 3 installed, it is possible to eliminate the gaseous-phase portion (compressed gas) in the first vessel 1 as far as possible. Even if leakage should take place from the first vessel, it will be safe because the pressure in the first vessel instantaneously attenuates for few compressed portions exist and the fluid in the first vessel is non-compressive even if it leaks. If a gaseous phase portion should exist in the first vessel, it is hazardous because the portion will inflate, thereby letting the fluid continue jetting out through the leaking point.

[0056] Cavitation bubbles have a collapsing impact force dependent upon the air content of the fluid in the first vessel 1, too. If the fluid in the first vessel should have its air content increased as a result of exposure to the atmosphere, the cavitation bubble will have its collapsing impact force attenuated. In other words, the treatment capability of the cavitating jet will be decreased. Installing the second vessel 3, however, prevents the fluid in the first vessel from being exposed directly to the atmosphere. As a result, the fluid in the first vessel has its air content scarcely changed so that the cavitating jet can maintain nearly constant treatment capability.

[0057] The second embodiment of the present invention, furthermore, will be described while referring to Figure 3. In the figure, P is a fluid from the high-pressure pump, C a cavitating jet, D a lid to hermetically seal after inserting the workpiece, N a nozzle, W a workpiece and 6 and 10 flow control valves.

[0058] The second embodiment differs from the first embodiment in the method of draining the fluid from the first vessel 1. In other words, the second embodiment has the fluid discharged into the second vessel by way of Flow Control Valve 10. In addition, the fluid in the second vessel is drained from the second vessel to the exterior by way of Flow Control Valve 8. This configuration allows for an effective elimination of residual bubbles within the first vessel after cavitation forms have collapsed.

[0059] Figure 4 shows the compressive residual stresses that have arisen from treating with compressive residual stresses introduced into the tool (forging die material) employed in the present invention. In Figure 4, the material is SKD61, nozzle diameter 2 millimeters and injection pressure 30 MPa. With the first vessel pressurized (K in the figure), an enhancing treatment can be completed in 10 minutes. Without pressurizing the vessel (J in the figure), 150 minutes are required while compressive residual stresses remain at a level of approximately 60%.

[0060] Figure 5 depicts the compressive residual stresses that have arisen from treating with compressive residual stresses introduced to carburized gear material employed in the present invention. In Fig. 5, the nozzle has a diameter of 2 millimeters, with injection pressure 30 MPa and pressurizing pressure 0.32 MPa.

[0061] Figure 6 shows an example comparing the workpiece hardening, with nozzle diameter 2 millimeters, injection pressure 30 MPa and treatment pressure 0.32 MPa.

[0062] Described above are a variety of embodiment forms involved in the present invention. Nevertheless, flow control valves, pressure valves and the like are available in either automatic or manual control types. For fluid, either water or oil and the like are applicable. In each embodiment form referred to above, the fluid may have its temperature rise excessively because the motor power may change into heat through a cavitating jet when it is poured into the first vessel. In this case, the pressure in the first vessel is utilized to cool down the fluid in the first vessel by sending the fluid to various cooling means known to the public other than the first vessel. Later, it is possible to re-supply the pump with the fluid again. If such a technique of feeding the fluid pressure in the first vessel to another cooling means is employed, it is unnecessary to provide a new pump to send the fluid in the first vessel to the cooling means so that the fluid can be readily cooled down in reality.

[0063] To pour the cavitating jet and pressurizing fluid into the first vessel, it is possible to arrange both cavitat-

ing jet nozzle and pressurizing water nozzle adjacently in each of the embodiment forms referred to above. In addition, a cavitating jet nozzle may be located at the center of the vessel and the pressurizing water pouring nozzles may be arranged to surround the former so that the cavitating jet can strike the workpiece as if it were surrounded by the pressurizing water.

[0064] In addition, it is possible to change the positional relations between cavitating jet nozzle and pressuring water pouring nozzle to another form as required. It is possible, as might be required, to freely set the arrangement of the workpiece, based on its shape. As an example, it is possible to form the nozzle itself as an integral part of the vessel.

[0065] The present invention may be also embodied in any other forms without departing from its principal features. In this sense, the embodiment forms referred to above are given for the purpose of example and must by no means be interpreted in any restrictive sense.

Industrial Applicability

[0066] With the prevent invention as described in detail above, the workpiece is placed within first vessel, which is in turn hermetically sealed. Then, a high-pressure fluid is injected from a nozzle to generate the cavitation around the jet to strike cavitation bubble against the workpiece. Consequently, the collapsing impact force of the cavitation bubble acts on the workpiece, thereby bringing about the surface modification and cleaning effects, such as workpiece hardening, residual stress improvement, fatigue strength enhancement and so on. In a case in which a method of loading a first vessel on the workpiece is employed, it is also possible to improve the surface of a long steel plate, a large-sized die and the like. In addition, it is also applicable for cleaning the floor by a cavitating jet. Forming a pressurizing section in a pipe or conduct, will also permit the internal surface of the pipe to be treated and cleaned. If the poured water to pressurize the first vessel is provided apart from the cavitating jet pressurizing water, it is also possible to set up the equipment at a lower cost without the necessity of a large-flow plunger pump. Such excellent effects as referred to above could be brought about by the present invention.

Claims

1. A metal part and other surface modification and cleaning method, comprising: placing the part (w) to be treated within a first vessel (1), which is filled with a pressurised fluid, said first vessel being placed within a second vessel (3), which is filled with a fluid, and applying a peening effect to the surface of the part by generating cavitation (9) by injecting a pressurized fluid from a nozzle (4) distant from said part on the surface so that the collapsing impact force of the cavitation bubble may be used to strengthen and clean the surface of the treated part.

2. A metal part and other surface modification and cleaning method according to Claim 1 comprising pressurizing the first vessel (1) by controlling the flow rates of both fluids flowing in and out of said first vessel and thereby increasing the collapsing impact force of the cavitation bubble (9) to strengthen and clean the treated part (w) by applying a peening effect under such impact force.

3. A metal part and other surface modification and cleaning method according to Claim 1 or 2, comprising inserting a substance with different acoustic impedance between said first and second vessels (1,3).

4. A metal part and other surface modification and cleaning method according to any one of claims 1 to 3 comprising controlling the temperature of the fluid in said first vessel (1) by controlling the temperature of the fluid that fills the space between said first and second vessels (1,3).

5. A metal part and other surface modification and cleaning method according to any one of Claims 1 to 4 comprising sending fluid for the cavitating jet from the first vessel (1) to cooling means and returning the fluid to a cavitating jet pump (p) after cooling it in said cooling means.

6. A metal part and other surface modification device composed of a first vessel (1), which in use accommodates the part (w) to be treated in a pressurised fluid, a lid (2) hermetically enclosing the first vessel, a second vessel (3), which in use accommodates said first vessel, a nozzle (4) to inject a pressurized fluid jet into the pressurized fluid within the first vessel, a flow rate control valve (6) to control the jet pressure from said nozzle and a pressure control valve (8) to control the fluid pressure in the first vessel.

7. A metal part and other surface modification device according to claim 6 above, in which two or more said nozzles (4) are provided.

8. A metal part and other surface modification device according to claim 6 or 7, in which said second vessel (3) is configured to have a larger depth than the height of the first vessel (1).

9. A metal part and other surface modification device according to any one of claims 6 to 8, in which a substance with different acoustic impedance is arranged between said first and second vessels (1,3).

10. A metal part and other surface modification device

according to any one of claims 6 to 9, in which the lid (2) on said first vessel (1) is closed with a specified force.

11. A metal part and other surface modification device according to any one of claims 6 to 10, in which a means of heating or cooling the fluid in said second vessel (3) is provided.

12. A metal part and other surface modification device according to any one of claims 6 to 11, in which said part (w) to be treated is loaded on a carriage means to carry such part to be treated.

Patentansprüche

1. Oberflächenmodifikations- und Reinigungsverfahren für ein Metall- und anderes Teil, umfassend: Platzieren des zu behandelnden Teils (W) in einen ersten Behälter (1), der mit einem Druckfluid gefüllt wird, wobei der erste Behälter in einen zweiten Behälter (3) platziert wird, der mit einem Fluid gefüllt wird, und Anwenden eines Hämmereffekts auf die Oberfläche des Teils durch Erzeugen von Kavitation (9) durch Einspritzen eines Druckfluids aus einer von dem Teil entfernt angeordneten Düse (4) auf die Oberfläche, so dass die Kollabierschlagkraft der Kavitationsblase verwendet werden kann, um die Oberfläche des behandelten Teils zu härten und zu reinigen.

2. Oberflächenmodifikations- und Reinigungsverfahren für ein Metall- und anderes Teil nach Anspruch 1, umfassend: Druckbeaufschlagen des ersten Behälters (1) durch Steuern der Durchsätze von beiden in den ersten Behälter hinein- und aus ihm herausfließenden Fluiden und **dadurch** Erhöhen der Kollabierschlagkraft der Kavitationsblase (9), um das behandelte Teil (W) durch Anwenden eines Hämmereffekts unter einer solchen Schlagkraft zu härten und zu reinigen.

3. Oberflächenmodifikations- und Reinigungsverfahren für ein Metall- und anderes Teil nach Anspruch 1 oder 2, umfassend: Einsetzen einer Substanz mit einer unterschiedlichen Schallimpedanz zwischen dem ersten und zweiten Behälter (1, 3).

4. Oberflächenmodifikations- und Reinigungsverfahren für ein Metall- und anderes Teil nach einem der Ansprüche 1 bis 3, umfassend: Steuern der Temperatur des Fluids in dem ersten Behälter (1) durch Steuern der Temperatur des Fluids, das den Raum zwischen dem ersten und zweiten Behälter (1, 3) füllt.

5. Oberflächenmodifikations- und Reinigungsverfahren für ein Metall- und anderes Teil nach einem der Ansprüche 1 bis 4, umfassend: Senden von Fluid für den kavitierenden Strahl von dem ersten Behälter (1) zu Kühleinrichtungen und Rückführen des Fluids zu einer Kavitationsstrahlpumpe (P) nach seinem Kühlen in den Kühleinrichtungen.

6. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil, die zusammengesetzt ist aus: einem ersten Behälter (1), der im Gebrauch das zu behandelnde Teil (W) in einem Druckfluid aufnimmt, einem Deckel (2), der den ersten Behälter hermetisch umschließt, einem zweiten Behälter (3), der im Gebrauch den ersten Behälter aufnimmt, einer Düse (4), um einen Druckfluidstrahl in das Druckfluid im ersten Behälter einzuspritzen, einem Durchsatzsteuerventil (6), um den Strahldruck von der Düse zu steuern, und einem Drucksteuerventil (8), um den Fluiddruck im ersten Behälter zu steuern.

7. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach Anspruch 6 oben, bei der zwei oder mehr der Düsen (4) vorgesehen sind.

8. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach Anspruch 6 oder 7, bei der der zweite Behälter (3) so konfiguriert ist, dass er eine größere Tiefe als die Höhe des ersten Behälters (1) aufweist.

9. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach einem der Ansprüche 6 bis 8, bei der eine Substanz mit einer unterschiedlichen Schallimpedanz zwischen dem ersten und zweiten Behälter (1, 3) angeordnet ist.

10. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach einem der Ansprüche 6 bis 9, bei der der Deckel (2) auf dem ersten Behälter (1) mit einer spezifizierten Kraft geschlossen ist.

11. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach einem der Ansprüche 6 bis 10, bei der eine Einrichtung zum Heizen oder Kühlen des Fluids in dem zweiten Behälter (3) vorgesehen ist.

12. Oberflächenmodifikationsvorrichtung für ein Metall- und anderes Teil nach einem der Ansprüche 6 bis 11, bei der das zu behandelnde Teil (W) auf einer Wageneinrichtung geladen ist, um ein solches zu behandelndes Teil zu tragen.

Revendications

1. Procédé de modification et de nettoyage de pièces métalliques et d'autres surfaces, comprenant les

étapes consistant à : placer la pièce (W) à traiter à l'intérieur d'une première cuve (1) qui est remplie avec un fluide sous pression, ladite première cuve étant placée à l'intérieur d'une deuxième cuve (3) qui est remplie avec un fluide, et appliquer un effet de martelage sur la surface de la pièce en engendrant une cavitation (9) en injectant un fluide sous pression à partir d'une buse (4) à distance de ladite pièce sur la surface, de manière à ce que la force de choc d'écrasement de la bulle de cavitation puisse être utilisée pour renforcer et nettoyer la surface de la pièce traitée.

2. Procédé de modification et de nettoyage de pièces métalliques et d'autres surfaces, selon la revendication 1, comprenant le fait de mettre sous pression la première cuve (1), en régulant les débits des deux fluides s'écoulant à l'intérieur et à l'extérieur de ladite première cuve, de manière à accroître la force de choc d'écrasement de la bulle (9) de cavitation pour renforcer et nettoyer la pièce (W) traitée, en appliquant un effet de martelage sous une telle force de choc.

3. Procédé de modification et de nettoyage de pièces métalliques et d'autres surfaces, selon la revendication 1 ou 2, comprenant le fait d'insérer une substance ayant une impédance acoustique différente, entre lesdites première et deuxième cuves (1, 3).

4. Procédé de modification et de nettoyage de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 1 à 3, comprenant le fait de réguler la température du fluide dans ladite première cuve (1), en régulant la température du fluide qui remplit l'espace entre lesdites première et deuxième cuves (1, 3).

5. Procédé de modification et de nettoyage de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 1 à 4, comprenant le fait d'envoyer du fluide pour le jet de cavitation, de la première cuve (1) à un moyen de refroidissement et de faire revenir le fluide vers une pompe (P) à jet de cavitation, après l'avoir refroidi dans ledit moyen de refroidissement.

6. Dispositif de modification de pièces métalliques et d'autres surfaces, composé d'une première cuve (1) qui en cours d'utilisation, loge la pièce (W) à traiter dans un fluide sous pression, un couvercle (2) fermant hermétiquement la première cuve, une deuxième cuve (3) qui en cours d'utilisation, loge ladite première cuve, une buse (4) pour injecter un jet de fluide sous pression dans le fluide sous pression à l'intérieur de la première cuve, une soupape (6) de régulation de débit pour réguler la pression du jet provenant de ladite buse et une soupape (8) de régulation de pression pour réguler la pression du fluide dans la première cuve.

7. Dispositif de modification de pièces métalliques et d'autres surfaces, selon la revendication 6 ci-dessus, dans lequel deux ou davantage desdites buses (4) sont prévues.

8. Dispositif de modification de pièces métalliques et d'autres surfaces, selon la revendication 6 ou 7, dans lequel ladite deuxième cuve (3) est configurée pour présenter une profondeur supérieure à la hauteur de la première cuve (1).

9. Dispositif de modification de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 6 à 8, dans lequel une substance ayant une impédance acoustique différente, est disposée entre lesdites première et deuxième cuves (1, 3).

10. Dispositif de modification de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 6 à 9, dans lequel le couvercle (2) sur ladite première cuve (1) est fermé selon une force spécifiée.

11. Dispositif de modification de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 6 à 10, dans lequel un moyen destiné à chauffer ou à refroidir le fluide dans ladite deuxième cuve (3) est prévu.

12. Dispositif de modification de pièces métalliques et d'autres surfaces, selon l'une quelconque des revendications 6 à 11, dans lequel ladite pièce (W) à traiter est chargée sur un moyen formant chariot destiné à porter une telle pièce à traiter.

FIG. 1

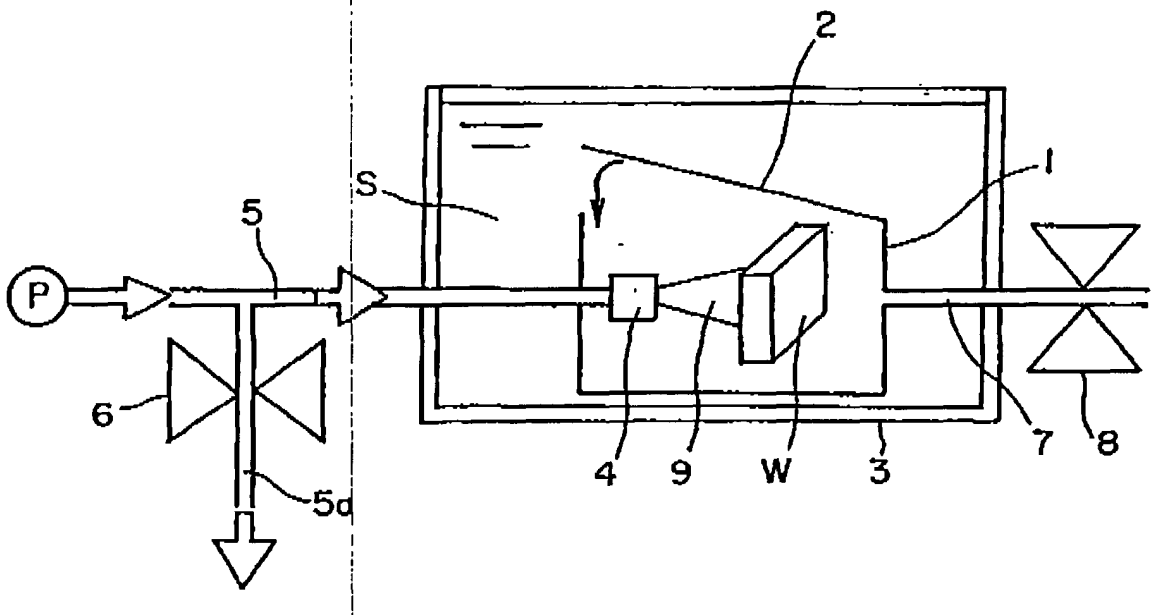

FIG. 2

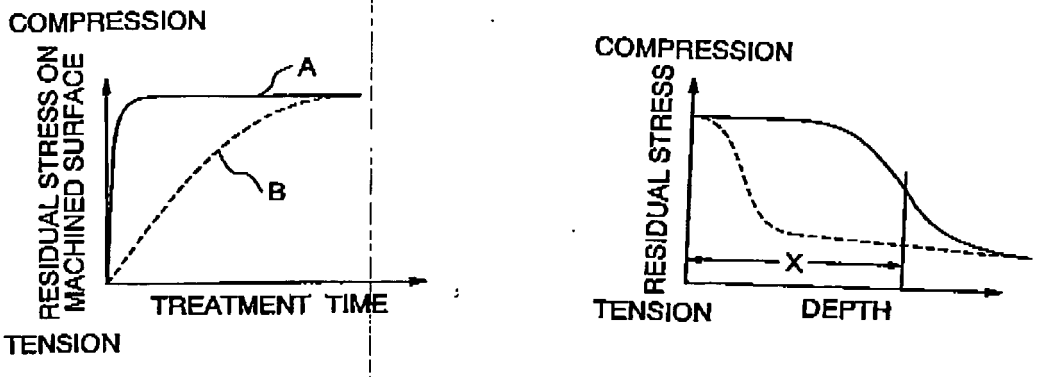
COMPRESSION
RESIDUAL STRESS ON MACHINED SURFACE
A
B
TREATMENT TIME
TENSION
COMPRESSION
RESIDUAL STRESS
X
TENSION
DEPTH

FIG. 3

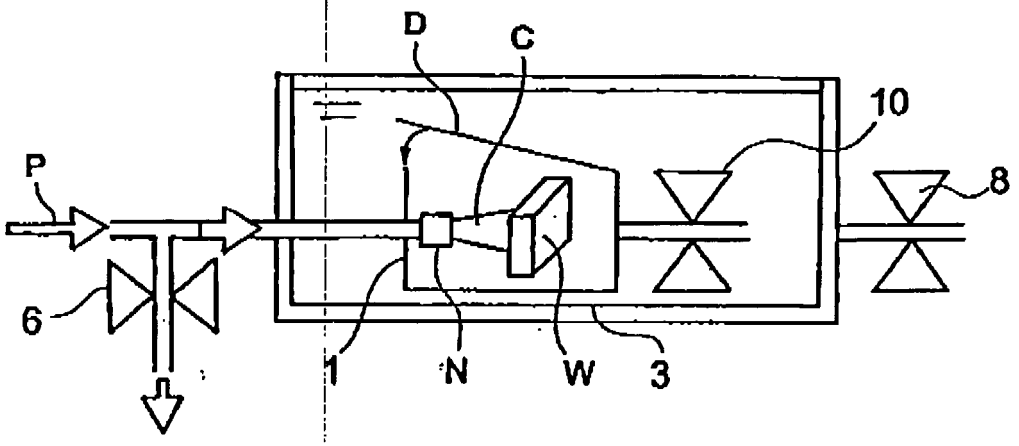
D
C
10
P
8
6
1
N
W
3

FIG. 4

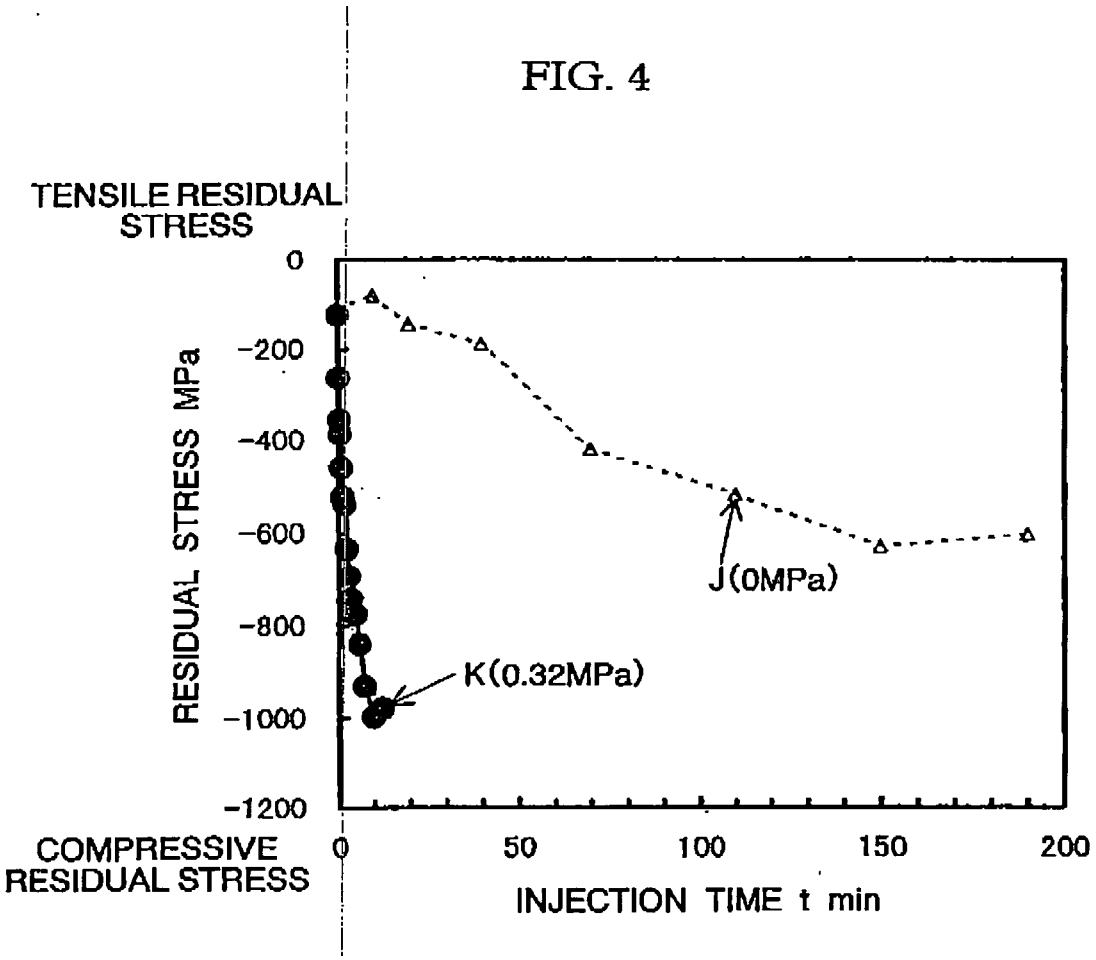
TENSILE RESIDUAL STRESS
0
-200
-400
-600
-800
-1000
-1200
RESIDUAL STRESS MPa
COMPRESSIVE RESIDUAL STRESS
J(0MPa)
K(0.32MPa)
0
50
100
150
200
INJECTION TIME t min

FIG. 5

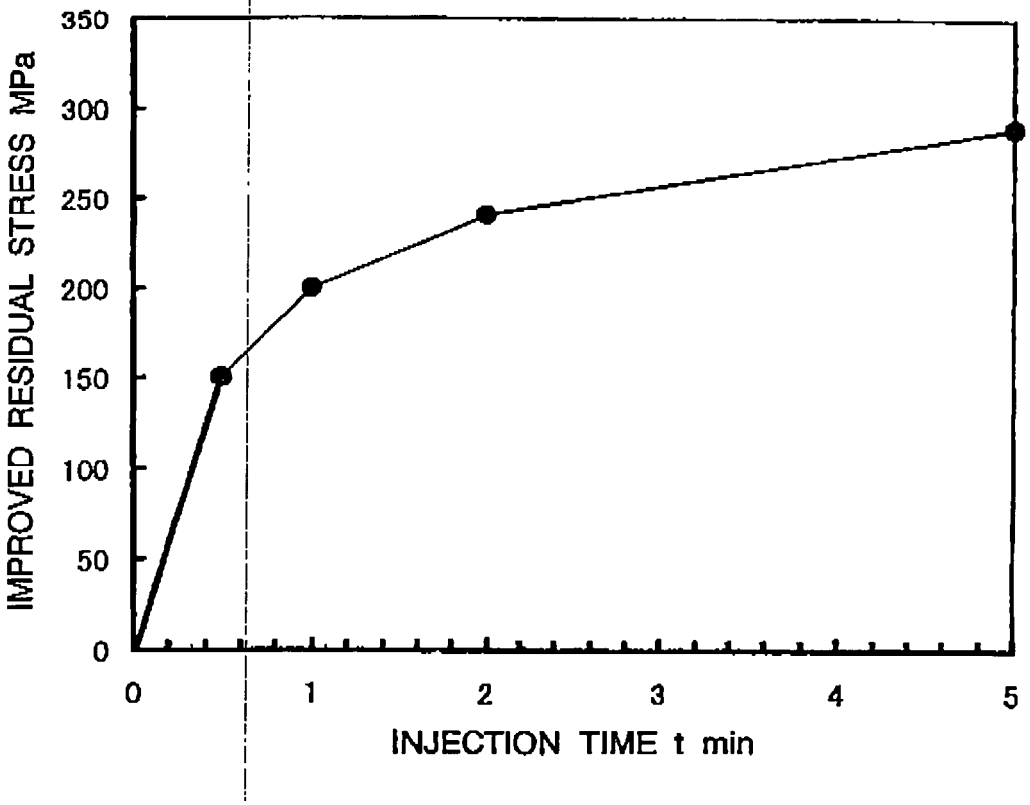
IMPROVED RESIDUAL STRESS MPa
350
300
250
200
150
100
50
0
0
1
2
3
4
5
INJECTION TIME t min

FIG. 6

MATERIAL	SURFACE BEFORE PEENING	SURFACE AFTER PEENING	HARDNESS
SKD61	633	800	VICKERS Hv
SKD61	83	86	ROCKWELL SUPERFICIAL HR15N
SUP7	76	78	ROCKWELL SUPERFICIAL HR15N
SUS304	55	57	ROCKWELL SUPERFICIAL HR15N
TITANIUM	55	60	ROCKWELL SUPERFICIAL HR15N
S20C	51	61	ROCKWELL SUPERFICIAL HR15N