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(54) **METHOD FOR THE SURFACE TREATMENT OF A STAINLESS STEEL WORKPIECE, AND MEANS FOR IMPLEMENTING THE METHOD**

VERFAHREN ZUR OBERFLÄCHENBEHANDLUNG EINES WERKSTÜCKS AUS ROSTFREIEM STAHL UND VORRICHTUNGEN ZUR DURCHFÜHRUNG DES VERFAHRENS

PROCÉDÉ DE TRAITEMENT DE SURFACE D'UNE PIÈCE EN TRAITEMENT EN ACIER INOXIDABLE, ET MOYENS POUR LA MISE EN OEUVRE DU PROCÉDÉ

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(56) References cited:
**US-A- 4 663 005 US-A- 5 057 108
US-A- 5 507 923 US-A- 5 531 874**

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Description

[0001] The present invention relates to a method for the surface treatment of a stainless steel workpiece. The invention further relates to the means for implementing this method.

[0002] The principle object of the present invention is to provide a method for the surface treatment of a stainless steel workpiece, that allows one or more slip and non-stick surfaces to be produced on said workpiece.

[0003] In particular, an object of the aforesaid method according to the invention is to provide an alternative to the use of materials known as "non-stick", which are applied to the surfaces of stainless steel articles to provide them with slip and non-stick surfaces.

[0004] Document US 5,057,108 A discloses a method and apparatus for manufacturing a stainless steel orthopaedic implant, comprising the steps of shot blasting with cold-worked stainless steel shots having a nominal size of 0.1778 mm to 0.7112 mm, the shots being originally cylindrical and becoming spherical during blasting, and electropolishing, then passivating the substrate.

[0005] Document US 5,531,874 A discloses an apparatus for electroetching a workpiece, the apparatus comprising two movable cathodes arranged opposite the surfaces of the workpiece. The cathodes are mounted on guide rails via a traverse support member, in order to move the cathodes along the opposing surfaces of the workpiece.

[0006] For a better understanding of the present invention, it must be noted that the surface of a stainless steel article, perfectly smooth or mirror polished, either mechanically or electrolytically, provides a "suction" effect, i.e., an effect of high adhesion with respect to another body in contact with the same article.

[0007] Starting from this consideration and in order to overcome this drawback, the present invention provides a method including at least two essential steps. According to a first essential step of surface treatment of a stainless steel workpiece, a micro-roughness is formed on the surface of said workpiece, i.e. said surface is provided with a plurality of micro-peaks and micro-valleys, reducing the area of contact of the worked surface and consequently the friction with respect to another body placed in contact with said workpiece and limiting the aforesaid "suction" effect. However, the aforesaid surface micro-roughness of the workpiece can have consequences that at times are worse than the aforesaid "suction" effect, as said micro-peaks, by means of their sharp peaks, still represent an obstacle to the surface slip of the treated workpiece.

[0008] Therefore, the method according to the present invention provides a second essential step of treatment, in which the peaks of said micro-peaks of the surface of the workpiece are rounded, removing surface material from these peaks, improving the non-stick and slip properties of the workpiece. It is important, in this second essential step of the method according to the present

invention, to accurately control the parameters relating to the operating times and procedures for carrying out the same step, as small deviations from the correct process parameters can lead to a result that is insufficient or even contrary to expectations.

[0009] The method for the surface treatment of a stainless steel workpiece according to the present invention is defined by appended independent claim 1. The system for implementing the said method is defined by appended independent claim 8.

[0010] For a better understanding of the present invention, some non-limiting examples of the operating steps, some optional, others necessary, of the aforesaid method for the surface treatment of a stainless steel workpiece are explained below.

[0011] Firstly, preliminary analysis is conducted on the workpiece to identify the variables and the parameters determining the choice of the processing steps of the method according to the invention, namely: the type of steel, its surface hardness, the type of product or food with which the surface of the worked workpiece is destined to come into contact; after all these evaluations the operating method is decided and the production cycle commences.

DEGREASING (optional step)

[0012] Degreasing is a step that is almost always advisable and unavoidable. This is a simple but important step, as all the greases and various contaminating oils that normally deposit on the workpiece during the preceding processes are eliminated. Degreasing can be carried out in many ways and combinations: hot, cold, by immersion or spraying, either in chemical or electrolytic form, with alkaline or acid products, or with solvents, etc. The best solution to obtain a perfect and reliable degreasing, especially for concave parts or parts with complicated shapes, is hot degreasing with alkaline products using ultrasound.

[0013] In addition to the chemical action, using this treatment it is possible to obtain an important mechanical action called cavitation, capable of penetrating all parts of the workpiece and ensuring effective and complete cleaning. The degreasing treatment is followed by the usual rinsing and optional drying operations.

PICKLING (optional step)

[0014] Pickling is not obligatory as it is only necessary when oxides are present on the surface to be treated, coming from weld areas, heat treatments or from various types of contaminants, which deposit forming a layer of surface oxide. Even if the article is not pickled if oxides are present, the subsequent treatment, essential in the method of the present invention, i.e., the mechanical shot peening/shot blasting treatment, by means of the mechanical action will in any case break the layers of oxides that have formed on the surface of the workpiece.

[0015] In some cases it is even advisable to avoid pickling, which due to its chemical action reacts not only on the oxidized areas of the surface, but also on the whole of the steel surface, damaging both the chrome and nickel ion, which are important elements underlying the corrosion resistance of stainlessness steel. Therefore, this is an operation to be carried out only where necessary or in mild form.

[0016] Pickling treatment can be carried out in many modes and combinations: hot, cold, with alkaline or acid products, chemically and electrolytically, or mechanically as mentioned above.

[0017] It is advisable, based on the oxide that has formed on the surface of the workpiece, to carry out simple and quick pickling of a few minutes by immersion with acid compound at room temperature, only to break up and dislodge the oxides; it is not necessary to eliminate them completely as, as explained previously, in conformity with the method according to the invention, it is obligatory to carry out the shot peening/shot blasting step, where the residues of surface oxides will be removed mechanically.

[0018] The pickling treatment is followed by the usual washing, rinsing, and optionally drying, operations.

VIBRATION / TUMBLING (optional step)

[0019] Vibration or tumbling is carried out with machines with vibratory, centrifugal or centrifugal-vibratory action, with the tanks that contain abrasives of circular, rectangular, octagonal and other shapes. The machines can operate semi-automatically, automatically, with a continuous or discontinuous cycle. The object of the present treatment step is to deburr, smooth, uniform and finish the surface of the workpiece in a homogeneous manner.

[0020] The workpiece can come from raw material or from disc grinding, lapping or belt grinding.

[0021] On average, several steps are carried out with greatly variable times, using plastic or ceramic abrasive media or other compositions, having a variety of shapes, measurements and grit sizes, mixed with abrasive-chemical products and water to improve abrasion and, consequently, smoothing of the workpiece.

[0022] This treatment step is also carried out, if necessary, depending on the desired finish results to be obtained and on the condition of the part to be treated.

DEBURRING / DISC-GRINDING / BELT GRINDING / SMOOTHING (optional steps)

[0023] Also in this case, these are operations to prepare the workpiece and it is not necessary to perform them all. In very rare cases, if the surface of the workpiece is suitable for the subsequent step, one or more of the aforesaid steps can even be omitted.

[0024] Usually, in the manufacture of an article it is necessary to carry out various mechanical operations

which create surface imperfections. As the basis of the invention is the formation of a perfectly uniform surface roughness on the surface of the workpiece, it is necessary to eliminate from the same surface all the various imperfections of bending, welding and scratches of various depths, in order to obtain a uniform and homogeneous surface with as little as possible roughness, according to the use and to the contact for which the workpiece was designed and to the times and steps that will follow.

[0025] Mechanical deburring, disc-grinding, belt-grinding and smoothing operations vary in a very wide range, differ for types of abrasive media and for number of passes with different grit sizes, while operations can be carried out both manually or with semi-automatic or automatic machinery.

SHOT PEENING/SHOT BLASTING (essential step)

[0026] This is the first of two essential treatments of the method according to the present invention.

[0027] The terms shot peening, shot blasting or, in certain cases, also sanding in layman's terms, define the type of abrasive media used; shot peening corresponds, as the name suggests, to a round abrasive, shot blasting to a needle shaped abrasive media, while sanding is a mixture of various products deriving from silica, which is normally used to remove paint or clean masonry parts.

[0028] Shot abrasive usually has less cutting capacity than needle-shaped abrasive in bead form which, at the same blasting speed, creates much deeper and more jagged roughness. Of these two abrasives, to ensure the formation of the roughness required according to the method of the invention, shot is the best shape (substantially round), but for the aforesaid reasons an abrasive with an even more optimized shape, i.e. cylindrical, has been selected. This is due to the fact that the cylindrical shape has a higher cutting capacity and consequently also a lower processing time than round shot. Moreover, during processing also the cylindrical shape tends to become rounded and consequently both the rounded and cylindrical shapes can be used, as the end result is similar.

[0029] With regard to the diameter of the spherical body, respectively of the cross section of the cylindrical body of the abrasive, this varies greatly depending on the roughness to be obtained, which turn varies in several process aspects. In any case, the aforesaid diameter can vary on average from $\varnothing$ 0.4 mm to $\varnothing$ 0.8 mm.

[0030] For the chemical composition of the abrasive material there are two options: a stainless steel abrasive, if possible an electrocast 300 series austenitic steel, or, a better option with higher performance, once again stainless steel but from metal wire instead of electrocast material. This latter abrasive is the most optimized, least contaminating and has a much greater hardness and duration than electrocast abrasive.

[0031] There are many other abrasives with various shapes and compositions that could be used, such as

corundum, quartz, ceramic and glass abrasives, the last being the most widely used. However, all these abrasives and others still are not suitable for the method of the invention, as they are composed of various oxides, such as silicon, sodium, zirconium oxide, etc. With the shot peening treatment, these oxides are driven mechanically onto the treated surface, forming a layer of oxide that, as the method according to the invention progresses, i.e., the electrolytic polishing treatment, does not offer the possibility of removing material from the previously shot blasted surface. The layer of oxide thus formed is a barrier layer to the passage of electrical current, and would therefore make it necessary to re-pickle the workpiece chemically to be able to eliminate the surface oxides and finally allow electropolishing of the same workpiece. This process is much longer, contaminating, pointless and costly, but above all does not guarantee the success of correct electrolytic removal and consequently of achieving the roughness required, according to the present invention, to ensure that the treated surface has slip and non-stick properties.

[0032] After the shape and the chemical compound of the abrasive have been established, the machines-systems to be used must then be established: manual or automatic, vacuum pressure, high pressure or turbine.

[0033] This relation does not consider manual high pressure systems, as they do not guarantee continuity and, consequently, uniform roughness, and vacuum pressure systems, as they would not be able to convey the abrasive selected according to the present invention, especially those made of steel coming from metal wire, which would be too heavy.

[0034] Therefore, two types of system remain, both automatic: high pressure and turbine systems, the latter being preferred. The number of turbines of the system or machine used depends on the size of the workpiece and therefore on the size of the cabin of the same machinery. With this machine the workpieces are hooked on special frames, which in turn rotate first clockwise and then counter-clockwise, moving forward and backward along the shot peening cabin, while the turbines are capable of adjusting the angles of the abrasive jet, which is a very important aspect.

[0035] However, the machine alone is not complete for the purposes of the present invention, as an inverter is required, naturally only for turbine machines, to be able to adjust the revolutions of the turbines and therefore the blasting speed of the abrasive, above all to obtain the roughness useful according to the method of the invention and, secondly, to avoid, where possible, deforming delicate and thin workpieces. The inverter is essential in the method according to the invention, as it makes it possible to calibrate, with absolute certainty, the roughness required to create a non-stick surface. In fact, in addition to the shapes and thicknesses of the workpieces to be treated, there is another very important factor that must be kept under control: surface hardness. At times steel laminates made of the same material, but coming from

laminations in different steel works, do not have the same hardness. Therefore, certain time or processing parameters of the method according to the invention may require to be modified based on the actual hardness of the material to be treated.

[0036] At the end of the shot peening/shot blasting cycle, before carrying out the subsequent electro-polishing treatment, the parts must be blown with compressed air, either manually or automatically, in order to eliminate all residues of abrasive and any dust.

[0037] This is followed by testing and checking with a roughness meter in several parts of the surface of the workpiece (in at least 5 points), to check that the roughness falls within the parameters required in conformity with the method according to the invention.

ELECTRO-POLISHING (essential step)

[0038] The second essential step of the method according to the invention is the electro-polishing treatment for stainless steel.

[0039] In this case, the known process is improved by means of appropriate innovations to the plant design, equipment and operating methods, which optimally improve the efficiency of the method according to the invention.

[0040] Electro-polishing is carried out in an electric field and the chemical compound used is the electrical conductor. According to the present invention, to obtain the best process result, a particular plant construction of the tank used for electro-polishing is implemented.

[0041] There is produced an iron tank, for galvanic treatment with electrolytic cell, coated by means of a first inner coating made of PVC, like the normal tanks currently used for galvanic treatment, which is however modified, to make the maximum use of the passage of current, i.e., completely lined by means of a second inner coating made of AISI 316/L stainless steel, thereby insulating the tank with the PVC and then electrically connecting the second inner coating made of steel to the cathode means of the electrolytic cell, in this case to the negative polarity, distributing the electrical field on the total surface of said second coating (bottom and four side walls).

[0042] There is thus produced an electrolytic cell for the galvanic bath, in which said second stainless steel coating is electrically connected to the cathode means of the electrolytic cell, and wherein the workpiece is arranged in the galvanic bath in electrical connection with respect to the anode means of the electrolytic cell and is maintained during the galvanic treatment at a distance variable on average from around 100 to 150 mm with respect to said cathode means.

[0043] For this reason, after having connected the whole surface of said second inner coating to the negative current rectifier (cathode), copper guides are applied along the edges of two heads of the tank and are also connected to said second coating, and copper sliding blocks to support the AISI 316/L plates are engaged, in

electrical and sliding contact, at least partially immersed in the galvanic bath and which can substantially slide along the whole of the width of the same tank, said plates thus providing respective moving cathodes. In particular, the workpiece, connected to the anode means, is maintained fixed in position, substantially at the centre of the tank, while said two plates, forming moving cathodes, are arranged on opposite sides with respect to said workpiece.

[0044] Therefore, the system according to the invention operates in a different way with respect to normal electro-polishing systems, where the cathodes are fixed to the two sides of the tank. According to the invention, it is instead possible to move the cathodes considerably towards or away from the workpieces, based on their shapes and sizes, maintaining that optimal distance of around 10/15 cm, and thus obtaining a homogeneous passage of current and optimal operating results.

[0045] To further improve the electrolytic treatment, without prejudice to the importance of the uniform passage of electrical current, according to the invention there are provided auxiliary cathodes for those workpieces with complicated shapes to be treated, such as casings, box-shaped elements, tubing and the like, which must also be treated internally. In fact, with respect to the internal parts the electrical current is shielded, and can only manage to pass for a few centimetres, depending on the sizes and shape of the workpiece to be treated. To overcome this problem, there are provided auxiliary cathodes for the internal parts of the workpiece, structured as copper cathodes-frames, with a copper diamond mesh measuring 8x8 mm, thk 1.5 mm (naturally, other sizes and thicknesses can also be used).

[0046] The specific auxiliary cathodes-frames, made of titanium or stainless steel, currently used, form turbulences and consequent temperature increases inside the workpiece, which cause defects, such as gas bubbles, marks or burns on the surface of the workpiece. To prevent this problem, according to the invention said copper auxiliary cathodes-frames, provided with a mesh, are used, so that any gas bubbles can rise freely to the surface and consequently the heating points are limited.

[0047] Taking account of the above, the tank with electrolytic cell is equipped with electrical cables, the sections of which are chosen in relation to the related amperage and which are connected to copper strips on the cathode part of the tank, two on one side of the tank and two on the other side, and which have a length greater than half of the same tank, in order to easily couple and clamp the brass terminals of the same cables to the auxiliary cathodes.

[0048] Moreover, the electrolytic compound, its additives and continuous control of the temperature and of the density of the electrolyte in the electrolytic bath, greatly variable during the processing steps, are of primary importance in the method according to the invention.

[0049] In fact, during the process the density of the electrolyte increases, due to the continuous removal of

material. To overcome this problem, the temperature of the electrolyte has a fundamental role, and must remain within specific limits, established in the method according to the invention at around 45°C to 55°C.

[0050] Moreover, the density of the electrolyte, fundamental for the correct passage of electrical current, must be maintained at an advantageously constant value, established in the method according to the invention as 1.750 g/mL at 20°C.

[0051] All the aforesaid innovative process and technical-plant layout characteristics are provided, according to the invention, to maintain an optimal and uniform removal of material from the workpiece, a fundamental operation to obtain the result of correct surface roughness of the workpiece and consequently the success of the method according to the invention.

[0052] The above-described electro-polishing treatment of the workpiece is followed by a dripping step and by various washing and drying steps, after which the workpiece, before being transferred for any packaging, is tested and checked with a roughness meter on various parts of the surface (in at least 5 points), ensuring that the roughness falls within the process parameters according to the present invention.

[0053] This is the end of the production cycle.

[0054] The attached drawing is provided purely by way of example, to better illustrate the invention, and wherein:

- Fig. 1 is a flow chart indicatively illustrating the various steps of the aforesaid production cycle;
- Fig. 2 schematically illustrates in a vertical cross-section an example of embodiment of the electrolytic cell system for implementing the method according to the present invention;
- Figs. 3A and 3B are diagrammatic representations of the surface roughness of a workpiece according to the method of the invention, respectively at the end of the shot peening step (fig. 3A) and of the electro-polishing step (Fig. 3B).

[0055] The flow chart of Fig. 1 indicatively illustrates the various steps of the aforesaid production cycle. Said Fig. 1 indicates how the steps that precede the shot peening/shot blasting step are not all necessary, but can be alternative to one another or at times also repeated. The directions of the arrows that connect the various boxes indicative of the aforesaid steps describe the possible process sequences, also alternative or repetitive.

[0056] Downstream of the shot peening/shot blasting step, the further essential step according to the present invention is the electro-polishing step. Further steps, which precede or follow this step, can relate to roughness checks and washing of the workpiece.

EXAMPLES OF EMBODIMENT OF THE METHOD ACCORDING TO THE INVENTION

EXAMPLE 1 - Cycle, times and method steps on a AISI 304 stainless steel workpiece, namely "finishing shield" of a system for a mill for processing and converting coffee beans into ground coffee.

[0057] While it is being processed, ground coffee has a compact and very sticky mass. To overcome problems of adhesion, manufacturers of the related processing plants have used various measures, among which the insertion of vibrators or compressed air blowers in the walls, casings and all those areas to which the product adheres and deposits, techniques that are very costly and do not solve the problem.

1st STAGE - DEGREASING TREATMENT

[0058] The workpiece or part, namely "finishing shield", is chemically degreased in an immersion tank, using an alkaline product at a temperature from 50/70°C with an immersion time of 3/5'. At the end of this step, the part passes into a dripping tank, and is subsequently rinsed twice with filtered water and finally dried with hot air jets.

[0059] In this case, the part is not pickled as there are no evident oxides present.

2nd STAGE - MANUAL DISC-GRINDING AND BELT-GRINDING TREATMENT

[0060] The part has various defects caused by the preceding metalworking processes on its surface. To remedy this, a first disc-grinding pass is carried out with a pneumatic angular grinder and with a zirconia abrasive fibre disc $\varnothing$ 115 gr. 80, followed by a second pass with a flap disc gr. 150.

[0061] This is followed by manual belt-grinding using a horizontal power tool with abrasive sleeve, also made of zirconia, with two passes with differentiated grain size, a first gr. 150 and a second gr. 220, eliminating all the surface defects to make the part homogeneous and with low roughness (smooth), suitable for the subsequent shot peening treatment.

3rd STAGE - SHOT PEENING TREATMENT

[0062] The part is subjected to mild degreasing with a solvent and then hooked on a specific frame and inserted in a machine with two turbines, loaded with cylindrically shaped AISI 304 stainless steel abrasive obtained from metal wire $\varnothing$ 0.4 mm. The inverter of the turbines is adjusted, calibrating the blast speed of the abrasive at 1600 rpm for a treatment time of 8'.

4th STAGE - INTERMEDIATE CHECKS

[0063] After the shot peening process, the part is blown

with compress air and the roughness obtained is checked using the roughness meter in at least five different points of the treated part, resulting in an average roughness of **Ra 1.68**.

5th STAGE - ELECTRO-POLISHING TREATMENT

[0064] The part is partially hooked on a copper bar and an auxiliary cathode, made of 8x8 diamond copper mesh, thk 1.5 mm is inserted into the concave part, which is immersed in the electrolyte having the following formulation:

50% by weight (up to) of sulfuric acid 66 Be'

50% by weight (up to) of phosphoric acid 60 Be'
0.5-2% nigrosin B.

Temperature 48°C (with variations from 45°C to 55°C)

Voltage 8V (with auxiliary cathode inserted)

Time 5'.

[0065] After the treatment, the part is inserted in a drip tank, and subsequently receives a first acid wash with consequent dripping, followed by further two washes with demineralized water and terminating with further dripping and drying with hot air jets.

6th STAGE - FINAL CHECKS

[0066] Before packaging, the surface roughness is subjected to a final check with the roughness meter in an average of at least five points of the treated surface; the final result is **Ra 1.45**.

OBSERVATIONS

[0067] The part treated with the method according to the invention has excellent non-stick properties, as shown by the practical tests carried out on plate treated in conformity with the invention, where at an angle of just 30-35° the ground coffee slips and detaches naturally without leaving residues, while on the mirror polished plate, even at an angle of 90°, the ground coffee still remains firmly attached and the plate must be moved several times to dislodge it and, notwithstanding this, small/medium-sized deposits of ground coffee still remain.

[0068] The test confirms the validity and functionality of the non-stick properties of the surface of the part treated with the method according to the invention.

EXAMPLE 2 - Cycle, times and method steps according to the invention on a part called "sliding surface" consisting of an AISI 304 stainless steel plate measuring 200 x 30, thk 10 mm for a boxing system for pre-wrapped chocolates.

[0069] The part treated is part of a boxing system for

chocolates, formed of various lines that converge in a single automatic sorter called "tank", i.e., a track composed of different stainless steel plates in which pre-wrapped chocolates are positioned by pushing in groups of 5 to be boxed. At the end of the boxing cycle, the track rotates allowing other chocolates to slide onto other empty plates, and this sequence continues.

1st STAGE - DEGREASING TREATMENT

[0070] The part (consisting of a plate) follows the same methods as the previous example 1.

[0071] Also in this case the pickling treatment is not essential, as there are no signs of weld oxides or the like.

2nd STAGE - CALIBRATION / SMOOTHING / BELT GRINDING TREATMENT

[0072] The part is treated using a semi-automatic calibration / smoothing / belt grinding machine, on which it is arranged on a conveyor belt and subjected to the correct calibration-pressure passing under 3 contact rollers that rotate with zirconia abrasive fibre belts with different grain sizes: first roller gr. 180, second roller gr. 220 and third roller gr. 320; to optimize the surface to be treated two passes through the machine are required.

[0073] After the contact surface has been calibrated and smoothed, further manual processing is carried out using a cleaning-belt grinding machine to deburr and bevel the sharp lateral edges; this is slight bevelling with a single pass of the abrasive belt or with flap wheels gr. 320.

3rd STAGE -SHOT PEENING TREATMENT

[0074] The part follows the same methods as the previous example 1.

[0075] Maintaining the same machine, the same abrasive, the same diameter, changing only the number of revolutions of the turbine and the treatment time: turbine rpm 2000, treatment time 10'.

4th STAGE -INTERMEDIATE CHECKS

[0076] At the end of the shot peening treatment, the part is blown with compressed air and the roughness checks are carried out by means of a roughness meter in at least five different points of the treated part, the average of which is **Ra 2.47**.

5th STAGE - ELECTROLYTIC TREATMENT

[0077] The electro-polishing treatment is carried out on the same system and using the same electrolytic composition as in example 1.

[0078] Only the auxiliary cathodes, no longer required as the shape of the part to be treated is simple and linear, are eliminated; only the moving cathodes, which slide by means of copper sliding blocks, on specific copper

guides, are moved to a distance of around 10 cm from the part to be treated; the treatment is carried out at 10V for 10'.

[0079] This is followed by the same dripping, washing and drying steps as example 1.

6th STAGE - FINAL CHECKS

[0080] Before packaging, the surface roughness is subjected to a final check with the roughness meter, on an average of at least five points of the treated surface: the final result is **Ra 1.78**.

OBSERVATIONS

[0081] The part obtained with this treatment cycle and having the aforesaid final roughness was compared to plates measuring 200x30, thk 10 mm, made of the materials and coatings listed below:

- stainless steel plate treated with the method according to the invention;
- satin finished stainless steel plate;
- mirror-polished steel plate;
- Teflon coated steel plate;
- Teflon coated aluminum plate;
- anodized aluminum plate;
- mirror polished aluminum plate;
- chrome-plated iron plate.

[0082] Positioning all the plates on a rack with the same inclination of around 15° and placing wrapped chocolates thereon, it was possible to note and prove that the chocolates slid easily downwards only on three plates: the plate treated with the method according to the invention and two others plates, one made of stainless steel and one made of aluminum, both Teflon-coated. Continuing the tests it was however noted that the wrapped chocolates slid more rapidly on the stainless steel plate treated with the method according to the invention than the chocolates arranged on the Teflon-coated plates. Therefore, it can be confirmed that the treatment carried out with the method according to the invention ensures greater slip with respect to the parts obtained with the normal Teflon-coating treatment.

EXAMPLE 3 - Cycle, times and method steps according to the invention relative to a "slide/hopper" made of AISI 304 stainless steel for spun paste.

[0083] Known machinery and systems for processing spun paste cheeses (mozzarella, scamorza, provolone, etc.) are coated in Teflon or other similar non-stick products that, being applied materials, over time and due to continuous rubbing and pressure of the products treated, tend to detach and, therefore, to be discharged into the product during the various processing steps, creating serious problems of contamination of these products.

1st STAGE - DEGREASING TREATMENT

[0084] The part being processed follows the same methods as in the previous examples 1 and 2.

2nd STAGE - PICKLING TREATMENT

[0085] Unlike the previous examples, the part has various weld seams and points, with a great many oxides on the surface, and therefore a pickling treatment is necessary.

[0086] Chemical picking with a compound with the following formulation was chosen:

- Compound:

30% nitric acid concentrate 67%,
3-5% hydrofluoric acid concentrate 38%.

- Additives:

0.5 - 1 g/L surfactants (or inhibitors) at 10% non ionic and at 5% cationic.

Temperature:

room, optimal from 40°C to 60°C,
Average immersion time around 60' (variable according to the temperature).

[0087] The treatment is followed by dripping and by a first and a second wash. At times it is advisable to wash complex parts with jets of pressurized water.

3rd STAGE - MANUAL DISC-GRINDING AND BELT-GRINDING TREATMENT

[0088] The part is treated with the same methods as example 1.

4th STAGE - SHOT PEENING TREATMENT

[0089] In this case, as the "slide/hopper" is in contact with a food in paste and spun form, a much greater roughness must be created. Therefore, high pressure shot peening is carried out in a shot peening cabin with pressure of 8 atm at a constant distance of around 50 cm with cylindrical abrasive obtained from AISI 304 metal wire $\varnothing$ 0.4 mm; treatment time 5'.

5th STAGE -INTERMEDIATE CHECKS

[0090] At the end of the shot peening procedure, the part is blown with compressed air and the surface roughness is checked with the roughness meter in at least five different points of the treated part, the average of which is **Ra 4.79**.

6th STAGE - ELECTROLYTIC TREATMENT

[0091] The electro-polishing treatment is carried out in the same system and using the same electrolytic composition described in examples 1 and 2.

[0092] Once again the auxiliary cathode made of copper mesh is inserted into the inner part of the channel of the "slide/hopper", as the shape itself forms a shield for the electrical current, which can prevent the electrolytic treatment from removing the material uniformly, altering the uniformity of the roughness.

[0093] To obtain greater roughness and obtain deeper and wider valleys, it was decided to use electro-polishing with very high times, with repetitions of 10' each, for 4 passes with a total treatment time of 40' at 10V.

[0094] The time of 40' cannot be continuative as, not having suitable means for slight movement of the part, preferential channels could be formed due to gas bubbles, which could alter the removal of material and consequently the roughness.

[0095] The material must be treated for 40' for the following reasons:

- To obtain, from the preceding shot peening treatment, wider and deeper valleys, much higher peaks were also formed, which must be removed and rounded, and therefore treatment times must be extended.

- By treating the material for 40', a viscous and water-repellent anodic film forms, which further improves the slip and non-stick properties of products coming into contact with it.

- Extension of the treatment times considerably increases the resistance to corrosion by both acid and alkaline products.

[0096] This is followed by the same dripping, washing and drying steps described in examples 1-2.

7th STAGE - FINAL CHECKS

[0097] Before packaging, the surface roughness is subjected to a final check with the roughness meter, in an average of at least five points of the treated surface; the final result is **Ra 2.85**.

OBSERVATIONS

[0098] With reference to Figs. 3A and 3B, the following can be observed:

- Fig. 3A illustrates an example of surface roughness created on a workpiece with the shot peening treatment according to the method of the invention, which considerably reduces the contact surface, but forms pointed peaks that hold the materials or products in

contact with the aforesaid surface;

- Fig. 3B illustrates an example of surface roughness after the electro-polishing treatment according to the method of the invention, in which the aforesaid peaks are rounded by removal of material.

[0099] The result is more than satisfactory, as the spun paste detaches easily from the "slide/hopper" in a similar manner, as a result of slipping, to Teflon coated parts.

[0100] It must nonetheless be mentioned that Teflon or other similar products are always and in any case coating products and therefore, as a result of wear, subject to consumption and detachment, which must not be underestimated, above all if the parts treated are used in contact with pharmaceutical or, as in the case in hand, food products.

[0101] A strength and one of the advantages of the present invention lies in the possibility of reducing contamination, while maintaining the effectiveness of the non-stick properties of the treated part intact. In this case, with the same non-stick results, the present invention in fact achieves the important and considerable advantage of preventing the possibility of contamination of the aforesaid products.

[0102] Therefore, the method for the surface treatment of a stainless steel workpiece according to the invention enables the following advantages and the improvements indicated below to be achieved with respect to the current state of the art.

- Excellent slip of the treated surface, making it completely non-stick. In this regard, see examples 1, 2 and 3 described above.
- Overcoming, due to the absence of the addition of different material than that of the workpiece, all critical issues deriving from the detachment of material from the treated workpiece, as instead commonly occurs in products treated with known applications of non-stick materials, thereby avoiding serious problems of contamination. In this regard, see examples 1, 2 and 3 described above.
- Improvement of the resistance to fatigue of the treated workpiece, increasing its useful life.

[0103] In relation to resistance to fatigue, besides creating the particular surface roughness useful for slip and non-stick properties, by means of the continuous surface hammering operation, the shot peening/shot blasting treatment of the method according to the invention compresses the fibres of the material, removing the residual tensile stresses, generated during the previous operations, from the metal. The resulting effect is an increase in the life of all those parts subjected to repeated stresses (fatigue strength).

- Improvement of corrosion resistance. In this regard, the electro-polishing treatment that according to the present invention provides for levelling of the rough-

ness, removing material first on the peaks, rounding them, and then on the valleys, also has the advantage, in this removal step, of eliminating all the surface impurities, forming a passivating gaseous anodic film, which considerably increases the corrosion resistance.

- Reduction of the release of chrome, nickel and manganese, obtaining suitability for contact with foodstuffs in any situation and with any food, and also for products for personal use, pursuant to Ministerial Decree 21 March 1973 and subsequent updates in conformity with the EC Directives. Suitability for contact with foods of the treated material represents an extremely advantageous and important point, as the method according to the present invention allows a noteworthy decrease (compared with other known processes) in the release of metals, above all chrome and nickel. Therefore, the treated part falls favourable and fully within the framework of the limits and tolerances required by the current law (Ministerial Decree 21 March 1973 and subsequent updates in conformity with EC Directives), in relation to contact with foods and products for personal use. It is therefore possible to certify the suitability of the method according to the present invention.
- Excellent visual appearance of the surface finish of the workpiece treated. Although the object of the present invention is that of providing the surface of the treated workpiece with slip and non-stick properties, at the same time during the steps of the treatment cycle of the method according to the invention a surface finish is formed that makes the treated part uniform and provides it with a visually pleasing silvery, semi-gloss appearance.

[0104] With reference to Fig. 2, there is described below an example of embodiment of the electrolytic cell system for implementing the method according to the present invention.

[0105] Said system is indicated as a whole with 10. The system 10 comprises an iron tank 11 with a galvanic bath with electrolytic cell, which has a first inner coating 12 made of insulating plastic material, such as PVC, and a second inner coating 13 made of AISI 316/L stainless steel, superimposed on the first coating. Said second stainless steel coating 13 is electrically connected to cathode means (negative polarity) of the electrolytic cell, with formation of an electrical field extended to the total surface of said second inner coating 13 (bottom and side walls), while the workpiece P, arranged in the galvanic bath, is electrically connected to the anode means (positive polarity) of the electrolytic cell and is maintained, by means of fixed support means 14, at a distance generally variable from around 100 to 150 mm with respect to the cathode means.

[0106] It must be noted that the whole surface of said second coating 13 is electrically connected with respect to the current rectifier of said cathode means, while along

the opposite edges of the said inner coating 13 there are arranged sliding support means, which comprise copper guides, connected to said second coating 13 and along which there are engaged, in electrical and sliding contact, copper sliding blocks 15, which support plates 16 opposite one another, at least partially immersed in the galvanic bath and forming respective moving cathodes, made of AISI 316/L stainless steel, sliding each for around half the width of said inner coating 13. The fixed support means 14 of the workpiece P, and the workpiece P itself, are arranged between said moving cathodes 16.

[0107] Therefore, contrary to normal electro-polishing systems, in which the cathodes are fixed to the two sides of the tank, according to the invention it is possible to move the cathode means towards, respectively away from, the workpiece P, taking account of its shapes and sizes, so as to maintain a predetermined optimal distance, for example 10/15 cm, between the cathode means and the workpiece. In this way, a homogeneous passage of current and excellent results can be achieved.

[0108] Moreover, the system according to the invention may be provided with auxiliary cathodes, structured as copper frames with diamond mesh, to be used in the galvanic bath for the inner parts of a workpiece of complex shape.

Claims

1. Method for the surface treatment of a stainless steel workpiece, **characterized in that** it comprises at least the following steps:

- shot peening/shot blasting of at least one surface of said workpiece, wherein there are used shots/beads made of electrocast austenitic stainless steel, respectively stainless steel obtained from metal wire, and which are essentially spherical, respectively cylindrical, with a diameter of the spherical body, respectively of the cross section of the cylindrical body, substantially from around 0.4 to 0.8 mm; said method being implemented in an automatic turbine system with inverter, which controls the continuous variation of the rotation speed of the turbine motor and therefore the blasting speed of the shot/beads, so that on said at least one surface of said workpiece there is provided a surface micro-roughness, having micro-peaks and micro-valleys that reduce the area of contact of the worked surface, and
- electro-polishing of said at least one surface of the workpiece by means of tank with an galvanic bath with electrolytic cell, wherein said tank, made of an electroconductive material, comprises a first inner coating made of insulating plastic material and a second inner coating made of stainless steel, superimposed on the

said first coating and electrically connected to cathode means of the electrolytic cell, with formation of a corresponding electrical field extended to the total surface of said second inner coating, and **in that** guides made of a good electrically conductive material are applied to the two opposite edges of said tank and are electrically connected with respect to said second coating and to the corresponding cathode means of the electrolytic cell, while support bars with respective sliding blocks made of a good electrically conductive material are engaged, in electrical contact and sliding, along said guides, and are electrically connected with at least two steel plates, at least partially immersed in the galvanic bath, forming moving cathodes and arranged on opposite sides with respect to the workpiece, which is supported fixed in said galvanic bath and electrically connected with respect to the anode means of the electrolytic cell, and which is maintained during the galvanic treatment at a distance variable from around 100 to 150 mm with respect to the said moving cathode means, so that said surface microroughness is reduced, lowering and rounding by removal of material of said micro-peaks of the surface of the workpiece.

2. A method according to claim 1, **characterized in that** said tank of the galvanic bath is provided with a first inner coating made of an insulating plastic material and is further completely lined by means of a second inner coating made of stainless steel, wherein said second coating made of stainless steel is electrically connected to the cathode means of the electrolytic cell, with formation of an electrical field extended to the total surface of the bottom and of the side walls of said second coating, arranging said workpiece in the galvanic bath electrically connected with respect to the anode means of the electrolytic cell and maintaining it during the galvanic treatment at a distance variable from around 100 to 150 mm with respect to said cathode means.

3. A method according to claims 1 and/or 2, **characterized in that** it also comprises in the electro-polishing step:

- introducing into the galvanic bath auxiliary cathodes for the internal parts of the workpiece, which are produced in the form of copper cathode frames, which are provided with a copper mesh;
- electrical connection to said auxiliary cathodes of two pairs of electrical cables, provided with respective electrical terminals that clamp said auxiliary cathodes.

4. A method according to claim 1, 2 and/or 3, **characterized in that** in said electro-polishing step density control of the electrolyte of the galvanic bath, maintaining the density substantially constant at a value of around 1.750 g/mL at 20°C, and temperature control of said electrolyte at a temperature range of around 45°C to 55°C are carried out.
5. A method according to claim 1, 2, 3 and/or 4, **characterized in that** at the end of the shot peening/shot blasting cycle, the workpiece is subjected to a surface cleaning by means of a jet of compressed air, to eliminate all possible processing residues present on the surface.
6. A method according to claim 1, 2, 3, 4 and/or 5, **characterized in that** after the electrolytic polishing treatment the workpiece is subjected to at least one washing and subsequent dripping with subsequent drying.
7. A method according to claim 5 and/or 6, **characterized in that** after cleaning with compressed air, respectively after drying, the workpiece is tested and checked with a roughness meter in several parts of the surface, ensuring that the roughness falls within predefined process parameters.
8. A system (10) for implementing the method according to one or more of the preceding claims, **characterized in that** it comprises:
- an automatic turbine system with inverter for controlling the continuous variation of the rotation speed of a turbine motor and therefore the blasting speed of shot/beads,
 - an iron tank (11) with a galvanic bath with electrolytic cell, comprising a first inner coating (12) made of insulating plastic material and a second inner coating (13) made of stainless steel, superimposed on the first coating and wherein said second stainless steel coating is electrically connected to cathode means (negative polarity) of the electrolytic cell, with formation of an electrical field extended to the total surface of said second inner coating (13),
 - and **in that** guides made of a good electrically conductive material are applied to the two opposite edges of said tank and are electrically connected with respect to said second coating and to the corresponding cathode means of the electrolytic cell, while support bars with respective sliding blocks made of a good electrically conductive material are engaged, in electrical contact and sliding, along said guides, and are electrically connected with at least two steel plates, at least partially immersed in the galvanic bath, forming moving cathodes and arranged on opposite sides with respect to the workpiece,

which is supported fixed in said galvanic bath and electrically connected with respect to the anode means (positive polarity) of the electrolytic cell, and fixed support means (14) maintaining the workpiece at a distance variable from around 100 to 150 mm with respect to said moving cathode means.

9. A system (10) according to claim 8, **characterized in that** the surface of said second coating (13) is electrically connected with respect to the current rectifier of said cathode means, while along two opposite edges of said tank (11) there are arranged sliding support means (15), which comprise copper guides, connected to said second coating (13) and along which there are engaged, in electrical and sliding contact, copper sliding blocks, which support plates (16) opposite one another and forming moving cathodes, sliding, each for around half the width of said tank (11), while said fixed support means (14) of the workpiece (P), and said workpiece (P) immersed in the galvanic bath, are arranged between said moving cathodes (16), so that it is possible to move the cathode means towards, respectively away from, the workpiece (P), taking account of its shapes and sizes, to a predetermined optimal distance between said cathode means (16) and the workpiece (P).
10. A system (10) according to claim 8 and/or 9, **characterized in that** it comprises auxiliary cathodes structured as copper frames with mesh, immersed in the galvanic bath for the internal parts of a workpiece of complex shape.

Patentansprüche

1. Ein Verfahren zur Oberflächenbehandlung eines Werkstücks aus rostfreiem Stahl, **dadurch gekennzeichnet, dass** es mindestens die folgenden Schritte umfasst:
- Kugelbestrahlung/Schleifen von mindestens einer Oberfläche des besagten Werkstücks, bei dem elektrogegossenes Schrot/Korn aus austenitischem rostfreiem Stahl verwendet wird, das wiederum aus rostfreiem Stahl, gewonnen aus Draht, erhalten wird und eine im Wesentlichen kugelförmige bzw. zylindrische Form und einen Durchmesser des kugelförmigen Körpers, bzw. des Querschnitts des zylindrischen Körpers von im Wesentlichen zwischen etwa 0,4 und 0,8 mm aufweist; wobei das besagte Verfahren in einem automatischen Turbinensystem mit Wechselrichter ausgeführt wird, der die kontinuierliche Veränderung der Rotationsgeschwindigkeit des Turbinenmotors und somit die Schrot-/Korn-Abschussgeschwindigkeit steuert.

ert, so dass die besagte mindestens eine Oberfläche des besagten Werkstücks mit einer Mikrorauigkeit der Oberfläche versehen ist, die Mikrospitzen und Mikrosenken aufweist, die die Kontaktfläche der bearbeiteten Oberfläche reduzieren, sowie

- Elektropolieren der besagten mindestens einer Oberfläche des Werkstücks mittels einer galvanischen Wanne mit elektrolytischer Zelle, wobei die besagte Wanne, die aus elektrisch leitendem Material hergestellt ist, eine erste Innenbeschichtung aus isolierendem Kunststoffmaterial und eine zweite Innenbeschichtung aus rostfreiem Stahl aufweist, die über der besagten ersten Innenbeschichtung liegt und elektrisch mit den Kathodenvorrichtungen der elektrolytischen Zelle verbunden ist, wobei ein entsprechendes elektrisches Feld gebildet wird, das sich auf die gesamte Oberfläche der besagten zweiten Innenbeschichtung erstreckt,

und **dadurch gekennzeichnet, dass** Führungen, die aus einem elektrisch gut leitenden Material hergestellt sind, in Übereinstimmung mit zwei gegenüberliegenden Rändern der besagten Wanne angebracht sind und elektrisch in Bezug auf die besagte zweite Beschichtung und mit den entsprechenden Kathodenvorrichtungen der elektrolytischen Zelle verbunden sind, während Stützstäbe mit entsprechenden Kufen, hergestellt aus einem elektrisch gut leitenden Material, in elektrischem und gleitendem Kontakt entlang der besagten Führungen in Anspruch genommen und elektrisch mit mindestens zwei Stahlblechen verbunden werden, die mindestens teilweise in das galvanische Bad eingetaucht sind, und die bewegliche Kathoden bilden und an gegenüberliegenden Seiten in Bezug auf das Werkstück angeordnet sind, das fest in dem besagten galvanischen Bad und in elektrischer Verbindung mit den Anodenvorrichtungen der elektrolytischen Zelle gehalten werden, und während der galvanischen Behandlung in einem Abstand zwischen etwa 100 und 150 mm in Bezug auf die besagten beweglichen Kathodenvorrichtungen gehalten wird, so dass die besagte Mikrorauigkeit der Oberfläche verringert wird, indem die Spitzen der Mikrospitzen der Werkstückoberfläche abgesenkt und durch Materialabtrag abgerundet werden.

2. Ein Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die besagte galvanische Wanne mit einer ersten Innenbeschichtung aus isolierendem Kunststoffmaterial versehen ist und weiter vollständig mit einer zweiten Innenbeschichtung aus rostfreiem Stahl ausgekleidet ist, wobei die besagte zweite Beschichtung aus rostfreiem Stahl elektrisch mit den kathodischen Mitteln der elektrolytischen Zelle verbunden ist, mit Bildung eines elektrischen

Feldes, das sich auf die gesamte Oberfläche des Bodens und der Seitenwände der besagten zweiten Beschichtung erstreckt, wobei das besagte Werkstück in dem galvanischen Bad in elektrischer Verbindung mit den Anodenvorrichtungen der elektrolytischen Zelle angeordnet und während der galvanischen Behandlung in einem variablen Abstand zwischen etwa 100 und 150 mm in Bezug auf die besagten Kathodenvorrichtungen gehalten wird.

3. Ein Verfahren gemäß Anspruch 1 und/oder 2, **dadurch gekennzeichnet, dass** es außerdem in der Elektropolierphase auch Folgendes umfasst:

- die Einführung von Hilfskathoden in das galvanische Bad, für die inneren Teile des Werkstücks, die in Form von Rahmenkathoden aus Kupfer hergestellt werden;
- die elektrische Verbindung zu den besagten Hilfskathoden von zwei Paaren elektrischer Kabel, versehen mit entsprechenden elektrischen Klemmen, die die besagten selbigen Hilfskathoden festklemmen.

4. Ein Verfahren gemäß den Ansprüchen 1, 2 und/oder 3, **dadurch gekennzeichnet, dass** in der besagten Elektropolierphase die Kontrolle der Dichte des Elektrolyten des galvanischen Bades kontinuierlich durchgeführt wird, wobei die Dichte selbst im Wesentlichen konstant auf einem Wert von etwa 1,750 g/mL bei 20°C und die Temperaturkontrolle des besagten Elektrolyten innerhalb eines Temperaturbereiches von etwa 45°C bis 55°C gehalten werden.

5. Ein Verfahren gemäß den Ansprüchen 1, 2, 3 und/oder 4, **dadurch gekennzeichnet, dass** das Werkstück am Ende des Kugelstrahl-/Schleifzyklus einer Oberflächenreinigung durch Blasen von Druckluft unterzogen wird, um auf der Oberfläche vorhandene Bearbeitungsrückstände zu beseitigen.

6. Ein Verfahren gemäß den Ansprüchen 1, 2, 3, 4 und/oder 5, **dadurch gekennzeichnet, dass** das Werkstück nach der elektrolytischen Polierbehandlung mindestens einem Waschvorgang und einem anschließenden Abtropfen mit anschließendem Trocknen unterzogen wird.

7. Ein Verfahren gemäß Anspruch 5 und/oder 6, **dadurch gekennzeichnet, dass** am Ende der Reinigung mit Druckluft bzw. nach dem Trocknen das Werkstück an mehreren Stellen der Oberfläche mit einem Rauheitsmessgerät geprüft und kontrolliert wird, wobei überprüft wird, dass die Rauheit innerhalb vordefinierter Prozessparameter liegt.

8. Eine Anlage (10) für die Durchführung des Verfahrens gemäß einem oder mehreren der oben genannten

ten Ansprüche, **dadurch gekennzeichnet, dass** sie Folgendes umfasst:

- ein automatisches Turbinensystem mit Wechselrichter zur Steuerung der kontinuierlichen Veränderung der Rotationsgeschwindigkeit eines Turbinenmotors und damit der Schrot-/Korn-Abschussgeschwindigkeit, 5
- eine galvanische Wanne (11) aus Eisen für ein galvanisches Bad mit elektrolytischer Zelle, umfassend eine erste Innenbeschichtung (12) aus isolierendem Kunststoff und eine zweite Innenbeschichtung (13) aus rostfreiem Stahl, die der ersten Beschichtung überlagert ist und mit der die besagte zweite Beschichtung aus rostfreiem Stahl elektrisch mit Kathodenvorrichtungen (negative Polarität) der elektrolytischen Zelle verbunden ist, mit Bildung eines elektrischen Feldes, das sich auf die gesamte Oberfläche der besagten zweiten Innenbeschichtung (13) erstreckt, und **dadurch gekennzeichnet, dass** Führungen aus elektrisch gut leitfähigem Material in Übereinstimmung mit zwei gegenüberliegenden Rändern der besagten Wanne angebracht sind und elektrisch mit der besagten zweiten Beschichtung und mit den entsprechenden Kathodenvorrichtungen der elektrolytischen Zelle verbunden sind, während Tragstäbe mit entsprechenden Gleitkufen aus elektrisch gut leitendem Material in elektrischem und gleitendem Kontakt entlang der besagten Führungen in Anspruch genommen und elektrisch mit mindestens zwei Stahlblechen verbunden werden, die zumindest teilweise in das galvanische Bad eingetaucht sind, bewegliche Kathoden bilden und auf gegenüberliegenden Seiten in Bezug auf das Werkstück angeordnet sind, das in dem besagten galvanischen Bad und in elektrischer Verbindung in Bezug auf die Anodenvorrichtungen (positive Polarität) der elektrolytischen Zelle fixiert gehalten wird, und feste Stützvorrichtungen (14), die das Werkstück in einem variablen Abstand zwischen etwa 100 und 150 mm in Bezug auf die besagten Kathodenvorrichtungen halten. 20

9. Eine Anlage (10) gemäß Anspruch 8, **dadurch gekennzeichnet, dass** die Oberfläche der besagten zweiten Beschichtung (13) in Bezug auf den Stromgleichrichter der besagten Kathodenvorrichtungen elektrisch verbunden ist, während entlang zweier gegenüberliegender Ränder der besagten Wanne (11) Gleitstützvorrichtungen (15) angeordnet sind, die Kupferführungen umfassen die mit der besagten zweiten Beschichtung (13) verbunden sind und längs welchen Kupferkufen in elektrischem und gleitendem Kontakt in Anspruch genommen werden, die einander gegenüberliegende und bewegliche, gleitende Kathoden bildende Bleche (16) tragen, ein jedes für etwa die Hälfte der Breite der besagten Wanne (11), während die besagten festen Stützmittel (14) des Werkstücks (P) und das besagte Werkstück (P), das in das galvanische Bad eingetaucht ist, zwischen den besagten beweglichen Kathoden (16) angeordnet sind, so dass es möglich ist, die Kathodenvorrichtungen in Bezug auf das Werkstück (P) unter Berücksichtigung seiner Formen und Abmessungen in einem vorbestimmten optimalen Abstand zwischen den besagten Kathodenvorrichtungen (16) und dem Werkstück (P) anzunähern bzw. zu entfernen. 25

tende Kathoden bildende Bleche (16) tragen, ein jedes für etwa die Hälfte der Breite der besagten Wanne (11), während die besagten festen Stützmittel (14) des Werkstücks (P) und das besagte Werkstück (P), das in das galvanische Bad eingetaucht ist, zwischen den besagten beweglichen Kathoden (16) angeordnet sind, so dass es möglich ist, die Kathodenvorrichtungen in Bezug auf das Werkstück (P) unter Berücksichtigung seiner Formen und Abmessungen in einem vorbestimmten optimalen Abstand zwischen den besagten Kathodenvorrichtungen (16) und dem Werkstück (P) anzunähern bzw. zu entfernen. 30

10. Eine Anlage (10) gemäß Anspruch 8 und/oder 9, **dadurch gekennzeichnet, dass** sie Hilfskathoden in Form von Kupferrahmen mit Netz aufweist, die in das galvanische Bad für die inneren Teile eines Werkstücks mit komplexer Form eingetaucht sind. 35

Revendications

1. Procédé pour le traitement de surface d'une pièce en traitement en acier inoxydable, **caractérisé par le fait qu'il** comprend au moins les étapes suivantes :

- grenailage de précontrainte/sablage d'au moins une surface de ladite pièce en traitement, où sont utilisées des billes/ grenailles en acier inoxydable austénitique électrofondu, respectivement en acier inoxydable obtenu à partir de fil métallique, et qui ont une forme essentiellement sphérique, respectivement cylindrique, avec un diamètre du corps sphérique, respectivement de la section transversale du corps cylindrique, substantiellement compris entre 0,4 et 0,8 mm environ ; ladite méthode étant mise en œuvre dans un système automatique à turbine avec convertisseur, qui contrôle la variation continue de la vitesse de rotation du moteur de la turbine et donc la vitesse de projection des billes/grenailles, de sorte que sur ladite au moins une surface de ladite pièce en traitement, il est prévu une micro-rugosité de surface, ayant des micro-crêtes et des micro-vallées qui réduisent la superficie de contact de la surface traitée, et - électropolissage de ladite au moins une surface de la pièce en traitement au moyen d'une cuve avec un bain galvanique à cellule électrolytique, où ladite cuve, en matériau électroconducteur, comprend un premier revêtement interne en matériau plastique isolant et un second revêtement interne en acier inoxydable, superposé sur ledit premier revêtement interne et électriquement connecté aux moyens à cathode de la cellule électrolytique, avec formation d'un 40 45 50 55

champ électrique correspondant étendu à la surface totale dudit second revêtement interne,

et **par le fait que** des guides en matériau bon conducteur électrique sont appliqués au niveau de deux bords opposés de ladite cuve et sont connectés électriquement par rapport audit second revêtement et aux moyens à cathode correspondants de la cellule électrolytique, tandis que des barres de support avec des patins correspondants en matériau bon conducteur électrique sont engagées, en contact électrique et coulissant, le long desdits guides et sont électriquement connectées avec au moins deux tôles d'acier, au moins partiellement immergées dans le bain galvanique, formant des cathodes mobiles et disposées sur des côtés opposés par rapport à la pièce en traitement, qui est supportée fixe dans ledit bain galvanique et en connexion électrique par rapport aux moyens à anode de la cellule électrolytique, et est maintenue pendant le traitement galvanique à une distance variable entre 100 et 150 mm environ par rapport aux moyens à cathode mobiles, de sorte que ladite micro-rugosité de surface est réduite, en abaissant et en arrondissant par enlèvement de matière les pointes desdits micro-crêtes de la surface de la pièce en traitement.

2. Procédé selon la revendication 1, **caractérisé par le fait que** ladite cuve avec bain galvanique est dotée d'un premier revêtement interne en matériau plastique isolant et est ultérieurement revêtue complètement au moyen d'un second revêtement interne en acier inoxydable, où ledit second revêtement en acier inoxydable est électriquement connecté aux moyens à cathode de la cellule électrolytique, avec formation d'un champ électrique étendu à la surface totale du fond et des parois latérales dudit second revêtement, en disposant ladite pièce en traitement dans le bain galvanique en connexion électrique par rapport aux moyens à anode de la cellule électrolytique et en la maintenant durant le traitement galvanique à une distance variable entre 100 et 150 mm environ par rapport auxdits moyens à cathodes.

3. Procédé selon la revendication 1 et/ou 2, **caractérisé par le fait qu'il** comprend également dans la phase d'électropolissage :

- l'introduction dans le bain galvanique de cathodes auxiliaires, pour les parties internes de la pièce en traitement, qui sont réalisées en forme de châssis-cathodes en cuivre, lesquelles sont dotées d'une grille en cuivre ;
- la connexion électrique auxdites cathodes auxiliaires de deux paires de câbles électriques, dotées de borniers électriques respectifs qui serrent lesdites cathodes auxiliaires.

4. Procédé selon la revendication 1, 2 et/ou 3, **caractérisé par le fait que** dans ladite phase d'électropolissage le contrôle de la densité de l'électrolyte du bain galvanique, en maintenant substantiellement constante la densité même à une valeur d'environ 1,750 g/ml à 20 °C, et le contrôle de la température dudit électrolyte dans une plage de température de 45 °C à 55 °C environ sont effectués de manière continue.

5. Procédé selon la revendication 1, 2, 3 et/ou 4, **caractérisé par le fait qu'à** la fin du cycle de grenaillage de précontrainte/sablage, la pièce en traitement est soumise à un nettoyage de surface au moyen d'un jet d'air comprimé, pour éliminer tous les éventuels résidus de traitement présents sur la surface.

6. Procédé selon la revendication 1, 2, 3, 4 et/ou 5, **caractérisé par le fait qu'**après le traitement électrolytique de polissage, la pièce en traitement est soumise à au moins un lavage puis un égouttage avec séchage suivant.

7. Procédé selon la revendication 5 et/ou 6, **caractérisé par le fait qu'à** la fin du nettoyage avec air comprimé, respectivement après le séchage, la pièce en traitement est testée et contrôlée avec un rugosimètre sur plusieurs parties de la surface, en vérifiant que la rugosité se situe dans les paramètres de processus procédé prédéfinis.

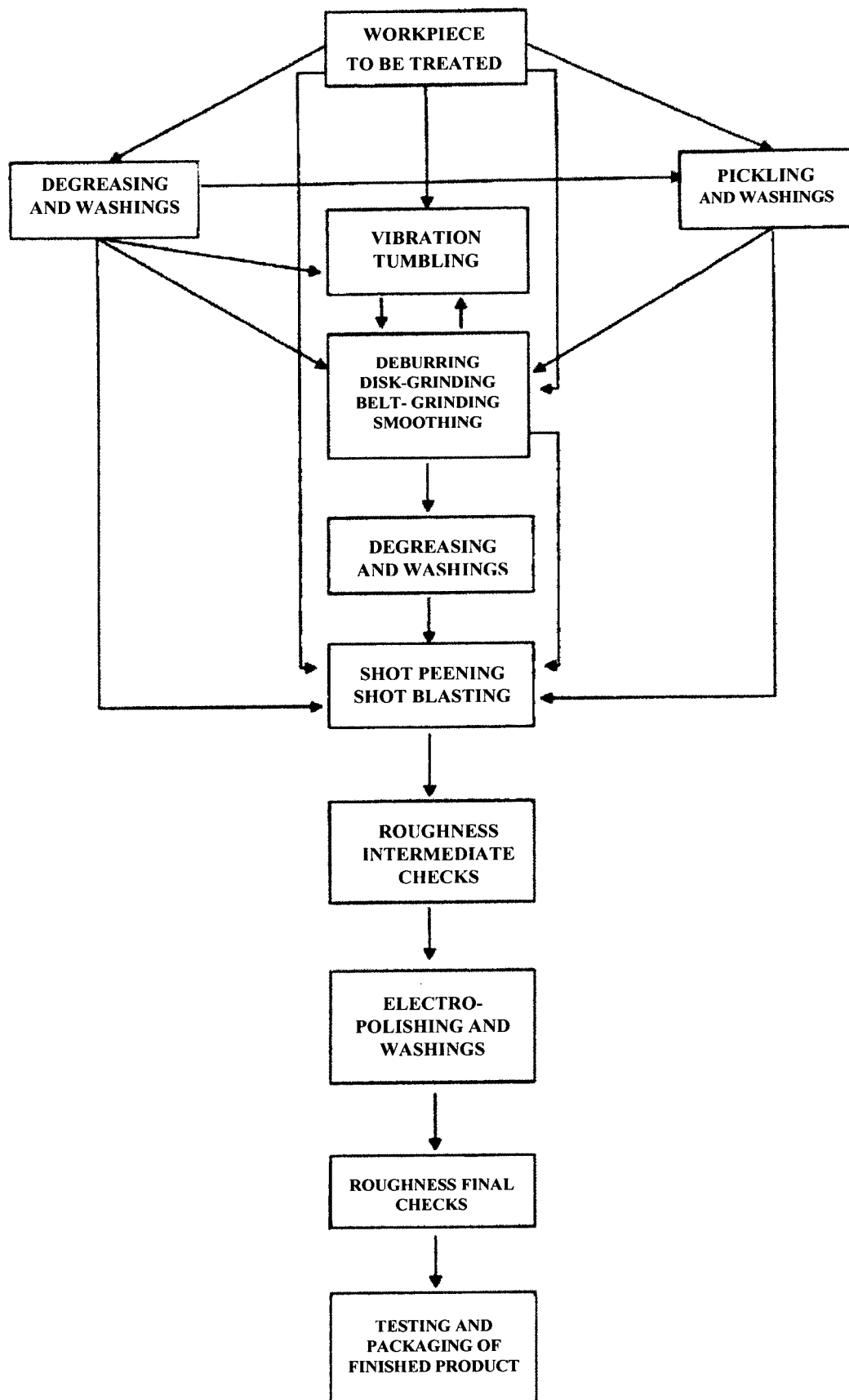
8. Système (10) pour la mise en œuvre du procédé selon un ou plusieurs des revendications précédentes, **caractérisé par le fait qu'il** comprend :

- un système automatique à turbine avec convertisseur pour contrôler la variation continue de la vitesse de rotation d'un moteur de la turbine et donc la vitesse de projection des billes/grenailles,
- une cuve (11) en fer pour bain galvanique en cellule électrolytique, comprenant un premier revêtement interne (12) en matériau plastique isolant et un second revêtement interne (13) en acier inoxydable, superposé au premier revêtement et où ledit second revêtement en acier inoxydable est électriquement connecté aux moyens à cathode (polarité négative) de la cellule électrolytique, avec formation d'un champ électrique étendu à la surface totale dudit second revêtement interne (13), et **par le fait que** des guides en matériau bon conducteur électrique sont appliqués au niveau de deux bords opposés de ladite cuve et sont connectés électriquement par rapport audit second revêtement et aux moyens à cathode correspondants de la cellule électrolytique, tandis que des barres de support avec des patins correspondants en ma-

tériau bon conducteur électrique sont engagées, en contact électrique et coulissant, le long desdits guides et sont électriquement connectées avec au moins deux tôles d'acier, au moins partiellement immergées dans le bain galvanique, formant des cathodes mobiles et disposées sur des côtés opposés par rapport à la pièce en traitement, qui est supportée fixe dans ledit bain galvanique et en connexion électrique par rapport aux moyens à anode (polarité positive) de la cellule électrolytique, et des moyens de supports fixes (14) qui maintiennent la pièce en traitement à une distance variable entre 100 et 150 mm environ par rapport auxdits moyens à cathode.

9. Système (10) selon la revendication 8, **caractérisé par le fait que** la surface dudit second revêtement (13) est électriquement connectée par rapport au redresseur de courant desdits moyens à cathode, tandis que le long de deux bords opposés de ladite cuve (11) sont disposés des moyens de support coulissant (15), lesquels comprennent des guides en cuivre, connectés audit second revêtement (13) et le long desquels sont engagés, en contact électrique et coulissant, des patins en cuivre, qui supportent des tôles (16) opposées entre elles et formant des cathodes mobiles, coulissantes, chacune sur la moitié de la largeur de ladite cuve (11), tandis que lesdits moyens de support (14) fixes de la pièce en traitement (P), et ladite pièce en traitement (P) immergée dans le bain galvanique, sont disposés entre lesdites cathodes mobiles (16), de sorte qu'il est possible d'approcher, respectivement d'éloigner les moyens à cathodes par rapport à la pièce (P) en traitement, compte tenu de ses formes et dimensions, à une distance prédéterminée optimale entre lesdits moyens à cathode (16) et la pièce en traitement (P).
10. Système (10) selon la revendication 8 et/ou 9, **caractérisé par le fait qu'il** comprend des cathodes auxiliaires conformées comme des châssis en cuivre avec grille, immergées dans le bain galvanique pour les parties internes d'une pièce en traitement de forme complexe.

FIG. 1



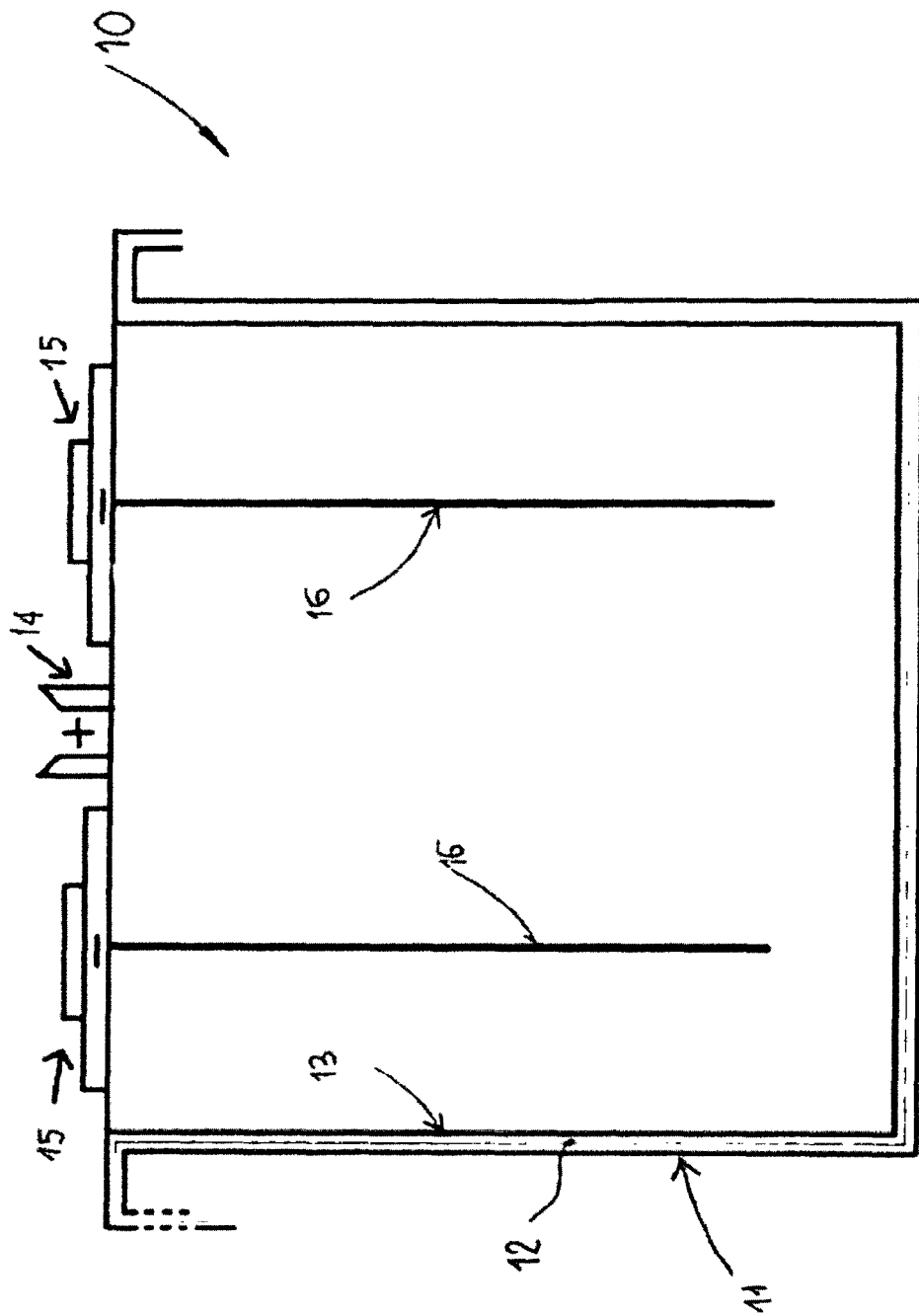


FIG. 2

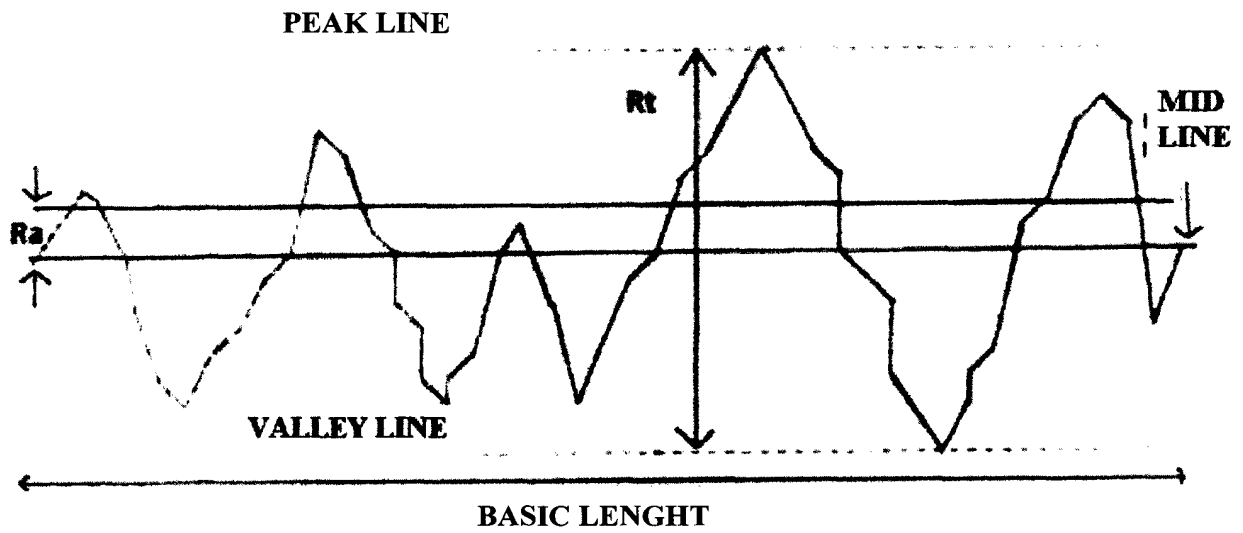


FIG. 3A

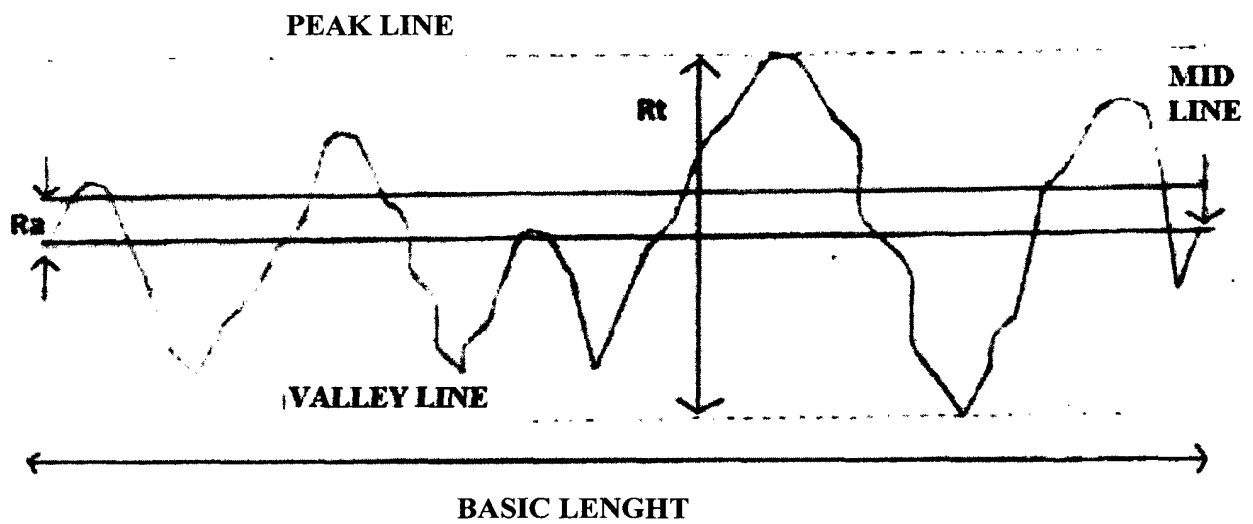


FIG. 3B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5057108 A [0004]
- US 5531874 A [0005]