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(54) ANNEALING PROCESS OF A STAINLESS STEEL BAND

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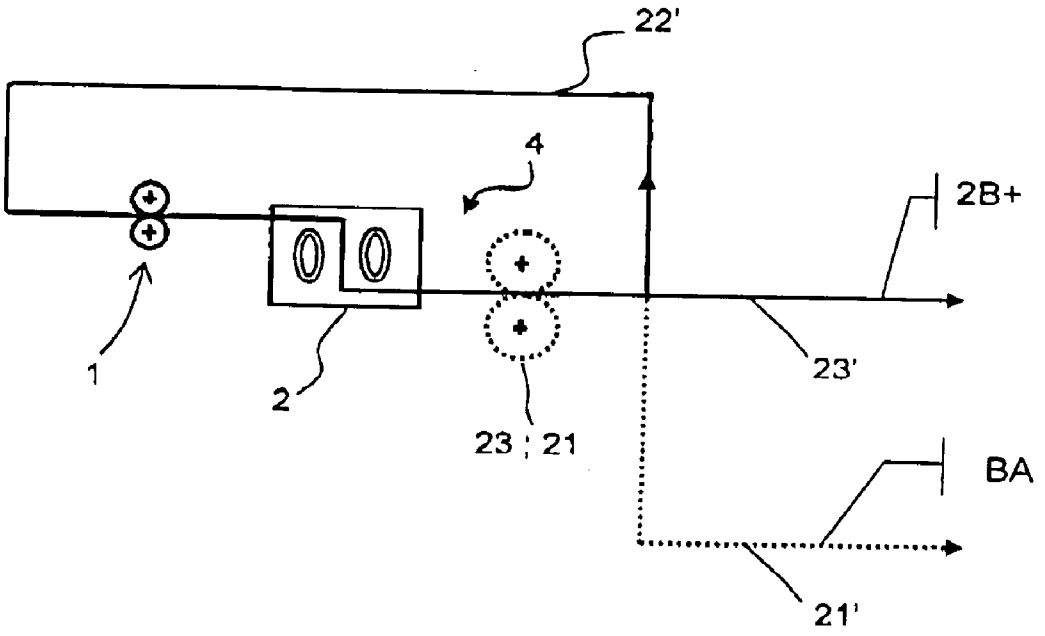
(57) **ABSTRACT**

The annealing process of a stainless steel band includes the following steps, in any order: Heating the stainless steel band under reducing atmosphere; Cooling the stainless steel band; and Printing on the surface a roughness onto said stainless steel band. The invention also relates to an annealing device for implementing the method. The annealing device includes a heating mechanism under reducing atmosphere for the stainless steel band, a cooling mechanism for the stainless steel band, and a printing mechanism, on the surface, for a roughness onto the stainless steel band.



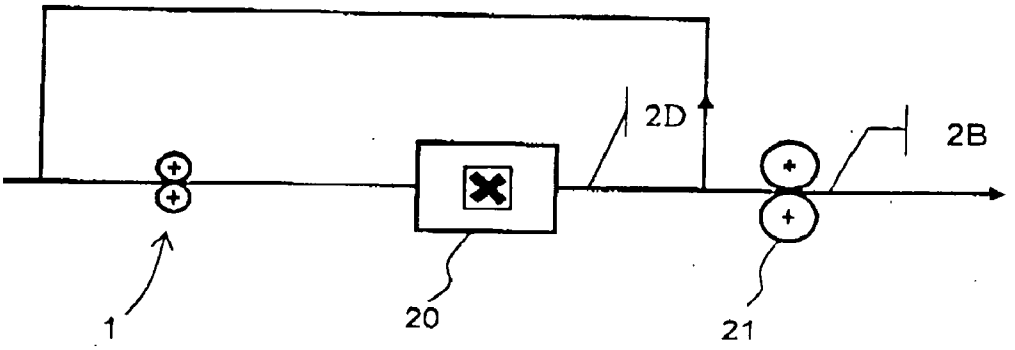


FIG. 1

PRIOR ART

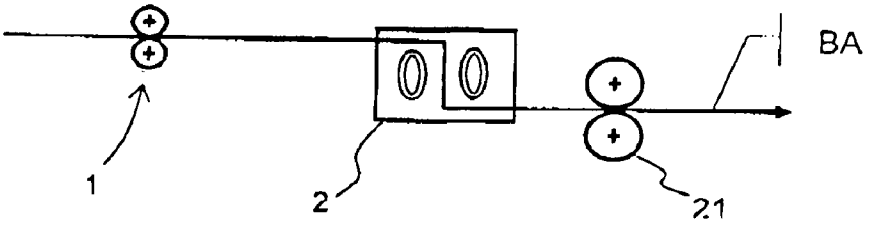


FIG. 2

PRIOR ART

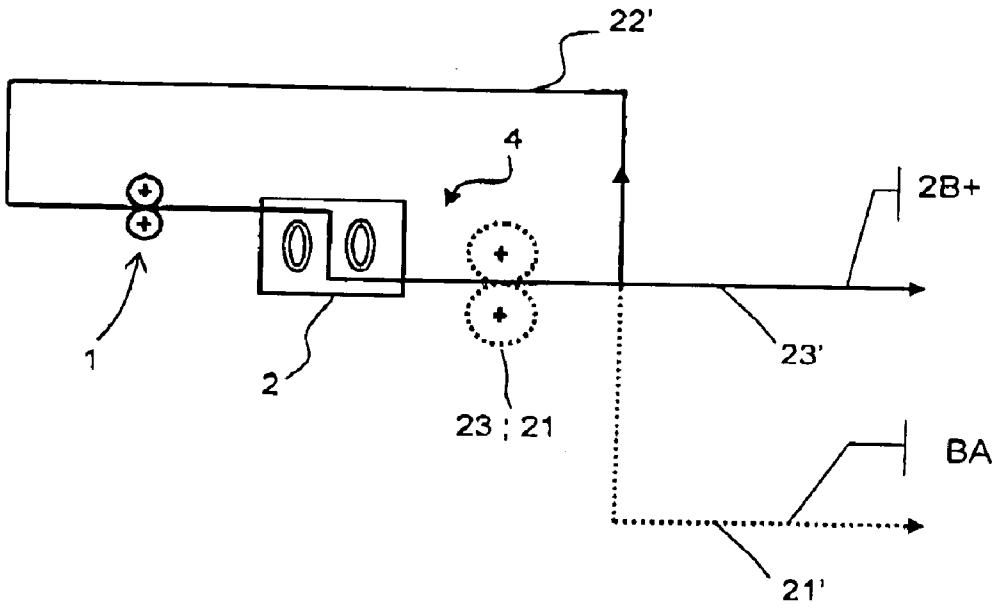


FIG. 3

ANNEALING PROCESS OF A STAINLESS STEEL BAND

RELATED U.S. APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

REFERENCE TO MICROFICHE APPENDIX

[0003] Not applicable.

FIELD OF THE INVENTION

[0004] This invention relates to an annealing process of a stainless steel band.

BACKGROUND OF THE INVENTION

[0005] In the metal industry, it is known to make sheet reels while subjecting the metal to one or several cold rolling steps.

[0006] To do so, a sheet metal band runs on a determined pathway and is rolled between two cylinders for reducing the thickness thereof.

[0007] Consequently, the material hardens and loses its ductility further to the high loads imparted.

[0008] To be able to rework the metal band, annealing methods are known which consist in bringing the material back to a stable state, whereby the material is then softened and the ductility thereof is restored.

[0009] Then two annealing types may be singled out, i.e. so-called intermediate annealing and so-called final annealing.

[0010] To obtain the requested sheet metal thickness, it is often necessary to subject the stainless steel metal band to several successive cold rolling steps. In such a case, the stainless steel band circulates along a closed loop to pass several times between the rolling cylinders.

[0011] Nevertheless, after each passing sequence between said cylinders, the metal band should be softened to conduct a new sequence: it is intermediate annealing.

[0012] After exposure to a last cold rolling step, the sheet metal or stainless metal band should be softened and exhibit faultless finish to be sellable: it is final annealing.

[0013] It should be understood that the finish quality to be obtained after the intermediate annealing process is not necessarily the same as the final annealing. A suitable method is thus known: annealing and etching by chemical agent.

[0014] Final annealing may be either glossy annealing, i.e. said annealing-etching.

[0015] Glossy annealing is conducted in a closed chamber furnace and under non-oxidizing controlled atmosphere which is composed of a mixture H_2/N_2 with a maximum proportion of N_2 at 25%, possibly even pure H_2.

[0016] It is realized traditionally using an electric resistor furnace, a gas-operated muffle furnace, or still, a hydride furnace combining both previous technologies.

[0017] Glossy annealing may also be realized by means of a transversal magnetic flux induction heating method, which enables to increase directly the temperature of the band.

[0018] Generally, the furnace is followed by at least a pair of cylinders whereof the enveloping wall is polished like a mirror, so-called "pass skin", capable of imparting superficial rolling to the band.

[0019] Such glossy annealing process provides good results and enables to obtain sheet metals whereof the finish is of quality, defined BA according to the International metal qualification.

[0020] Nevertheless, this finish quality exhibits too small roughness, which does not enable, subsequently, easy stamping of said sheet metals. Indeed, too smooth a surface is ill-suited for stamping.

[0021] In such a case, it is known for treating the steel band by the annealing-etching process which enables to obtain sufficient surface roughness for easier stamping.

[0022] Annealing is then conducted in an open chamber furnace. The oxygen content is controlled between 3 and 6% according to the steel grade. Because of the oxidizing atmosphere, a chemical etching treatment is necessary for removing the oxide layer, still called scale.

[0023] This chemical treatment implies the implementation of different chemicals in relation to the grade of the steel treated, generating effluents which may be in gaseous or liquid state.

[0024] Examples of chemical substances known may be:

[0025] sodium sulphate used as an electrolysis bath for AISI 300 and AISI 400, nevertheless. this solution generates Cr^{6+};

[0026] nitric acid (HNO_3) for passivation of AISI 400, nevertheless the reaction generates nitrates;

[0027] a mixture of acids composed of hydrofluoric acid (HF) and nitric acid (HNO_3); nevertheless, this reaction generates NO_x fumes (yellow in color), nitrates and fluorides.

[0028] At the end of this etching step, the finish quality is so-called 2D according to the International metal qualification. The sheet metal band may then pass between two polished mirror cylinders for obtained small roughness while subjecting it to very small elongation.

[0029] After this step, the finish quality is so-called 2B. Nevertheless, it should be understood the chemicals necessary to the etching, as well as the energy for using them, notably for heating chemical baths and electrolysis, as well as the dispositions to be taken for de-pollution represent significant running costs.

[0030] It should be noted that the known annealing and etching process by chemical agents has a production capacity ranging generally between 180,000 tons per annum and 230,000 tons per annum. Glossy annealing with traditional

furnace, for its own part, has smaller production capacity ranging between 60,000 tons per annum and 100,000 tons per annum.

BRIEF SUMMARY OF THE INVENTION

[0031] The purpose of this invention is to provide a method and an annealing device which remedy the aforementioned shortcomings, and notably breaking free from using chemical agents.

[0032] Another purpose of the invention is to provide a final annealing process of stainless steel bands, equivalent to qualities 2D and 2B, authorizing later on the stamping operations.

[0033] Other aims and advantages of this invention will appear in the following description, given solely by way of example and without limitation thereto.

[0034] The invention relates first of all to an annealing process of a stainless steel band, after exposure to at least one first rolling step, wherein at least the following steps are conducted, notably successively:

[0035] heating under reducing atmosphere said stainless steel band,

[0036] cooling said stainless steel band,

[0037] printing on the surface a roughness onto said stainless steel band.

[0038] The invention also relates to an annealing device for implementing the method comprising:

[0039] means for heating under reduced atmosphere said stainless steel band,

[0040] means for cooling said stainless steel band,

[0041] means for printing on the surface a roughness onto said stainless steel band.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0042] The invention will be understood better when reading the description, accompanied by the appended drawings.

[0043] **FIG. 1** is a schematic view of an illustration of a cold rolling method comprising notably an annealing and etching step by chemical agent of the previous art.

[0044] **FIG. 2** is a schematic view of an illustration of a cold rolling method comprising a final glossy annealing process of the previous art.

[0045] **FIG. 3** is a schematic view of an illustration of a cold rolling method comprising an annealing process according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0046] **FIG. 1** illustrates a cold rolling method **1**, comprising an annealing process of the previous art, and comprises a first annealing and chemical agent etching step **20**.

[0047] As illustrated, the quality of the stainless steel band upon completion of this step is called 2D according to the International metal qualification.

[0048] The stainless steel band is then subjected to a superficial rolling step by means in particular of polished mirror cylinders **21**. The quality of the stainless steel band at the outlet of this step is called 2B according to the International metal qualification.

[0049] The annealing process **20**, formed of the annealing and etching step, may constitute an intermediate annealing process. Indeed, the metal band may follow a closed loop and undergo several passages through the rolling cylinders until the requested thickness of the band is obtained.

[0050] **FIG. 2** illustrates schematically a cold rolling method comprising final annealing step, of known glossy annealing type of the previous art. It should be noted that in the glossy annealing, no chemical treatment is necessary. Advantageously, the dew point in each glossy annealing furnace should be as low as possible.

[0051] Nowadays, three technologies are available for glossy annealing furnaces, all exhibiting a vertical design:

[0052] the brick furnace heated by means of electric resistors: it is an older design with small flexibility and high dew point. The capacity of this furnace reaches maximum 15 tons per hour,

[0053] the gas-heated muffle type furnaces: they are the most reliable furnaces. Nevertheless, their capacity is limited to 10 tons per hour by reason of the length of their muffle limited to 26-27 meters,

[0054] the mixed fours: it is a complex combination of both previous designs authorizing a maximum capacity of 12 to 13 tons per hour.

[0055] Transversal magnetic flux induction heating furnaces are also known. The main advantages of induction heating lies in their high electric throughput, and high surface power enabling to reach, as quickly as possible, the right temperature in said band.

[0056] According to the invention, the principle of glossy annealing is suited to a method enabling to provide a product equivalent to that obtained in the annealing etching by chemical agent.

[0057] The invention relates therefore to an annealing process **4** of a stainless steel band, after prior exposure to a first rolling step wherein at least the following steps are performed, regardless of the order:

[0058] heating said stainless steel band under reducing atmosphere,

[0059] printing on the surface a roughness onto said stainless steel band.

[0060] According to an embodiment, the stainless steel band is cooled efficiently after being heated.

[0061] According to an embodiment, the following steps are carried out. in particular successively:

[0062] heating said stainless steel band under reducing atmosphere,

[0063] cooling said stainless steel band, in particular under reducing atmosphere,

[0064] printing on the surface a roughness onto said stainless steel band.

[0065] The reducing atmosphere may in particular be formed of a mixture H_2/N_2 containing a maximum proportion of N_2 of 25% or, possibly, pure H_2.

[0066] According to diverse variations, heating by means of a gas-operating furnace, by means of electric resistors or still by the heating techniques by longitudinal or transversal magnetic flux induction.

[0067] The implantation of the heating sections of the band will be vertical.

[0068] Advantageously, said steel band is cooled by circulating a reducing gas.

[0069] The method will enable to reach significant production capacities above 200,000 tons/year. Thus, heating and rapid cooling will be implemented, with heating powers of the order of the Mega W/m2 and cooling speeds of the order of 100° C./s.

[0070] Advantageously, a roughness by superficial rolling is printed causing very small elongation of the stainless steel band.

[0071] According to an embodiment, sufficient roughness is printed by superficial rolling for easier stamping of the stainless steel band.

[0072] According to an embodiment, a roughness equivalent to the roughness of a stainless steel of quality 2D defined by the International metal qualification is printed. This quality of stainless steel, may in particular be obtained, with the annealing methods of the previous art by an annealing and etching process.

[0073] According to another embodiment, a roughness equivalent to the roughness of a stainless steel of quality 2B defined by the International metal qualification is printed. This steel quality may in particular be obtained, with the annealing methods of the previous art by an annealing-etching step to which a superficial rolling step is added by means of polished mirror cylinders.

[0074] The invention also relates to an annealing device for implementing the method, the device comprising:

[0075] means **2** for heating under reducing atmosphere said stainless steel band,

[0076] means **2** for cooling said stainless steel band,

[0077] means **23** for printing on the surface a roughness onto said stainless steel band.

[0078] The means for printing on the surface a roughness onto said stainless steel band are formed by a rolling device comprising at least one pair of cylinders with a rough surface.

[0079] According to an embodiment, the heating means are formed by a vertical furnace **2** exhibiting induction heating means.

[0080] According to an embodiment, the vertical furnace **2** comprises the following elements in all or in part:

[0081] inlet sealing means,

[0082] means for controlling and measuring the tension of the stainless steel band,

[0083] actuating means for regulating the tension of the stainless steel band,

[0084] transversal magnetic flux induction heating means,

[0085] cooling means,

[0086] outlet sealing means.

[0087] The induction heating means may be constituted advantageously of two reels parallel to said steel band and capable of generating a magnetic field transversal to said band. They enable to bring the stainless steel band to a temperature to 1,200° C.

[0088] The cooling means enable to accelerate the temperature drop of said band.

[0089] These cooling means may in particular take on the form of gas circulation means.

[0090] Advantageously, the circulating cooling gas is non-oxidizing.

[0091] Advantageously, the cooling means enable a temperature loss at a speed equal to or greater than 100° C./s.

[0092] According to an embodiment, the device may exhibit moreover means for measuring the roughness of the stainless steel band and/or actuating means capable of controlling the pressure of the cylinders with a rough surface.

[0093] As illustrated on **FIG. 3**, a rolling plant comprises cold rolling cylinders **1** and an annealing device according to the invention, composed of a transversal induction vertical furnace **2** and of a superficial rolling device comprising at least one pair of cylinders **23** with a rough surface.

[0094] Advantageously, the annealing device is situated downstream of said rolling cylinders **1**. The stainless steel band may also travel through a closed loop **22'** enabling several passage sequences of said band between the rolling cylinders **1**. After passing between the cylinders with a rough surface **23**, the quality of said stainless steel bond is called $2B^+$(of a quality equivalent to the quality 2B obtained traditionally with an annealing etching process).

[0095] The annealing process will find a particular application in a rolling process such as an intermediate annealing process intended for softening the material and restoring the ductility of said stainless steel band.

[0096] The annealing process will find another application in a rolling process such as a final annealing process. It will be in particular used such as a final annealing process for stainless steel bands intended to be stamped. The stainless steels regarded by this annealing process will be in particular of two types, i.e. AISI 300 or AISI 400.

[0097] The main difference between a stainless steel AISI 300 of quality 2B obtained by tho traditional annealing and etching process and the stainless steel AISI 300 of quality $2B^+$will be its milky white appearance in the case of the 2B which will be non-polished grey in the case of the $2B^+$.

[0098] The annealing process according to the invention enables to have significant temperature rising speed and high energetic throughput.

[0099] The method according to the invention enables to avoid polluting chemical agents. Therefore, this annealing process may be advantageous from an ecological viewpoint.

[0100] Advantageously, a given rolling plant may be modular and might be fitted, according to the use with rough cylinders or with polished mirror cylinders. Thus, the cylinders will be dismountable to be changed according to the use.

[0101] Thus, as illustrated on **FIG. 3**, the plant is fitted with a superficial rolling device comprising at least a pair of cylinders **23** with a rough surface which enables at output **23'** to obtain a stainless steel band of quality $2B^+$.

[0102] It is desirable to obtain at output **21'**, a steel quality BA, the cylinders with a rough surface **23** may be replaced with polished mirror cylinders **21**.

[0103] Besides, in the case when the annealing is only intermediate and the steel band follows a closed loop **22'** to be subjected to a new rolling sequence **1**, the steel band may not undergo any superficial rolling and in particular the cylinders with a rough surface **23** or still the polished mirror cylinders **21** may be simply open.

[0104] Obviously, other embodiments, understandable to the man of the art, could have been contemplated without departing from the framework of the invention.

I claim:

1. An annealing process of a stainless steel band, after exposure to at least one first rolling step, comprising the following steps:

heating under reducing atmosphere said stainless steel band,

cooling said stainless steel band, and

printing on a surface thereof a roughness onto said stainless steel band.

2. A process according to claim 1, wherein heating is performed by a gas-operating furnace, electric resistors or longitudinal or transversal magnetic flux induction.

3. A process according to claim 1, wherein said stainless steel band is cooled by circulating a reducing gas.

4. An annealing process of a stainless steel band according to claim 1, wherein sufficient roughness is printed by superficial rolling for easier stamping of the stainless steel band.

5. An annealing process of a stainless steel band according to claim 1 wherein a roughness equivalent to roughness of a stainless steel of quality 2B or 2D defined by the International metal qualification is printed.

6. An annealing device for implementing the method according to claim 1 comprising:

means for heating under reducing atmosphere said stainless steel band,

means for cooling said stainless steel band, and

means for printing on the surface a roughness onto said stainless steel band.

7. An annealing device, according to claim 6, wherein the means for printing on the surface a roughness onto said steel band is a rolling device comprising at least a pair of cylinders with a rough surface.

8. An annealing device according to claim 6, wherein the heating means is comprised of a vertical furnace exhibiting induction heating means.

9. An annealing device according to claim 6, wherein the means for cooling the band is comprised of a means for circulating a cooling gas.

10. An annealing device according to claim 8, wherein the vertical furnace is comprised of:

inlet sealing means,

means for controlling and measuring tension of the stainless steel band,

actuating means for regulating the tension of the stainless steel band,

transversal magnetic flux induction heating means,

cooling means, and

outlet sealing means.

11. An annealing device according to claim 6, further comprising:

means for measuring the roughness of the stainless steel band, and

actuating means controlling printing pressure of the cylinders with a rough surface.

12. A use of the annealing process according to claim 1 in a rolling process such as an intermediate annealing process intended for softening the material and restoring the ductility of said stainless steel band.

13. A use of the annealing process according to claim 1 in a rolling process such as a final annealing process.

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