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[54] **DESCALING APPARATUS FOR STEEL**
3 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** ..... **266/3 R,** 134/2, 134/15, 134/29, 134/64

[51] **Int. Cl.** **C21d 9/62**

[50] **Field of Search** ..... 134/2, 15, 3, 4, 29; 266/3, 3 P

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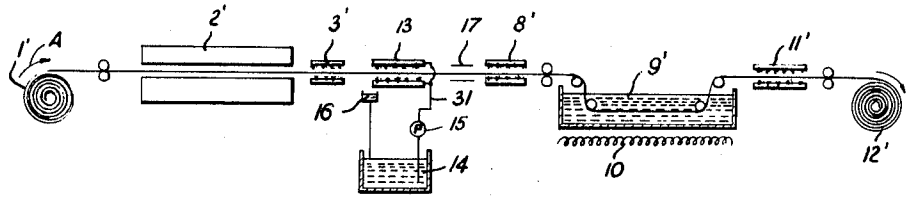
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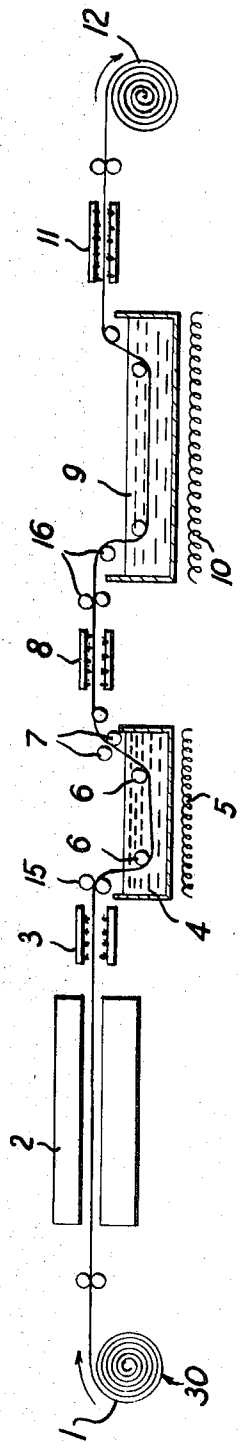
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ABSTRACT: Steel is descaled by applying a thin layer of alkali metal hydroxide to the surface to be descaled and subsequently heating the coated steel to a temperature above the melting point of the alkali metal hydroxide in an oxygen-containing atmosphere.

According to an alternative embodiment, an alkali metal salt solution is sprayed onto hot steel emanating from an annealing zone, whereby the water of the solution evaporates substantially immediately and the alkali metal salt melts. Apparatus for the alternative embodiment is also disclosed.





(PRIOR ART)
FIG. 1

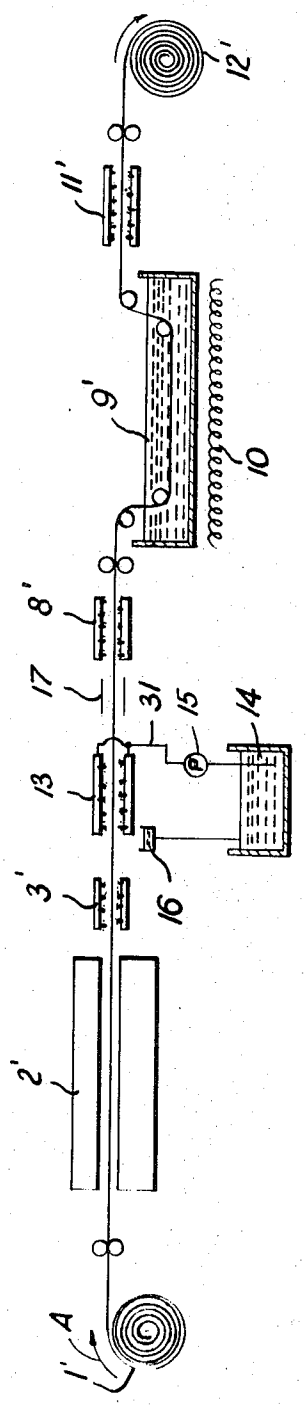


FIG. 2

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DESCALING APPARATUS FOR STEEL

CROSS-REFERENCE TO PRIOR APPLICATION

This is a continuation-in-part of our copending application Ser. No. 818,110 filed Apr. 21, 1969, now abandoned.

SUMMARY OF THE INVENTION

This invention generally relates to the descaling of steel and is particularly directed to an improved method of descaling chromium-containing or stainless steels, such as chromium-containing special or alloy steels, by treatment with alkali metal hydroxides or salts. The inventive procedure is particularly suitable for use in continuous processes wherein steel in band, strip, or web formation travels through the plant and is descaled during its travel.

In recent years, the tendency has been to descale steels by a method which is generally referred to as "fused alkali treatment" according to which the undesired oxide coatings (hereinafter referred to as "scale" on the exterior surfaces which are formed inter alia during the rolling or annealing procedures are removed for the purpose of improving the steel surface and with a view of meeting the ever increasing requirements which are placed on steel used in modern technology.

An important consideration in descaling procedures is simplicity of operation and the speed of the scale removal. Prior art processes are lacking in this respect since the descaling reaction is relatively time consuming and requires elaborate equipment.

In the prior art, fused alkali treatment, the scale is removed without affecting the steel body or mother metal proper and the resulting steel product has generally satisfactory characteristics. The descaling treatment is usually followed by an aftertreatment wherein the steel body is immersed for a short period of time in an acid which further improves the surface characteristics.

According to this known fused alkali treatment, the steel body from which the scale is to be removed is immersed in a molten bath of mixed alkali metal hydroxides or salts consisting primarily of caustic soda which is maintained in the fused or molten state at a temperature of about 400° to 500° C. However, if the steel is merely immersed in the fused or molten caustic soda bath, insufficient descaling takes place. For this reason, it is necessary, according to this prior art method, to enrich the caustic soda bath with additives. According to the type of additives, which are added to the caustic soda, such prior art descaling procedures are referred to as the "sodium hydride method" or the "Hooker method". In the sodium hydride method, the steel workpiece is immersed for a certain period of time in the caustic soda bath which is maintained at about 370° C., while 1.5 to 2 percent of sodium hydride (NaH) are added as a reducing agent to the caustic soda. In this procedure, the scale component $FeO{\cdot}Cr_2O_3$ is converted into a readily acid-soluble iron or chromium oxide as indicated in the following equation (1) and is then subjected to washing with water or immersion in sulfuric acid, nitric acid or hydrofluoric acid for a short period of time to complete the descaling procedure.

$$Fe0{\cdot}Cr_20_3+2NaH=Fe+2CrO+2Na0H \quad (1)$$

In respect to the Hooker method, as referred to above, the workpiece, by contrast, is immersed in a caustic soda bath maintained at a temperature of 400 to 500° C., with the addition of 5 to 40 percent of sodium nitrate. The sodium nitrate acts as an oxidizing agent, whereby the scale component is converted into soluble salts as shown in equation (2). The soluble salts are dissolved and the steel is thereafter subjected to an aftertreatment which may consist of washing with an acid to complete the descaling procedure.

$$2(Fe0{\cdot}Cr_20_3)+14Na0H+7NaN0_3=2Na_3Fe0_3+4Na_2Cr0_4+7NaN0_{2b} \quad (2)$$

In more recent times, a further method has been proposed according to which the descaling is carried out while oxygen or air is bubbled through the molten bath of alkali metal hydroxide, the alkali metal hydroxide being caustic soda. According to a modification of this latter procedure, sodium nitrate may be added to facilitate the descaling operation.

In all these prior art methods in which caustic soda or a different alkali metal hydroxide or salt is used as the principal descaling agent, the alkali metal compound is always employed in the form of a molten bath and the workpiece or steel is immersed in the molten system. Such procedure is disadvantageous from a practical point of view, since it is cumbersome to prepare the molten alkali metal compound bath. This requires considerable expenditure in equipment and installation. Moreover, handling and operation is troublesome and connected with considerable hazards to the operator.

Accordingly, it is a principal object of the present invention to provide an alkali metal compound descaling procedure which avoids the disadvantages and drawbacks of the prior art and wherein the steel can be effectively descaled without first having to prepare a molten bath of alkali metal compounds.

Generally, it is an object of this invention to improve on steel-descaling procedures as presently practiced.

Briefly, and in accordance with one embodiment of the invention, chromium-containing or stainless steels, such as chromium alloy steels are descaled by first wetting the surface of the steel from which the scale is to be removed with an aqueous solution of an alkali metal hydroxide, such as caustic soda or caustic potash, or with an aqueous solution of an alkali metal salt which is capable of forming caustic soda or caustic potash by hydrolysis. Such alkali metal salts are, for example, sodium silicate, potassium silicate, sodium carbonate and potassium carbonate. The wetting of the steel with the alkali metal compound containing solution is performed for the purpose of forming a thin layer of the respective solution thereon, whereafter the steel, with the alkali metal compound on its surface, is subjected to a gaseous phase oxidation reaction in air or another oxygen-containing atmosphere. This oxidation reaction is performed for a short period of time and at a temperature at which the thin alkali metal compound layer on the steel is in the molten state.

It has been ascertained that in accordance with the invention, effective descaling can be achieved in this manner without adding any reducing agent or oxidizing agent to the system. In other words, the descaling takes place by the use of the alkali metal compound alone although caustic soda per se generally has no descaling effect. However, the inventive procedure may be facilitated by adding an oxidizing agent such as, for example, sodium nitrate in which event the descaling takes place at a lower temperature and more rapidly than in the prior art alkali salt immersion procedure according to the Hooker method. This is so because the oxidation reaction then is synergistic, to wit: the oxidizing agent acts from the inside and the oxygen in the ambient atmosphere acts from the outside.

Without wanting to be limited to any theories advanced, it is believed that the descaling, in accordance with the present invention, proceeds according to equation 3 by utilizing a gaseous phase oxidation in the presence of air or an oxygen-containing atmosphere.

$$2(Fe0{\cdot}Cr_20_3)+14NaOH+3½0_2=2Na_3Fe0_3+4Na_2Cr04+7H_20 \quad (3)$$

In the inventive procedure, the oxidation reaction is effected in the presence of a molten thin film of alkali metal hydroxide which is applied to the surface to be descaled while, by contrast, in the prior art methods, the descaling is effected by immersion of the steel body into a molten alkali metal hydroxide bath in the presence of descaling-promoting additives. A distinction should thus be made between the presence of a thin film of alkali metal hydroxide which is applied to the steel surface and a procedure wherein the steel body is immersed in a bath of such alkali metal hydroxide, the former procedure, of course, being much simpler, less expensive and less hazardous.

The alkali metal compound may be applied in the form of a thin film to the steel body by various methods. For example, an aqueous alkali metal compound solution of suitable con-

centration may be sprayed onto the steel body or the steel body may be dipped or immersed into an aqueous bath of the alkali metal compound of suitable concentration so that the surface of the steel body is wetted with a desired amount of the solution.

According to a second embodiment of the invention, the descaling may be carried out while the steel is still hot from preceding treatments. For example, if a steel strip moves from the rolling or annealing stage in hot condition through the plant, the hot steel may be sprayed with a descaling solution, whereby the water in the solution rapidly evaporates, leaving a thin film of descaling alkali metal compound on the steel body. This thin film, due to the high temperature of the steel body, thus melts and, provided a sufficient amount of oxygen is present, effects the descaling. This second embodiment of the invention is thus particularly suitably applied if the descaling is effected in sequence after the rolling or drawing into wire shape and forms part of the processing steps usually carried out on the AP line.

According to this second embodiment of the invention, the stainless steel to be descaled and emanating from a steel heat treatment, such as annealing, is advantageously first cooled to a suitable temperature which, however, is still higher than the melting temperature of the respective alkali metal salt, whereafter the steel surface is wetted, for example, sprayed, with the aqueous solution of alkali metal hydroxide or alkali metal salt. The water in the aqueous solution thus flashes off and a thin layer of alkali metal compound remains on the steel body which melts and causes the descaling in the presence of oxygen. As in the first embodiment, alkali metal hydroxide, such as caustic soda or caustic potash, may be used for the inventive purposes. However, alkali metal salt such as alkali metal orthosilicate, alkali metal nitrite, alkali metal nitrate and alkali metal chlorate or alkali metal carbonate may also be used for this purpose. It is important, however, that the resulting alkali metal compound film in the molten stage is subjected for a selected period of time to air or the like oxygen-containing atmosphere, to make sure that the oxidation reaction takes place in the gaseous phase. This embodiment of the invention has the advantage that no additional heating of the steel body is required but the heat retained by the steel from the preceding treatment is utilized for the inventive purposes. As in the first embodiment, the last-mentioned procedure may be followed by water washing and washing in a slightly acidic pickling liquid such as an aqueous solution of sulfuric acid, nitric acid or hydrofluroic acid, so as to complete the descaling.

The descaling reaction precedes according to the same formula (3) as indicated above.

If an alkali metal salt such as, for example, sodium chlorate is used instead of alkali metal hydroxide, the alkali metal salt will be converted into alkali metal hydroxide due to prolysis under the evolvement of oxygen and chlorine as shown in the following equation (4). The reaction will then proceed as indicated in equation (5).

$$2NaClO_3+H_2O=2NaOH+2\tfrac{1}{2}O_2+Cl_2 \quad (4)$$

$$2(FeO\cdot Cr_2O_3)+14NaOh+3\tfrac{1}{2}O_2=2Na_{3FeO3}+4Na_2CrO_4+7H_2O \quad (5)$$

Therefore, if an alkali metal salt such as sodium chlorate is used, the decomposition of the chlorate supplies oxygen gas so that in many instances no additional oxygen or a lesser amount of oxygen need to be supplied to effect the descaling reaction.

The oxidation reaction may thus be carried out with satisfactory descaling effects either by heating the steel to a temperature higher than the melting point of the respective alkali metal compound after the alkali metal compound has been applied to the steel surface or by first heating to a temperature higher than the melting point of the alkali metal compound and then applying the alkali metal compound to the steel surface in any suitable manner.

The invention will now be described by several examples, it being understood however that these examples are given by way of illustration and not by way of limitation, and that many changes may be effected in the process conditions without affecting in any way the scope and spirit of the invention as recited in the appended claims.

EXAMPLE 1

A cold-rolled steel plate, SUS 27, of 0.8 mm. thickness was immersed for a short period of time in an aqueous solution of caustic soda of 50 percent concentration. The purpose of the immersion was to wet the surface of the steel plate with the solution. The wetted steel plate was thereafter inserted in a heating furnace, the latter being heated to a temperature of about 600° C. The steel plate was heated in the furnace for 40 seconds and until the surface temperature of the steel plate had reached a temperature higher than the melting point of caustic soda which is 328° C. In this example, the 40-second heating in the furnace resulted in a surface temperature of 400° C. The heat treatment resulted in the formation of sodium-iron and sodium-chromium salts pursuant to equation (3). The descaling procedure was completed by washing the plates in water. The thus-treated steel plate was then immersed in an aqueous solution containing 10 percent of nitric acid and 2 percent of hydrofluoric acid, the immersion being effected at normal room temperature for about 10 seconds. This latter procedure is in the nature of an aftertreatment to obtain a completely descaled metal surface of desirable luster.

EXAMPLE 2

A cold-rolled steel plate, SUS 24, of 0.8 mm. thickness was sprayed with an aqueous solution containing 5 percent by weight of caustic soda and 5 percent by weight of caustic potash, to wet the surface of the plate with the solution. The thus-treated plate was then charged to a high-frequency heating furnace where the plate was heated for 20 seconds and to a surface temperature higher than the melting point of the mixed alkali metal salt. The melting point of a mixture of caustic soda and caustic potash in the indicated proportion is about 200° C., and the 20-second treatment resulted in a surface temperature of 250° C. The oxidation reaction thus took place in the molten state of the alkali metal salt. After washing with water, the descaling was complete and an exposed clean metal surface was obtained. For aftertreatment purposes, the descaled steel plate was immersed in an aqueous sulfuric acid solution of 5 percent concentration for several seconds, whereby a metal surface of desirable luster was achieved.

EXAMPLE 3

The procedure described in example 2was repeated except that the caustic potash was replaced by sodium nitrate in the same amount. In order to heat the plate to a surface temperature of 250° C., a shorter heating time than in example 2 was sufficient. Thus heating for 10 seconds, instead of the 20 seconds of example 2, was sufficient to obtain the desired descaling effect.

EXAMPLE 4

A cold-rolled steel plate, AISI 309 of 1.2 mm. thickness was coated with an aqueous solution of 25 percent of caustic soda and 25 percent of sodium nitrate and the thus-coated sheet was inserted into a furnace heated to a temperature of 500° C. The plate was permitted to remain in the hot furnace for about 1.5 minutes which resulted in a surface temperature of the steel plate of 300° C., which is above the melting point of the caustic soda-sodium nitrate mixture. The oxidation reaction thus took place in the molten state of the salt layer. The descaling reaction which proceeded according to equation (3) was completed after washing with water. The thus-processed steel plate was then immersed in an aqueous solution containing 15 percent of nitric acid and 3 percent of hydrofluoric acid. The immersion of the steel plate in the mixed acid solution was effected for 15 minutes and at a temperature of 60° C. This immersion was in the nature of an aftertreatment to obtain a lustrous metal surface.

EXAMPLE 5

A cold-rolled steel plate, SUS 27, of 0.8 mm. thickness was immersed in a 50 percent aqueous solution of sodium orthosilicate. The immersion was effected for a short period of time to wet the surface of the plate. The wet plate was then charged to a furnace which latter was heated to a temperature of 600° C. The plate was subjected to heating in the furnace for 40 seconds and the oxidation reaction took place in the molten state of the layer. The thus-treated plate was then washed with water and, for aftertreating purposes, was immersed in a mixed aqueous acid solution containing 15 percent of nitric acid and 3 percent of hydrofluoric acid. The immersion of the plate in the aqueous acidic solution was effected at room temperature for 10 seconds, whereby a fully descaled metal surface of great luster was obtained.

EXAMPLE 6

A cold-rolled steel plate, SUS 24, of 0.8 mm. thickness was coated with an aqueous solution containing 25 percent of sodium carbonate and 25 percent of potassium carbonate. The thus-treated plate was then charged to a furnace which was heated at a temperature of 800° C. The heating of the plate in the furnace was effected for 1 minute and the oxidation took place in the molten state of the salt. After washing with water, the plate was immersed in an aqueous solution of mixed acid containing 15 percent of nitric acid and 3 percent of hydrofluoric acid. The immersion of the plate in the acidic solution was effected for 15 seconds and at a bath temperature of 60° C. This immersion is in the nature of an aftertreatment and results in a descaled metal surface of desirable luster and gloss characteristics.

As will be appreciated from the above, chromium-containing steel is descaled in accordance with the inventive procedure by applying to the surface of the steel an aqueous solution of at least one alkali metal hydroxide such as caustic soda and/or caustic potash or of alkali metal salts capable of forming the corresponding hydroxide under the conditions of the process. Such alkali salts are thus, for example, sodium silicate, potassium silicate, sodium carbonate and potassium carbonate. If necessary, the solution may also contain an oxidizing agent such as sodium nitrate, potassium nitrate or potassium chlorate. The application of the solution is effected in any suitable manner such as, for example, by dipping the steel in the solution, by spraying or the like coating procedures, the purpose of the application being to wet the surface of the steel to be descaled with the respective solution. The thus-wetted steel is then subjected to a heat treatment in an oxygen-containing atmosphere such as prevails, for example, in a furnace, which results in drying of the alkali metal hydroxide-containing surface layer and the melting thereof. The thin layer of alkali metal hydroxide, in the molten state, reacts in the oxygen-containing atmosphere with the scale to convert the scale, which is essentially insoluble in acid, into a water or acid-soluble alkali metal salt. The heat treatment is effected for predetermined periods which are very short since the reaction is very rapid. The steel is then washed or rinsed and, if necessary or desired, immersed for aftertreatment purposes in a suitable inorganic acid such as, for example, nitric acid, hydrochloric acid or sulfuric acid, whereby a lustrous or glossy surface is obtained.

The advantages and merits of the present procedure may be briefly summarized as follows, the summary considering particularly the prior art descaling methods which involve immersion of the steel in fused alkali metal hydroxide baths;

1. It is not necessary to add an oxidizing agent or reducing agent to the descaling solution.
2. The descaling reaction proceeds very rapidly, because the oxidation is carried out in a thin-film state of the alkali metal hydroxide.
3. The apparatus requirements are very small since the steel surface to be descaled is merely wetted by spraying, coating or the like and an immersion tank is not necessary.
4. The handling of the descaling solution is very simple because the alkali metal compound is used in the form of an aqueous solution while in the prior art procedures, the alkali metal compound is used in a fused state which requires considerable expenditure for the purpose of producing the fused alkali metal compounds.
5. Losses or waste of alkali metal compounds are considerably reduced by varying the concentration of the alkali metal compound according to the specific requirements. Thus, depending on the type of scale to be removed, the concentration of alkali metal compounds used may vary. Variations in the treatment solution can be easily accomplished by adjusting the water content therein in dependence on the particular scale to be removed.
6. In respect to the heat treatment, after wetting of the steel surface with the aqueous alkali metal compound, it is usually sufficient if the temperature of the furnace or the like heating space is maintained only slightly above the melting point of the respective alkali metal hydroxide. Thus, if the temperature is maintained about 20° above the respective melting point, excellent results are obtained. However, in some instances, particularly in respect to certain combinations of alkali metal compounds, the temperature of the heating space should be considerably higher than the melting point of the combined alkali metal compounds. Generally, however, it is not necessary to exceed a temperature which is more than 250° above the melting point of the alkali metal compound. Such temperature is still lower than that usually required in the prior art procedures. It is also of particular advantage that the heat treatment is very short.
7. Any heating method can be used for performing the heat treatment, such as for example, electric heating, electric induction heating or electric resistance heating.
8. The inventive procedure is readily applicable to continuous operation wherein a strip, band, or web of steel, for example, stainless steel or other alloyed steels move linearly through the plant. The inventive procedure can, of course, be effected on the steel while still hot after the annealing treatment and the oxidation reaction may then take place without requiring any reheating of the steel. This, of course, considerably simplifies the descaling procedure and reduces the costs.
9. The so-called iron rolls which are used in alkali immersion tanks are eliminated, so that surface scratching, which presents a considerable problem in prior art procedures, is completely eliminated.
10. The descaling speed is considerably higher than in prior art procedures, because the surface to be descaled is merely wetted with the aqueous alkali metal compound solution and is then heated for a short period only. If the steel is hot, at the time of the start of the procedure, the water in the alkali metal compound solution, when applied to the hot steel will immediately evaporate, resulting in a thin layer or coat of alkali metal compound, which furthermore facilitates the reaction time. As a matter of fact, the concentrated aqueous alkali metal compound solution will already react during the evaporation of the water, thus further shortening the reaction period. Due to diffusion of oxygen in the air, the oxidation reaction proceeds without difficulty.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its uses, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated a preferred embodiment of the invention.

IN THE DRAWINGS

FIG. 1 is a diagrammatical representation of a prior art annealing and pickling plant for producing stainless steel, while

FIG. 2 is a diagrammatical showing of one embodiment for an annealing and pickling plant suitable for carrying out the second embodiment of the present invention.

Referring now to the prior art showing of FIG. 1, a non-processed stainless steel strip or web 1 is moved from a supply roll 30 through the plant in the direction of arrow A. The steel strip 1 is annealed and pickled in a continuous manner, to be explained hereinafter, to yield a finished stainless steel strip which is wound to form roll 12. The installation indicated in FIG. 1 is generally referred to in the art as an AP line.

Reference numeral 2 indicates an annealing furnace in which the traveling strip 1 is heated to a temperature of about 1,100° C. The strip 1, after having passed through the furnace 2, is cooled in the device 3, device 3 indicating a so-called "fog quench" wherein water is sprayed onto the hot strip to form a foglike mist which cools the steel strip to a temperature of about 200–300° C., which is lower than the melting point of alkali metal hydroxide.

The strip, after passing through guide rollers 15, enters then the prior art salt bath 4, the salt bath consisting of a mixture of caustic soda and 5–40 percent by weight of sodium nitrate. The salt bath is kept at about 40014 500° C., and for this purpose suitable heating means are provided as schematically indicated by reference numeral 5. The passage of the steel strip 1 through the salt bath 4 is facilitated and guided by tension rolls 6. When the strip moves above the level of the salt bath 4 at the exit side of the latter, it passes through the nip of a roller mechanism 7, which is a throttle roll mechanism, for the purpose of removing excess salt which adhered to the surface of the steel strip. Such rolls are customarily made of iron and have a tendency to scratch the strip. The strip then enters the washing means 8 in which water is sprayed onto the strip surfaces to remove any remaining salt particles. By means of suitable guide rollers 16, the strip is then conveyed into the pickling tank 9 containing customarily an aqueous solution of nitric acid and hydrofluoric acid. An usual composition is 15 percent of nitric acid and 3 percent of hydrofluoric acid. The pickling tank solution is customarily heated to about 60° C., and for this purpose a suitable heating means is provided as diagrammatically indicated by reference numeral 10. The descaling is completed, while the strip passes through the pickling tank 9. The steel strip, after having traveled through the pickling tank 9, enters a further washing means 11 in which warm water is sprayed onto the strip surfaces to remove any adhering nitric and/or hydrofluoric acid. The strip is then dried and wound as indicated by reference numeral 12.

It will be appreciated that this prior art procedure is cumbersome and time consuming. Particularly, the provision of a salt bath, as indicated in the drawings by reference numeral 4, is disadvantageous. This is so because it is difficult to handle the required high temperatures of the salt bath. Moreover, the steel product tends to be scratched due to the use of the iron rolls 7. Furthermore, the salt bath has to be heated even during discontinuance of the operation, since otherwise the salt solidifies.

Referring now to the inventive construction as illustrated in FIG. 2, it will be noted that the steel strip 1' first passes in conventional manner through the annealing furnace 2' in the same manner as indicated in the construction of FIG. 1. However, after the steel strip has exited from the annealing furnace in which it has obtained a temperature of approximately 1,100° C., the steel strip is not cooled down to the 200–300° C. ranges as in the FIG. 1 embodiment, but is rather cooled to a temperature of about 600–900° C., only which is above the melting point of alkali metal hydroxide or salt. This cooling is effected by the cooling means 3' in which air is blown onto the hot steel strip. The cooling means 3' thus constitutes a forced-air cooler. The steel strip which thus has now a temperature of about between 600–900° C. is then sprayed with the alkali metal compound solution. This is accomplished by means of the spray means 13 which comprises a plurality of nozzles to which the solution is forced. The alkali metal compound spray is an aqueous solution of alkali metal hydroxide or alkali metal salt as indicated above. For example, excellent results are obtained with a solution containing 10 percent by weight of caustic soda. In order to insure the continuity of the process, the solution is provided in a storage vessel 14 and is forced from this vessel by means of a pump 15 which is connected in the line 31 connecting the storage vessel 14 with the spray nozzle mechanism 13. Excess aqueous alkali metal compound solution is returned to the storage vessel, via a liquid pool 16 which collects liquid flowing from the spray device 13. Due to the high temperature of the steel strip the water of the solution which is sprayed onto the steel surfaces flashes off substantially immediately. The temperature of the strip is also sufficiently high so that the remaining thin film of alkali metal compound melts and adheres to the hot steel surface in molten condition. The steel strip is subsequently passed through an oxidizing zone diagrammatically indicated by reference numeral 17. Excellent results are obtained if the passage of the strip through the zone 17 lasts for about 10 seconds. If necessary, air or another oxygen-containing gas, may be supplied to the oxidizing zone 17. The action of the molten alkali metal compound on the steel surface, in conjunction with the presence of oxygen, causes efficient descaling in accordance with equation 3 above. The thus-descaled steel strip is then washed in water by passing the strip through the washing means 8'. For example, if stainless steel of a chromium type such as SUS 24 is subjected to the inventive treatment in the apparatus depicted in FIG. 2, the washing in water as accomplished by washing means 8 successfully terminates the descaling procedure. However, in other types of stainless steel, such as for example steel of the nickel-chromium type such as SUS 27, a subsequent pickling treatment is recommended in order fully to complete the descaling procedure. For this purpose the steel strip should be passed through the pickling tank 9' which may contain a conventional pickling solution as indicated in the embodiment of FIG. 1. After the pickling in tank 9' the steel strip is then conveyed to the wash tank 11' where a final water washing is effected. The descaled steel strip is then wound in conventional manner as indicated by reference numeral 12'.

It will be appreciated that although in the above embodiment the cooling of the steel emanating from the annealing furnace 2' is effected by forced cooling air, it is perfectly feasible to cool the steel with water, prior to the spraying treatment, provided that care is taken that the cooling does not proceed to a level below the melting point of the respective alkali metal compound.

The sole purpose of the cooling means immediately adjacent the annealing furnace is to adjust the temperature of the steel strip so that it is still sufficiently hot adjacent the inlet of the spraying means 13 to cause substantially instantaneous evaporation of the sprayed water and melting of the remaining alkali metal compound film. From a practical point of view, a temperature range of from 600–900° C., is the most suitable.

It should be appreciated that the inventive procedure of the second embodiment has many advantages lacking in the prior art procedure. Since it is possible to dispense with a salt bath, the difficulties connected with the salt bath treatments are obviated. Further the inventive installation is less costly. The overall cost of the descaling procedure is considerably less since the heat retained by the preceding treatments is utilized for the descaling procedure.

Moreover, no extraneous oxidizing agent has to be admixed since air oxidation of molten alkali metal compound in a film state is utilized. The descaling speed is extremely high and the final product is free of scratches or other blemishes as they otherwise customarily appear in the prior art procedure due to the presence of iron rolls.

It should also be emphasized that the handling of the alkali metal compound solution is much easier than the handling of a molten bath. Since aqueous alkali metal solutions do not solidify, in contrast to the alkali metal salt bath of the prior art, additional advantages are obtained from an operational point of view and in respect to savings of energy.

Moreover, there is no waste of alkali metal compound since the required amount of alkali metal compound can be readily regulated by varying the concentration of the aqueous solution in dependence on the nature and type of the steel and scale.

Since the alkali metal compounds are used in the form of aqueous solutions, corrosion problems are practically obviated and accordingly less costly materials may be chosen for the spray nozzles and the apparatus in general. This again lowers the overall cost.

Since the alkali metal compound is used in the form of an aqueous solution, descaling and fog quenching can be carried out simultaneously due to the retained heat of the steel. Further, the mechanical shock action resulting from the rapid evaporation of the sprayed aqueous solution, has a beneficial effect on the surface of the scale since this shock action has the tendency to loosen the scale and to strip it from the steel body. This facilitates the descaling which is thus carried out at a higher speed and more efficiently as compared to descaling in a salt bath.

What is claimed is :

1. In combination with an annealing furnace in which stainless steel is to be continuously annealed apparatus for treating the steel emanating from the furnace, said apparatus comprising in combination:

a. Forced air cooling means adjacent the exit end of said annealing furnace adapted for cooling said steel to a temperature below the annealing temperature of the furnace but above the melting point of alkali metal hydroxide,

b. wetting means adjacent said cooling means for wetting the steel with aqueous alkali metal compound solution,

c. oxidizing means constituting an oxidizing zone which comprises a treatment chamber consisting essentially of (1) inlet area means for admitting said steel, (2) oxygen-containing gas treatment means and (3) exit means for passing said steel from said treatment chamber, said chamber being adjacent to said wetting means,

d. washing means adjacent said means constituting an oxidizing zone, and

e. means for conveying steel from the exit of said furnace successively past said means (a) through (d) substantially without scratching the surface of said steel.

2. Apparatus as claimed in claim 1, further comprising pickling means adjacent said washing means for pickling the steel and second washing means for washing the pickled steel.

3. Apparatus as claimed in claim 1, wherein said wetting means comprises a plurality of nozzles and means for continuously feeding solution to said nozzles.

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