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(54) **Method and system of treating a carbon steel strip, especially for pickling**

Verfahren und System zur Behandlung eines Kohlenstoffstahlbandes, insbesondere zur
Abbeizungsbehandlung

Procédé et système de traitement d'une bande d'acier au carbone, notamment pour un traitement de
décapage

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Description

BACKGROUND

[0001] In pickling processes, metal surfaces are treated by removing impurities such as typically rust or scale using treatment liquids, or pickle liquors, typically containing strong acids.

[0002] These impurities may occur during metal forming processes, in particular rolling and/or heat treatment. During the hot rolling process of metal strips a scale layer, mainly consisting of different metal oxides, is formed. The scale layer needs to be removed before further processing the steel strip. This is typically done in an acid pickling process, wherein the scale layer is dissolved in the acid, followed by a rinsing section to completely remove the pickling solution. So-called "secondary scale" is formed as the steel strip passes continuously through the hot strip finishing line and over the roller table where it cools and to some extent also in the coiling machine, where the strip is wound up into coils. Depending on the grade of material, on the final thickness of the hot-rolled strip, and on the rolling speed, both the thickness of the scale and its chemical composition can vary.

[0003] Scale itself is chemically quite similar to rust, being made up of iron and oxygen bonded together in various molecular arrangements. Like rust, scale typically develops at the surface of the steel product where the metal surface is exposed to air.

[0004] To eliminate this scale, the most common approach today is to use a pickling line having one or a plurality of acid baths, typically using a plurality of pickling tanks or pickling stations in a row, normally containing hydrochloric acid at a certain temperature in the range of typically between 50 °C and 95 °C. Cumulatively or alternatively other strong acids are used to descale or clean the metal surfaces, e.g. hydrochloric acid, sulfuric acid, etc. may be used as pickling agents (or treatment liquid) for pickling of e.g. ferrous metals.

[0005] The steel strip is pulled (or pushed or both pulled and pushed) through the pickling line - especially the treatment tank (or pickling tank) - at a certain speed (e.g. up to a couple of meters per second), then rinsed - typically with water -, and dried, normally air-dried. During pulling and/or pushing of the steel strip through the pickling line the layer of scale dissolves in the acid.

[0006] The concentration of the acid itself becomes depleted during the pickling operation, so that it is necessary to add fresh acid continuously. However, large amounts of spent acids are not only hazardous to the environment but usually also expensive. Thus it is desirable to reduce the amount of required acid for a given metal surface to be treated or to regenerate the spent acids for reuse. Furthermore, the pickling operation should be carried out such that the regeneration of the acids spent can be realized in a comparatively simple and comparatively environmentally compatible manner.

[0007] Since the beginning of pickling in general and

strip pickling in particular developments in this field had the target to improve the efficiency with regards to pickling time, consumption of chemicals and energy, and surface quality. In the beginning, pickling lines were operated with H₂SO₄. Later HCl replaced H₂SO₄ due to shorter pickling time, lower consumption and the possibility of total regeneration of the acid. Pickling acids are consumed during the pickling process. The acid dissolves the oxide scale and metal salts are formed. H₂SO₄ mainly forms FeSO₄ which can be removed from the pickling liquid and has to be disposed and consequently has to be replaced by fresh H₂SO₄. HCl on the contrary forms mainly FeCl₂ and a minor amount of FeCl₃ during the pickling process. Both can be converted back to HCL in the so called pyrohydrolysis reaction using fluidized bed or spray roaster regeneration plants resulting in a complete recovery of the spent pickling acid. Another advantage of HCl as pickling liquid is the fact that HCl acts less aggressive to the base metal than H₂SO₄ and consequently reducing the risk of over-pickling.

[0008] Beside the type of acid which is used during the pickling process, other factors influence the pickling efficiency. Higher temperature of the pickling acid for example reduces the required time which is needed to completely remove the scale layer. Therefore modern strip pickling lines using HCl as pickling liquid are operated at temperatures ranging from about 80 °C to about 90 °C. Since the pickling in acid containing pickling solutions is a chemical or electrochemical process, the media and energy exchange between the pickling acid and the strip surface is highly important with regards to the pickling efficiency.

[0009] Today pickling lines are designed as shallow tank turbulence installations comprising of several consecutive pickling tanks. The steel strip is pulled or pushed through the treatment tanks. The complete pickling section is arranged as a cascade, i.e. the fresh or regenerated acid is added to the last treatment tank (i.e. the most downstream treatment tank according to the direction of movement of the steel strip) and is then processed in a countercurrent flow to the strip transport direction in order to maximize the use of the pickling acid. At the entry and exit of the treatment tanks, wringer rolls are installed to remove the pickling acid from the strip to the greatest possible extent in order to enhance the cascade effect. German patent disclosure DE 40 31 234 describes this technology. JP H06 128774 A discloses a method for improving the sheet passing speed in a pickling vessel and to increase a production capacity by dripping or spraying hydrochloric acid before dipping into the pickling vessel. Furthermore, WO 02/081776 A1 discloses a process for pickling silicon containing electrical steel strip.

[0010] Inside the treatment tank, the pickling acid is injected on both sides of the tank creating a high turbulence between the strip surface and the pickling acid.

[0011] The pickling acid is then overflowing from the treatment tank to a circulation tank from where it is again

injected into the treatment tank by means of pumps. The high turbulence reduces the thickness of the liquid boundary layer on the strip surface resulting in an improved media and energy exchange and consequently reducing the required pickling time.

[0012] Another well-known pickling method is the spray pickling, wherein the pickling acid is directly sprayed onto the strip surface using several spray nozzles installed both above and below the steel strip. The pickling acid is then collected in a circulation tank from where it is pumped to the spray nozzles and sprayed on to the strip surface again. The spray nozzles are typically operated at a pressure above 1 bar. Due to the high impulse of the pickling acid sprayed onto the strip surface, the pickling efficiency and consequently the pickling time can be further improved. However this technology has never been used commercially in strip pickling lines. Laboratory tests, carried out for different steel grades, have proven, in particular when using HCl containing pickling solution, that the pickling speed of spray-pickling is up to five times higher compared to the shallow tank turbulence technology. However the dissolving speed of the base metal is increased in the same way or even further. Therefore, the pickling process is difficult to control with a high risk of over pickling the metal strip. One of the reasons for this aggressiveness with regards to the base metal is the formation of FeCl_3 in the pickling acid. The spray nozzles used in the spray pickling technology create fine droplets with a high surface which are in direct contact with air. The air, in particular the oxygen contained in the air, dissolves in the pickling acid and oxidizes the FeCl_2 together with the HCl forming FeCl_3 . While HCl is a non oxidizing acid and therefore dissolving the base metal only slowly, FeCl_3 is an oxidizing agent, consequently increasing the dissolving speed of the base material. In a pure spray pickling process the FeCl_3 concentration can reach 60 g/l and above.

[0013] Another drawback of the increased FeCl_3 concentration in the pickling acid is the effect on the regeneration process of the spent pickling acid. Spent pickling acid is typically regenerated using the pyrohydrolysis process. In this process FeCl_2 and FeCl_3 are converted back to HCl and Fe_2O_3 . FeCl_3 however has a much lower evaporation temperature than FeCl_2 and evaporates in the pyrohydrolysis reactor causing very fine Fe_2O_3 particles below 1 μm in size when converted to Fe_2O_3 . These fine particles are difficult to remove from the process off-gases causing high dust emissions.

SUMMARY

[0014] It is therefore an object of the present invention to provide method and a system for an improved steel strip treatment, especially pickling, such that fixed investment as well as maintenance costs are reduced, the treatment and pickling process is realized comparatively quickly, with high quality, and in an environmentally friendly manner.

[0015] The object of the present invention is achieved by a method according to claim 7.

[0016] According to the present invention, it is thereby advantageously possible to provide a treatment station that requires comparatively low installation costs as well as reduced maintenance costs. The present invention is related to a process for chemical or electrochemical treatment of the surface of carbon steel, preferably strip shaped, wherein the material is treated with a pickling solution, preferably containing HCl, in one or more treatment tanks to remove an oxide scale layer which was previously formed during the hot rolling process of the metal strip (steel strip). This treatment is needed to reach a clean surface for either further processing it in a cold rolling process or for direct commercial use.

[0017] According to the present invention, it is preferred that the process for chemical or electrochemical treatment of the surface of carbon steel is conducted using a pickling solution containing HCl as the only pickling agent, wherein the advantages of spray pickling are used to a maximum extend. Furthermore the process shall be controllable minimizing the risk of over-pickling so that the process can be realized in commercially used industrial scale pickling lines.

[0018] According to the present invention, the spent acid of such a process is of a quality such that it can be treated in regeneration plants without additional investment considering in particular the FeCl_3 concentration in such spent acid.

[0019] The present invention is also directed to the possibility to revamp existing pickling lines, in particular the treatment tanks, and to use more efficient pickling technology with improved efficiency while re-using existing equipment in order to reduce installation costs, as for example acid circulation circuits etc. can be reused.

[0020] According to the present invention, it is advantageously possible that such requirements can be achieved by the present invention, comprising a pickling process using an HCl containing pickling solution as the only pickling acid, wherein the material to be treated (i.e. the steel strip) is processed horizontally through one or more treatment tanks which are - in case of more than one treatment tank - operated as a pickling cascade.

[0021] According to the present invention, the carbon steel strip is a continuous steel strip being oriented substantially horizontally, both in its longitudinal and transverse directions, at least at the treatment station. This means that steel strip is mostly horizontally oriented in its transverse direction but is allowed to be sagging in its longitudinal direction. The height variation through the treatment station of the steel strip in its longitudinal direction may reach, e.g., up to 0,5 m. Preferably, also between the treatment station or between the plurality of treatment stations, the height variations of the steel strip in its longitudinal direction are also comprised up to 0,5 m. Generally, it is preferred according to the present invention that the height variation of the steel strip in its longitudinal direction is comprised between up to 0,5 m

throughout the complete treatment system, that potentially (and typically) comprises a plurality of treatment stations one after the other in the transport direction of the steel strip.

[0022] According to the present invention, two pickling technologies are directly combined in one treatment tank (i.e. in one treatment station), i.e. using physically the same pickling acids (or the same treatment liquid) in both pickling sections (i.e. in both the spray section and the immersion section of the considered treatment station), as described. By doing so, the concentration of FeCl_3 can be kept below a critical level throughout the entire pickling process, guaranteeing a uniform pickling result without the risk of over-pickling. Furthermore the spent acid of such process can be easily regenerated in regeneration plants without additional investment to reach the legally required emission values, especially regarding dust emissions.

[0023] According to the present invention, the efficiency of the treatment process (or pickling process) is increased. Tests have proven that a certain increase in the FeCl_3 concentration reduces the pickling time also for the dip pickling process. Consequently the process according to the present invention uses the advantage of the high efficient spray pickling process while the efficiency of the dip pickling process is improved as well, due to the common use of the pickling acid (i.e. the same treatment liquid is used both in the spray section and the immersion section of one and the same treatment station), and the consequently increased FeCl_3 level. Of course, in (the typical) case that more than one treatment stations are used in a pickling line or steel strip pickling installation, this does not mean that the same treatment liquid is used in all of such different treatment stations. To the contrary, in case of a plurality of treatment stations (i.e. having each a treatment tank comprising a spray section and an immersion section), a different treatment liquid is normally used for a different treatment station; however within the same treatment station/treatment tank, the same treatment liquid is used for both kinds of pickling processes (spray and dip pickling). Thereby, it is advantageously possible that the drawbacks of a comparatively high concentration in FeCl_3 can be avoided that would typically arise in case of combining spray pickling and dip pickling using different treatment liquids in the same treatment station.

[0024] According to the present invention, the design of the treatment line or pickling line is done in such a way that it is advantageously possible that the treatment stations or treatment tanks can easily replace existing treatment tanks in case of a required revamp (or refurbishment) while the circulation circuits can be reused. This is mainly attributed to the fact that the spray pickling technology and the dip pickling technology (i.e. the spray section and the immersion section) are combined in one treatment tank (i.e. as part of one treatment tank).

[0025] According to a preferred embodiment of the present invention, the spray section comprises an effective

spray length in parallel to the longitudinal direction of the steel strip such that - during the first step - the top and bottom surfaces of the steel strip receive the treatment liquid while being located within the effective spray length, wherein the immersion section comprises an effective immersion length in parallel to the longitudinal direction of the steel strip such that - during the second step - the steel strip is immersed - with its top and bottom surfaces - in the treatment liquid while being located within the effective immersion length, wherein the effective spray length and the effective immersion length are provided having a ratio of between and including 30:70 to 70:30, especially a ratio of 50:50.

[0026] According to the present invention, it is thereby advantageously possible to flexibly adapt process parameters of a pickling line to fit best with the intended operative use after construction. By means of defining the length of the immersion section (at a given transport speed of the steel strip through the pickling line), the time is defined during which the treatment liquid is effectively treating the steel strip in the immersion section. By means of defining the length of the spray section (equally at a given transport speed of the steel strip through the pickling line), the maximum time of spray pickling is defined in relation to the dip pickling time.

[0027] According to another preferred embodiment of the present invention, the effective spray length and hence the ratio of the effective spray length vs. the effective immersion length is varied by activating only a part of the spray nozzles.

[0028] According to the present invention, it is thereby advantageously possible to vary the spray pickling time even during operational use of the pickling line, i.e. by de-activating a part of the spray nozzles. By selectively activating and/or de-activating groups of spray nozzles, it is advantageously possible according to the present invention, that also the manner or the intensity of the spray pickling step can be varied in operational use of the pickling line, e.g. by using only every second spray nozzle such that spray pickling is less intensive in the spray section.

[0029] According to a preferred embodiment of the present invention, the spray section is located - along the transport direction of the steel strip - upstream with respect to the immersion section. According to an alternative preferred embodiment of the present invention, the spray section is located - along the transport direction of the steel strip - downstream with respect to the immersion section.

[0030] According to the present invention, it is thereby advantageously possible to provide the possibility of different pickling line architectures. E.g., it is advantageously possible (in case that at least two treatment stations are used) to provide both treatment stations such that the spray section is located upstream with respect to the immersion section (i.e. the steel strip passes the spray section first and afterwards the immersion section): This results in a pickling sequence of the kind of a spray and

dip pickling (using a first treatment liquid) in the first (or upstream) treatment station, followed by a spray and dip pickling (using a second treatment liquid) in the second (or downstream) treatment station. Alternatively, it is also advantageously possible (in case that at least two treatment stations are used) to provide the first treatment station such that the spray section is located downstream with respect to the immersion section (i.e. the steel strip passes the immersion section first and afterwards the spray section), and to provide the second treatment station such that the spray section is located upstream with respect to the immersion section (i.e. the steel strip passes the spray section (of the second treatment station) first and afterwards the dip section (of the second treatment station)): This results in a pickling sequence of the kind of a dip and spray pickling (using a first treatment liquid) in the first (or upstream) treatment station, followed by a spray and dip pickling (using a second treatment liquid) in the second (or downstream) treatment station. Of course, these building blocks of two treatment stations can be either repeated or combined with other treatment stations or configurations of treatment stations.

[0031] According to a preferred embodiment of the present invention, the method comprises using - besides using the treatment liquid in the treatment station - a further treatment liquid in a further treatment station, the further treatment station comprising a further treatment tank with a further spray section and a further immersion section, and the further treatment station comprising a further common collection means for the further treatment liquid, wherein the method comprises transporting the steel strip continuously through the further treatment station in the transport direction such that

- in a third step, the further treatment liquid is sprayed onto the top surface of the steel strip and onto the bottom surface of the steel strip while the steel strip being in the further spray section of the further treatment station,
- in a fourth step, the steel strip is immersed in the further treatment liquid while the steel strip being in the further immersion section of the further treatment station,

wherein, while treating the steel strip, the further treatment liquid is continuously pumped out of the further common collection means and through both the further spray section and the further immersion section of the further treatment station, wherein spraying of the further treatment liquid onto the top and bottom surfaces of the steel strip is provided using further spray nozzles, wherein the third and fourth steps are preceding the first and second steps or are subsequent to the first and second steps.

[0032] According to the present invention, it is thereby advantageously possible to combine at least two inventive treatment stations in a pickling line. Of course, it is also possible and preferred according to the present in-

vention to combine such two inventive treatment stations with a conventional treatment station (i.e. having solely a spray section or solely an immersion section in a treatment tank) or with a plurality of conventional treatment stations. In such an architecture of the pickling line, the two inventive treatment station are either located directly subsequent one after the other along the transport direction of the steel strip or the combination with one or a plurality of conventional treatment stations is provided such that the treatment station (or the first treatment station) is located upstream according to the transport direction of the steel strip with respect to a conventional treatment station (or with respect to a plurality of conventional treatment stations) and downstream with respect to this or these conventional treatment station(s) is located the further treatment station (or second treatment station) according to the present invention.

[0033] According to another preferred embodiment of the present invention, the treatment liquid and/or the further treatment liquid comprises

- hydrochloric acid in a concentration ranging from and including 150 g/l to and including 250 g/l and
- FeCl_3 in a concentration ranging from and including 10 g/l to and including 35 g/l, especially in a concentration ranging from and including 15 g/l to and including 30 g/l or especially in a concentration ranging from and including 19 g/l to and including 26 g/l and,
- FeCl_2^+ ions in a concentration ranging from and including 30 g/l to and including 300 g/l, especially in a concentration ranging from and including 30 g/l to and including 60 g/l or in a concentration ranging from and including 130 g/l to and including 180 g/l or in a concentration ranging from and including 230 g/l to and including 300 g/l.

[0034] According to the present invention, it is thereby advantageously possible to combine a high efficiency of the pickling process while retaining the possibility to comparatively easily regenerated the used pickling acids (treatment liquids).

[0035] The present invention also relates to a system according to claim 1.

[0036] According to the present invention, it is thereby advantageously possible to provide a system (or a treatment station) that requires comparatively low installation costs as well as reduced maintenance costs. According to the present invention, it is advantageously possible to combine the advantages of spray pickling and dip pickling and to minimize the risk of over-pickling. It is furthermore advantageous that the spent acid of such a system is of a quality such that it can be treated in regeneration plants without additional investment considering in particular the FeCl_3 concentration in such spent acid.

[0037] According to a preferred embodiment of the present invention - especially regarding the inventive system -, the spray section comprises an effective spray

length in parallel to the longitudinal direction of the steel strip such that the top and bottom surfaces of the steel strip receive the treatment liquid while being located within the effective spray length, wherein the immersion section comprises an effective immersion length in parallel to the longitudinal direction of the steel strip such that the steel strip is immersed - with its top and bottom surfaces - in the treatment liquid while being located within the effective immersion length, wherein the effective spray length and the effective immersion length are provided having a ratio of between and including 30:70 to 70:30, especially a ratio of 50:50.

[0038] According to the present invention, it is thereby advantageously possible to flexibly adapt process parameters of a pickling line to fit best with the intended operative use after construction.

[0039] According to a preferred embodiment of the present invention - especially regarding the inventive system -, the spray section is located - along the transport direction of the steel strip - upstream with respect to the immersion section. According to an alternative preferred embodiment of the present invention - especially regarding the inventive system -, the spray section is located - along the transport direction of the steel strip - downstream with respect to the immersion section.

[0040] According to the present invention, it is thereby advantageously possible to flexibly adapt process parameters of a pickling line to fit best with the intended operative use after construction.

[0041] According to the present invention, it is thereby advantageously possible to build the treatment tank in a very cost effective manner such that especially the volume of the treatment tank is comparably small (and hence less treatment liquid is to be used). The treatment liquid is pumped through the common collection means (or circulation tank) that is separated from the treatment tank.

[0042] According to another preferred embodiment of the present invention - related to both the method and the system -, the length of the treatment station is preferably 20 m or less, preferably between 16 m and 20 m. The treatment station comprising both the spray section and the immersion section is preferably assembled using two main components of the treatment tank such that the treatment tank is - after assembling the two main components - integrally formed using the two main components.

[0043] According to the present invention, it is thereby advantageously possible to provide the two main components forming the treatment tank such that each of the main components have a maximum length of 11,6 m, i.e. the two main components have a length of 11, 6 m or less. Thereby, it is advantageously possible to transport these main components of the treatment tank, used in a treatment station according to the inventive method, such that no welding of the two main components is required. Preferably, the main components of the treatment tank are slid into one another. This enables a much faster

setup of the treatment station which is especially advantageous in case of re-furbishing existing pickling lines, as the down-time due to the refurbishment can be considerably reduced. According to the present invention, it is preferred that one of the main components of the treatment tank realizes the spray section of the treatment station and the other of the main components of the treatment tank realizes the immersion section of the treatment station.

[0044] According to a preferred embodiment of the present invention - especially regarding the inventive system -, the system comprises - besides the treatment liquid in the treatment station - a further treatment liquid in a further treatment station, the further treatment station comprising a further treatment tank with a further spray section and a further immersion section, and the further treatment station comprising a further common collection means for the further treatment liquid, wherein the system is configured such that the steel strip is transported continuously through the further treatment station in the transport direction such that

-- the further treatment liquid is sprayed onto the top surface of the steel strip and onto the bottom surface of the steel strip while the steel strip being in the further spray section of the further treatment station, -- the steel strip is immersed in the further treatment liquid while the steel strip being in the further immersion section of the further treatment station,

wherein the system is configured such that the further treatment liquid is continuously pumped out of the further common collection means and through both the further spray section and the further immersion section of the further treatment station, wherein the system comprises further spray nozzles such that the further treatment liquid is sprayed onto the top and bottom surfaces of the steel strip using the further spray nozzles.

[0045] According to the present invention, it is thereby advantageously possible to combine at least two inventive treatment stations in a pickling line. Of course, it is also possible and preferred according to the present invention to combine such two inventive treatment stations with a conventional treatment station (i.e. having solely a spray section or solely an immersion section in a treatment tank) or with a plurality of conventional treatment stations.

[0046] According to a preferred embodiment of the present invention, the system comprises - besides the treatment liquid in the treatment station and the further treatment liquid in the further treatment station - a third treatment liquid in a third treatment station, the third treatment station comprising a third treatment tank with a third spray section and a third immersion section, and the third treatment station comprising a third common collection means for the third treatment liquid.

[0047] According to the present invention, it is thereby advantageously possible to combine at least three inven-

tive treatment stations in a pickling line. Of course, it is also possible and preferred according to the present invention to combine such three inventive treatment stations with a conventional treatment station (i.e. having solely a spray section or solely an immersion section in a treatment tank) or with a plurality of conventional treatment stations.

[0048] According to a further preferred embodiment of the present invention, the system comprises - besides the treatment liquid in the treatment station, the further treatment liquid in the further treatment station, and the third treatment liquid in the third treatment station - a fourth treatment liquid in a fourth treatment station, the fourth treatment station comprising a fourth treatment tank with a fourth spray section and a fourth immersion section, and the fourth treatment station comprising a fourth common collection means for the fourth treatment liquid. According to other embodiments, also the combination of five treatment stations according to the present invention is possible and preferred according to the present invention.

[0049] According to another preferred embodiment of the present invention, the treatment liquid and/or the further treatment liquid and/or the third treatment liquid comprises

- hydrochloric acid in a concentration ranging from and including 150 g/l to and including 250 g/l and
- FeCl_3 in a concentration ranging from and including 10 g/l to and including 35 g/l, especially in a concentration ranging from and including 15 g/l to and including 30 g/l or especially in a concentration ranging from and including 19 g/l to and including 26 g/l and,
- FeCl_2 in a concentration ranging from and including 30 g/l to and including 300 g/l, especially in a concentration ranging from and including 30 g/l to and including 60 g/l or in a concentration ranging from and including 130 g/l to and including 180 g/l or in a concentration ranging from and including 230 g/l to and including 300 g/l.

[0050] According to the present invention, it is thereby advantageously possible to combine a high efficiency of the pickling process while retaining the possibility to comparatively easily regenerated the used pickling acids (treatment liquids).

[0051] These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. The description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052]

Figure 1 schematically illustrates a treatment system comprising three different treatment stations, each one being configured according to the present invention, i.e. having a treatment tank with both a spray section and an immersion section such that a common collection means and the same treatment liquid is used for the treatment of the steel strip in both the respective spray section and the immersion section.

Figure 2 schematically illustrates a first embodiment of a treatment station having a treatment tank and a common collection means separated from the treatment tank, the treatment tank having its spray section and its immersion section to treat the steel strip with a common treatment liquid circulating between - and within - the common collection means on the one hand, and the spray and immersion sections on the other hand.

Figure 3 schematically illustrates a treatment station not belonging to this invention having a treatment tank and a common collection means separated from the treatment tank, the treatment tank having its spray section and its immersion section to treat the steel strip with a common treatment liquid circulating between - and within - the common collection means on the one hand, and the spray and immersion sections on the other hand.

DETAILED DESCRIPTION

[0053] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

[0054] Figure 1 schematically illustrates a treatment system comprising three different treatment stations 3, 31, 32 as an example of a pickling line according to the present invention. In one possible and preferred implementation of the pickling line for the treatment of a steel strip 1, represented in Figure 1, all three treatment stations 3, 31, 32 represent treatment stations according to the present invention, i.e. having a treatment tank with both a spray section and an immersion section such that a common collection means and the same treatment liquid is used for the treatment of the steel strip in both the respective spray section and the immersion section. In this implementation or architecture of the pickling line, all three treatment stations 3, 31, 32 are realized either according to a first embodiment of the present invention,

represented in Figure 2 for the exemplary case of the treatment station being represented by reference sign 3, or according to a second embodiment of the present invention, represented in Figure 3 for the exemplary case of the treatment station being represented by reference sign 3. Alternatively, a part of the three treatment stations 3, 31, 32 is or are realized according to the first embodiment of the present invention (Figure 2) and another part is or are realized according to the second embodiment of the present invention (Figure 3). In the context of the present invention, the terms 'treatment station' and 'first treatment station' as well as 'further treatment station' and 'second treatment station' are used synonymously and only aim to differentiate the treatment stations from one another. Typically, the naming convention typically (but not necessarily) relates to the location of a treatment station along the transport direction of the steel strip, the transport direction being represented by reference sign 2. In the implementation represented in Figure 1, a treatment station (or first treatment station) 3 is located upstream of a further treatment station (or second treatment station) 31. The further treatment station (or second treatment station) 31 is located upstream of a third treatment station 32. The treatment station (or first treatment station) 3 comprises a treatment tank (or first treatment tank) 4, and a common collection means (or first common collection means) 5. The further treatment station (or second treatment station) 31 comprises a further treatment tank (or second treatment tank) 41, and a further common collection means (or second common collection means) 51. The third treatment station 32 comprises a third treatment tank 42, and a third common collection means 52. In the exemplary implementation of the pickling line represented in Figure 1 (where all treatment stations are configured according to the present invention), all three treatment stations 3, 31, 32 each have a spray section and an immersion section as part of their respective treatment tank 4, 41, 42, i.e. the treatment station (or first treatment station) 3 has a spray section (or first spray section) and an immersion section (or first immersion section) using a treatment liquid (or first treatment liquid), the further treatment station (or second treatment station) 31 has a further spray section (or second spray section) (not depicted in Figure 1) and a further immersion section (or second immersion section) (not depicted in Figure 1) using a further treatment liquid (or second treatment liquid), and the third treatment station 32 has a third spray section (not depicted in Figure 1) and a third immersion section (not depicted in Figure 1) using a third treatment liquid. For the exemplary case of the treatment station 3 (first treatment station 3), the present invention is schematically shown in Figures 2.

[0055] Figure 2 schematically illustrates the first embodiment of the treatment station 3 having the treatment tank 4 and the common collection means 5 separated from the treatment tank 4, the treatment tank 4 having its spray section 13 and its immersion section 14 to treat the steel strip 1 with a common treatment liquid circulating

between - and within - the common collection means 5 on the one hand, and the spray and immersion sections 13, 14 on the other hand.

[0056] Figure 3 schematically illustrates a treatment station 3 not belonging to this invention having the treatment tank 4 and the common collection means 5 separated from the treatment tank 4, the treatment tank 4 having its spray section 13 and its immersion section 14 to treat the steel strip 1 with a common treatment liquid circulating between - and within - the common collection means 5 on the one hand, and the spray and immersion sections 13 on the other hand.

[0057] Figures 1 and 2 combined illustrate the inventive treatment process and system (or treatment station) for chemical or electrochemical treatment of the surface of the steel strip 1, the steel strip 1 being a carbon steel strip. The steel strip 1 is first horizontally transported through the treatment stations 3, 31, 32 in which the steel strip 1 is treated with a treatment liquid in the form of a pickling acid, normally containing HCl. At least one of the treatment stations 3, 31, 32 (or their respective treatment tanks 4, 41, 42) comprises a spray pickling section (as represented in Figures 2 and 3 as spray section 13 of the treatment station 3) and a dip pickling section (as represented in Figures 2 and 3 as immersion section 14 of the treatment station 3) according to the present invention. Figure 1 shows an exemplary implementation with three treatment station 3, 31, 32 (each having a treatment tank) as a preferred embodiment, however the number of treatment stations (and treatment tanks) is at least one and is not limited to three.

[0058] All treatment stations 3, 31, 32 comprise a common collection means, respectively (i.e. the respective treatment tanks 4, 41, 42 are connected to respective common collection means (or circulation tanks) 5, 51, 52), wherein the common collection means 5, 51, 52 are (i.e. potentially for each treatment station 3, 31, 32 differently) realized as separate tanks as shown in the first embodiment represented in Figure 2.

[0059] In the exemplary embodiment shown in Figure 1, the common collection means (or circulation tanks) 5, 51, 52 are operated as a cascade, i.e. the fresh or regenerated acid (i.e. the treatment liquid) is added (cf. reference sign 54) to the last common collection means (or last circulation tank) 52 - i.e. being related to the most downstream treatment station 32 according to the transport direction 2 of the steel strip 1 - and is consequently transferred to the other common collection means (or circulation tanks) in counter direction to the strip transport direction 2. Thereby, the level of free acid is the highest in the third treatment liquid (circulating in the third treatment station 32), the level of free acid is medium in the further treatment liquid (second treatment liquid) (circulating in the further (second) treatment station 31), and lowest in the treatment liquid (first treatment liquid) (circulating in the (first) treatment station 3. Finally the spent acid is removed (reference sign 55) from the (first) common collection means (or (first) circulation tank) 5. After

the pickling treatment in the three treatment stations 3, 31, 32 (in the exemplary implementation shown in Figure 1), the steel strip 1 is further processed in section 6 which comprises a rinse section and a dryer, if required.

[0060] According to the first embodiment of the common collection means (or circulation tank) 5, shown in Figure 2, the treatment station 3 comprises the treatment tank 4 with a separate common collection means 5 (or separate circulation tank 5). At the entry and exit section, wringer rolls 12 are installed to remove pickling acid from the strip and to guide the steel strip 1 inside the treatment tank 4. The wringer roll 12 in the entry section is only used when the treatment tank is the first tank in the pickling process like the treatment station 3 in Figure 1. The following treatment stations (or treatment tanks), like treatment stations 31, 32 in Figure 1, do not need such wringer roll 12. In the exemplary representation of Figure 2 (i.e. not necessarily), the first part (according to the transport direction of the steel strip 1) of the treatment tank 4 is a spray pickling section 13 or spray section 13, followed by a dip pickling section 14 or immersion section 14. In the spray pickling section 13, spray nozzles 15 are mounted above and below the surface of the steel strip 1. The pickling acid (or treatment liquid) is pumped from the circulation tank 5 (or common collection means 5) by means of pumps 17, 18 to both the spray pickling section 13 and the dip pickling section 14. In one or more of the pump circuits, a heat exchanger 19 is installed to heat the pickling acid (treatment liquid) to the required temperature. If required, a guide roll 20 can be installed between the spray pickling section 13 and the dip pickling section 14 in order to reduce the slack of the strip.

[0061] In Figure 3, a common collection means (or circulation tank) wherein the treatment station 3 comprises the treatment tank 4 with an integrated common collection means 5. The other components of the treatment station 3 are analogous to the description of Figure 2.

[0062] For example, the pickling line is configured for a maximum width of the steel strip 1 of 1890 mm, a maximum speed of the steel strip 1 of 255 m/min. Furthermore exemplarily, the distance of the spray nozzles 15 to the steel strip 1 (both from the spray nozzles to the top surface 1' of the steel strip 1, and to the bottom surface 1" of the steel strip 1) is 200 mm or approximately 200 mm. Additionally, the distance of the spray nozzles 15 to each other in the lateral direction of the steel strip 1 corresponds to 200 mm or approximately 200 mm. Additionally, the distance of the spray nozzles 15 to each other in the longitudinal direction of the steel strip 1 corresponds to 500 mm or approximately 500 mm. The treatment liquid is preferably pumped out of the spray nozzles having a pressure of between and including 1 bar to and including 3 bar, and the amount of treatment liquid per spray nozzle is preferably 12 l/min or approximately 12 l/min. For example, the total number of spray nozzles per treatment station corresponds to 306 or approximately 306, and the amount of pumped treatment liquid per treatment station corresponds to 220 m³/h or approximately

220 m³/h.

[0063] Test trials were carried out in a pilot plant. The pilot plant consisted of two treatment stations (each having a treatment tank) both arranged as described in the present invention with a first spray pickling section followed by a dip pickling section in each of the treatment tanks. The treatment tanks were designed so that the length of both sections was approximately the same. The pickling acid used was HCl with a concentration of approx. 200 g/l total acid in both tanks. The material treated during the test runs were different IF steel grades (interstitial Free steel), which belong to the group of steel grades that are more difficult to pickle mainly due to their high recoiling temperature. The test results have proven that the pickling time could be reduced by 40 - 45% compared to the conventional pickling process using dip pickling with shallow tank turbulence technology, while the FeCl₃ concentration was constantly below 30 g/l which is considered to be uncritical as far as the acid regeneration process is concerned. All tested materials showed uniform pickling results without any signs of over-pickling.

[0064] In another test using the same pilot plant, the material was treated with a reduced temperature of the pickling acid (treatment liquid). The results showed that the temperature could be reduced from 90 °C down to 70 °C while still reaching the same pickling time as for the conventional dip pickling process with shallow tank turbulence technology. This result is equivalent to a 20 % reduction of the energy which is needed to keep the process temperature in the pickling process.

[0065] As an example of the operation of the system and especially of the use of the treatment liquids as a cascade, an example is given of the concentration values for an example of using three treatment stations in a pickling line:

In the first treatment station 3, the concentration of HCl is in the range of between and comprising 205 g/l to and comprising 220 g/l, the concentration of FeCl₂ is in the range of between and comprising 260 g/l to and comprising 278 g/l, the concentration of FeCl₃ is in the range of between and comprising 22 g/l to and comprising 26 g/l. The temperature of the treatment liquid is in the range of between and comprising 88 °C to and comprising 91 °C.

In the second treatment station 31, the concentration of HCl is in the range of between and comprising 201 g/l to and comprising 211 g/l, the concentration of FeCl₂ is in the range of between and comprising 140 g/l to and comprising 146 g/l, the concentration of FeCl₃ is in the range of between and comprising 21 g/l to and comprising 26 g/l. The temperature of the treatment liquid is in the range of between and comprising 88 °C to and comprising 91 °C. In the third treatment station, the concentration of HCl is in the range of between and comprising 193 g/l to and comprising 206 g/l, the concentration of FeCl₂ is in the range of between and comprising 43 g/l to and

comprising 47 g/l, the concentration of FeCl₃ is in the range of between and comprising 19 g/l to and comprising 22 g/l. The temperature of the treatment liquid is in the range of between and comprising 88 °C to and comprising 91 °C.

REFERENCE SIGNS

[0066]

1	steel strip	10
2	transport direction of the steel strip	
3	treatment station	
4	treatment tank (of the treatment station)	
5	common collection means (of the treatment station)	15
12	wringer roll(s)	
13	spray section (of the treatment station)	
14	immersion section (of the treatment station)	
15	spray nozzles (of the treatment station)	20
17, 18	pumps	
19	heat exchanger	
20	guide roll(s)	
31	further treatment station	
41	further treatment tank (of the further treatment station)	25
51	further common collection means (of the further treatment station)	
32	third treatment station	
42	third treatment tank (of the third treatment station)	30
52	third common collection means (of the third treatment station)	
54	feeding of fresh treatment liquid	
55	removing of used treatment liquid	35

Claims

1. System for treating a steel strip (1), especially for a pickling treatment of the steel strip, by means of a treatment liquid in a treatment station (3), the system comprising the treatment station (3), wherein the treatment station (3) comprises a treatment tank (4) with a spray section (13), an immersion section (14), and the treatment station (3) comprising a common collection means (5) for the treatment liquid, wherein the common collection means (5) for the treatment liquid of both the spray section (13) and the immersion section (14) is a collection means (5) separated from the treatment tank (4) of the treatment station (3), wherein the steel strip (1) consists of carbon steel and is a continuous steel strip (1) being oriented substantially horizontally, both in its longitudinal and transverse directions, wherein the steel strip (1) has a top surface (1') and a bottom surface (1''), wherein the system is configured to transport the steel strip (1) continuously through the treatment station (3) in a transport direction, the transport direction being parallel to the longitudinal direction of the steel strip (1), such that
 - the treatment liquid is sprayed onto the top surface (1') of the steel strip (1) and onto the bottom surface (1'') of the steel strip (1) while the steel strip (1) being in the spray section (13) of the treatment station (3),
 - the steel strip (1) is immersed in the treatment liquid while the steel strip (1) being in the immersion section (14) of the treatment station (3),
 wherein the system is configured such that the treatment liquid is continuously pumped out of the common collection means (5) and through both the spray section (13) and the immersion section (14) of the treatment station (3), wherein the system comprises spray nozzles (15) such that the treatment liquid is sprayed onto the top and bottom surfaces (1', 1'') of the steel strip (1) using the spray nozzles (15).
2. System according to claim 1, wherein the spray section (13) comprises an effective spray length in parallel to the longitudinal direction of the steel strip (1) such that the top and bottom surfaces (1', 1'') of the steel strip (1) receive the treatment liquid while being located within the effective spray length, wherein the immersion section (14) comprises an effective immersion length in parallel to the longitudinal direction of the steel strip (1) such that the steel strip (1) is immersed - with its top and bottom surfaces (1', 1'') - in the treatment liquid while being located within the effective immersion length, wherein the effective spray length and the effective immersion length are provided having a ratio of between and including 30:70 to 70:30, especially a ratio of 50:50.
3. System according to one of claims 1 to 2, wherein - along the transport direction of the steel strip (1) - the spray section (14) is located upstream or downstream with respect to the immersion section (15).
4. System according to one of claims 1 to 3, wherein the system comprises - besides the treatment liquid in the treatment station (3) - a further treatment liquid in a further treatment station (31), the further treatment station (31) comprising a further treatment tank (41) with a further spray section and a further immersion section, and the further treatment station (31) comprising a further common collection means (51) for the further treatment liquid, wherein the system is configured such that the steel strip (1) is transported continuously through the further treatment station (31) in the transport direction such that

-- the further treatment liquid is sprayed onto the top surface (1') of the steel strip (1) and onto the bottom surface (1'') of the steel strip (1) while the steel strip (1) being in the further spray section of the further treatment station (31),
 -- the steel strip (1) is immersed in the further treatment liquid while the steel strip (1) being in the further immersion section of the further treatment station (31),

wherein the system is configured such that the further treatment liquid is continuously pumped out of the further common collection means (51) and through both the further spray section and the further immersion section of the further treatment station (31), wherein the system comprises further spray nozzles such that the further treatment liquid is sprayed onto the top and bottom surfaces (1', 1'') of the steel strip (1) using the further spray nozzles.

5. System according to one of claims 1 to 4, wherein the system comprises - besides the treatment liquid in the treatment station (3) and the further treatment liquid in the further treatment station (31) - a third treatment liquid in a third treatment station (32), the third treatment station (32) comprising a third treatment tank (42) with a third spray section and a third immersion section, and the third treatment station (32) comprising a third common collection means (52) for the third treatment liquid.
6. System according to one of claims 1 to 5, wherein the treatment liquid and/or the further treatment liquid and/or the third treatment liquid comprises

-- hydrochloric acid in a concentration ranging from and including 150 g/l to and including 250 g/l and
 -- FeCl_3 in a concentration ranging from and including 10 g/l to and including 35 g/l, especially in a concentration ranging from and including 15 g/l to and including 30 g/l or especially in a concentration ranging from and including 19 g/l to and including 26 g/l and,
 -- FeCl_2 in a concentration ranging from and including 30 g/l to and including 300 g/l, especially in a concentration ranging from and including 30 g/l to and including 60 g/l or in a concentration ranging from and including 130 g/l to and including 180 g/l or in a concentration ranging from and including 230 g/l to and including 300 g/l.

7. Method for treating a steel strip (1), especially for a pickling treatment of the steel strip (1), by means of a treatment liquid in a treatment station (3), the treatment station (3) comprising a treatment tank (4) with a spray section (13) and an immersion section (14), and the treatment station (3) comprising a common

collection means (5) for the treatment liquid, wherein the common collection means (5) for the treatment liquid of both the spray section (13) and the immersion section (14) is a collection means (5) separated from the treatment tank (4) of the treatment station (3), wherein the steel strip (1) consists of carbon steel and is a continuous steel strip (1) being oriented substantially horizontally, both in its longitudinal and transverse directions,
 wherein the steel strip (1) has a top surface (1') and a bottom surface (1''),
 wherein the method comprises transporting the steel strip (1) continuously through the treatment station (3) in a transport direction (2), the transport direction being parallel to the longitudinal direction of the steel strip (1), such that

-- in a first step, the treatment liquid is sprayed onto the top surface (1') of the steel strip (1) and onto the bottom surface (1'') of the steel strip (1) while the steel strip (1) being in the spray section (13) of the treatment station (3),
 -- in a second step, the steel strip (1) is immersed in the treatment liquid while the steel strip (1) being in the immersion section (14) of the treatment station (3),

wherein, while treating the steel strip (1), the treatment liquid is continuously pumped out of the common collection means (5) and through both the spray section (13) and the immersion section (14) of the treatment station (3), wherein spraying of the treatment liquid onto the top and bottom surfaces (1', 1'') of the steel strip (1) is provided using spray nozzles (15).

8. Method according to claim 7, wherein the spray section (13) comprises an effective spray length in parallel to the longitudinal direction of the steel strip (1) such that during the first step - the top and bottom surfaces (1', 1'') of the steel strip (1) receive the treatment liquid while being located within the effective spray length, wherein the immersion section (14) comprises an effective immersion length in parallel to the longitudinal direction of the steel strip (1) such that - during the second step - the steel strip (1) is immersed - with its top and bottom surfaces (1', 1'') - in the treatment liquid while being located within the effective immersion length, wherein the effective spray length and the effective immersion length are provided having a ratio of between and including 30:70 to 70:30, especially a ratio of 50:50.
9. Method according to one of claims 7 to 8, wherein the effective spray length and hence the ratio of the effective spray length vs. the effective immersion length is varied by activating only a part of the spray nozzles (15).

10. Method according to one of claims 7 to 9, wherein - along the transport direction of the steel strip (1) - the spray section (14) is located upstream or downstream with respect to the immersion section (15).

11. Method according to one of claims 7 to 10, wherein the method comprises using - besides using the treatment liquid in the treatment station (3) - a further treatment liquid in a further treatment station (31), the further treatment station (31) comprising a further treatment tank (41) with a further spray section and a further immersion section, and the further treatment station (31) comprising a further common collection means (51) for the further treatment liquid, wherein the method comprises transporting the steel strip (1) continuously through the further treatment station (31) in the transport direction such that

-- in a third step, the further treatment liquid is sprayed onto the top surface (1') of the steel strip (1) and onto the bottom surface (1'') of the steel strip (1) while the steel strip (1) being in the further spray section of the further treatment station (31),

-- in a fourth step, the steel strip (1) is immersed in the further treatment liquid while the steel strip (1) being in the further immersion section of the further treatment station (31),

wherein, while treating the steel strip (1), the further treatment liquid is continuously pumped out of the further common collection means (51) and through both the further spray section and the further immersion section of the further treatment station (31), wherein spraying of the further treatment liquid onto the top and bottom surfaces (1', 1'') of the steel strip (1) is provided using further spray nozzles, wherein the third and fourth steps are preceding the first and second steps or are subsequent to the first and second steps.

12. Method according to one of claims 7 to 11, wherein the treatment liquid and/or the further treatment liquid comprises

-- hydrochloric acid in a concentration ranging from and including 150 g/l to and including 250 g/l and

-- FeCl_3 in a concentration ranging from and including 10 g/l to and including 35 g/l, especially in a concentration ranging from and including 15 g/l to and including 30 g/l or especially in a concentration ranging from and including 19 g/l to and including 26 g/l and,

-- FeCl_2 in a concentration ranging from and including 30 g/l to and including 300 g/l, especially in a concentration ranging from and including 30 g/l to and including 60 g/l or in a concentration

ranging from and including 130 g/l to and including 180 g/l or in a concentration ranging from and including 230 g/l to and including 300 g/l.

5

Patentansprüche

1. System zum Behandeln eines Stahlbands (1), insbesondere für eine Abbeizbehandlung des Stahlbands, mittels einer Behandlungsflüssigkeit in einer Behandlungsstation (3), wobei das System die Behandlungsstation (3) umfasst, wobei die Behandlungsstation (3) einen Behandlungsbehälter (4) mit einem Sprühbereich (13), einem Eintauchbereich (14) und der Behandlungsstation (3), die eine allgemeine Sammeleinrichtung (5) für die Behandlungsflüssigkeit umfasst, wobei die allgemeine Sammeleinrichtung (5) für die Behandlungsflüssigkeit sowohl des Sprühbereichs (13) als auch des Eintauchbereichs (14) eine Sammeleinrichtung (5) ist, die von dem Behandlungsbehälter (4) der Behandlungsstation (3) getrennt ist, wobei das Stahlband (1) aus Kohlenstoffstahl besteht und ein fortlaufendes Stahlband (1) ist, das sowohl in seiner Längs- als auch seiner Querrichtung im Wesentlichen horizontal ausgerichtet ist, wobei das Stahlband (1) eine obere Fläche (1') und eine untere Fläche (1'') aufweist, wobei das System ausgelegt ist, um das Stahlband (1) fortlaufend durch die Behandlungsstation (3) in einer Transportrichtung zu transportieren, wobei die Transportrichtung derart parallel zur Längsrichtung des Stahlbands (1) ist, dass

-- die Behandlungsflüssigkeit auf die obere Fläche (1') des Stahlbands (1) und auf die untere Fläche (1'') des Stahlbands (1) gesprüht wird, während das Stahlband (1) in dem Sprühbereich (13) der Behandlungsstation (3) ist,

-- das Stahlband (1) in die Behandlungsflüssigkeit eingetaucht wird, während das Stahlband (1) in dem Eintauchbereich (14) der Behandlungsstation (3) ist,

wobei das System derart ausgelegt ist, dass die Behandlungsflüssigkeit fortlaufend aus der allgemeinen Sammeleinrichtung (5) und durch sowohl den Sprühbereich (13) als auch den Eintauchbereich (14) der Behandlungsstation (3) gepumpt wird, wobei das System Sprühdüsen (15) umfasst, derart, dass die Behandlungsflüssigkeit auf die obere und die untere Fläche (1', 1'') des Stahlbands (1) unter Verwendung der Sprühdüsen (15) gesprüht wird.

2. System nach Anspruch 1, wobei der Sprühbereich (13) eine effektive Sprühlänge umfasst, die derart parallel zur Längsrichtung des Stahlbands (1) verläuft, dass die obere und die untere Fläche (1', 1'')

des Stahlbands (1) die Behandlungsflüssigkeit aufnehmen, während sie innerhalb der effektiven Sprühlänge angeordnet sind, wobei der Eintauchbereich (14) eine effektive Eintauchlänge umfasst, die derart parallel zur Längsrichtung des Stahlbands (1) verläuft, dass das Stahlband (1) - mit seiner oberen und seiner unteren Fläche (1', 1'') - in die Behandlungsflüssigkeit eingetaucht wird, während es innerhalb der effektiven Eintauchlänge angeordnet ist, wobei die effektive Sprühlänge und die effektive Eintauchlänge mit einem Verhältnis von zwischen und einschließlich 30:70 bis 70:30, insbesondere einem Verhältnis von 50:50, versehen sind.

3. System nach einem der Ansprüche 1 bis 2, wobei der Sprühbereich (14) - entlang der Transportrichtung des Stahlbands (1) - in Bezug auf den Eintauchbereich (15) stromaufwärts oder stromabwärts angeordnet ist.

4. System nach einem der Ansprüche 1 bis 3, wobei das System - neben der Behandlungsflüssigkeit in der Behandlungsstation (3) - eine weitere Behandlungsflüssigkeit in einer weiteren Behandlungsstation (31) umfasst, wobei die weitere Behandlungsstation (31) einen weiteren Behandlungsbehälter (41) mit einem weiteren Sprühbereich und einem weiteren Eintauchbereich umfasst, und wobei die weitere Behandlungsstation (31) eine weitere allgemeine Sammeleinrichtung (51) für die weitere Behandlungsflüssigkeit umfasst, wobei das System derart ausgelegt ist, dass das Stahlband (1) fortlaufend durch die weitere Behandlungsstation (31) derart in der Transportrichtung transportiert wird, dass

-- die weitere Behandlungsflüssigkeit auf die obere Fläche (1') des Stahlbands (1) und auf die untere Fläche (1'') des Stahlbands (1) gesprüht wird, während das Stahlband (1) in dem weiteren Sprühbereich der weiteren Behandlungsstation (31) ist,
 -- das Stahlband (1) in die weitere Behandlungsflüssigkeit eingetaucht wird, während das Stahlband (1) in dem weiteren Eintauchbereich der weiteren Behandlungsstation (31) ist,

wobei das System derart ausgelegt ist, dass die weitere Behandlungsflüssigkeit fortlaufend aus der weiteren allgemeinen Sammeleinrichtung (51) und durch sowohl den weiteren Sprühbereich als auch den weiteren Eintauchbereich der weiteren Behandlungsstation (31) gepumpt wird, wobei das System weitere Sprühdüsen umfasst, derart, dass die weitere Behandlungsflüssigkeit auf die obere und die untere Fläche (1', 1'') des Stahlbands (1) unter Verwendung der weiteren Sprühdüsen gesprüht wird.

5. System nach einem der Ansprüche 1 bis 4, wobei das System - neben der Behandlungsflüssigkeit in der Behandlungsstation (3) und der weiteren Behandlungsflüssigkeit in der weiteren Behandlungsstation (31) - eine dritte Behandlungsflüssigkeit in einer dritten Behandlungsstation (32) umfasst, wobei die dritte Behandlungsstation (32) einen dritten Behandlungsbehälter (42) mit einem dritten Sprühbereich und einem dritten Eintauchbereich umfasst, und die dritte Behandlungsstation (32) eine dritte allgemeine Sammeleinrichtung (52) für die dritte Behandlungsflüssigkeit umfasst.

6. System nach einem der Ansprüche 1 bis 5, wobei die Behandlungsflüssigkeit und/oder die weitere Behandlungsflüssigkeit und/oder die dritte Behandlungsflüssigkeit

-- Salzsäure in einer Konzentration im Bereich von und einschließlich 150 g/l bis und einschließlich 250 g/l und

-- FeCl₃ in einer Konzentration im Bereich von und einschließlich 10 g/l bis und einschließlich 35 g/l, insbesondere in einer Konzentration im Bereich von und einschließlich 15 g/l bis und einschließlich 30 g/l oder insbesondere in einer Konzentration im Bereich von und einschließlich 19 g/l bis und einschließlich 26 g/l, und

-- FeCl₂ in einer Konzentration im Bereich von und einschließlich 30 g/l bis und einschließlich 300 g/l, insbesondere in einer Konzentration im Bereich von und einschließlich 30 g/l bis und einschließlich 60 g/l oder in einer Konzentration im Bereich von und einschließlich 130 g/l bis und einschließlich 180 g/l oder in einer Konzentration im Bereich von und einschließlich 230 g/l bis und einschließlich 300 g/l,

umfasst.

7. Verfahren zum Behandeln eines Stahlbands (1), insbesondere für eine Abbeizbehandlung des Stahlbands (1), mittels einer Behandlungsflüssigkeit in einer Behandlungsstation (3), wobei die Behandlungsstation (3) einen Behandlungsbehälter (4) mit einem Sprühbereich (13) und einem Eintauchbereich (14) umfasst, und die Behandlungsstation (3) eine allgemeine Sammeleinrichtung (5) für die Behandlungsflüssigkeit umfasst, wobei die allgemeine Sammeleinrichtung (5) für die Behandlungsflüssigkeit sowohl des Sprühbereichs (13) als auch des Eintauchbereichs (14) eine Sammeleinrichtung (5) ist, die von dem Behandlungsbehälter (4) der Behandlungsstation (3) getrennt ist, wobei das Stahlband (1) aus Kohlenstoffstahl besteht und ein fortlaufendes Stahlband (1) ist, das sowohl in seiner Längs- als auch seiner Querrichtung im Wesentlichen horizontal ausgerichtet ist,

wobei das Stahlband (1) eine obere Fläche (1') und eine untere Fläche (1'') aufweist, wobei das Verfahren das fortlaufende Transportieren des Stahlbands (1) durch die Behandlungsstation (3) in einer Transportrichtung (2) umfasst, wobei die Transportrichtung derart parallel zur Längsrichtung des Stahlbands (1) ist, dass

- in einem ersten Schritt die Behandlungsflüssigkeit auf die obere Fläche (1') des Stahlbands (1) und auf die untere Fläche (1'') des Stahlbands (1) gesprüht wird, während das Stahlband (1) in dem Sprühbereich (13) der Behandlungsstation (3) ist,
- in einem zweiten Schritt das Stahlband (1) in die Behandlungsflüssigkeit eingetaucht wird, während das Stahlband (1) in dem Eintauchbereich (14) der Behandlungsstation (3) ist,

wobei beim Behandeln des Stahlbands (1) die Behandlungsflüssigkeit fortlaufend aus der allgemeinen Sammeleinrichtung (5) und durch sowohl den Sprühbereich (13) als auch den Eintauchbereich (14) der Behandlungsstation (3) gepumpt wird, wobei das Sprühen der Behandlungsflüssigkeit auf die obere und die untere Fläche (1', 1'') des Stahlbands (1) unter Verwendung der Sprühdüsen (15) bereitgestellt wird.

8. Verfahren nach Anspruch 7, wobei der Sprühbereich (13) eine effektive Sprühlänge umfasst, die derart parallel zur Längsrichtung des Stahlbands (1) verläuft, dass - während des ersten Schritts - die obere und die untere Fläche (1', 1'') des Stahlbands (1) die Behandlungsflüssigkeit aufnehmen, während sie innerhalb der effektiven Sprühlänge angeordnet sind, wobei der Eintauchbereich (14) eine effektive Eintauchlänge umfasst, die derart parallel zur Längsrichtung des Stahlbands (1) verläuft, dass - während des zweiten Schritts - das Stahlband (1) - mit seiner oberen und seiner unteren Fläche (1', 1'') - in die Behandlungsflüssigkeit eingetaucht wird, während es innerhalb der effektiven Eintauchlänge angeordnet ist, wobei die effektive Sprühlänge und die effektive Eintauchlänge mit einem Verhältnis von zwischen und einschließlich 30:70 bis 70:30, insbesondere einem Verhältnis von 50:50, versehen sind.
9. Verfahren nach einem der Ansprüche 7 bis 8, wobei die effektive Sprühlänge und daher das Verhältnis der effektiven Sprühlänge gegenüber der effektiven Eintauchlänge variiert wird, indem nur ein Teil der Sprühdüsen (15) aktiviert wird.
10. Verfahren nach einem der Ansprüche 7 bis 9, wobei der Sprühbereich (14) - entlang der Transportrichtung des Stahlbands (1) - in Bezug auf den Eintauchbereich (15) stromaufwärts oder stromabwärts an-

geordnet ist.

11. Verfahren nach einem der Ansprüche 7 bis 10, wobei das Verfahren - neben dem Verwenden der Behandlungsflüssigkeit in der Behandlungsstation (3) - das Verwenden einer weiteren Behandlungsflüssigkeit in einer weiteren Behandlungsstation (31) umfasst, wobei die weitere Behandlungsstation (31) einen weiteren Behandlungsbehälter (41) mit einem weiteren Sprühbereich und einem weiteren Eintauchbereich umfasst, und wobei die weitere Behandlungsstation (31) eine weitere allgemeine Sammeleinrichtung (51) für die weitere Behandlungsflüssigkeit umfasst, wobei das Verfahren das fortlaufende Transportieren des Stahlbands (1) durch die weitere Behandlungsstation (31) in der Transportrichtung umfasst, derart, dass

- in einem dritten Schritt die weitere Behandlungsflüssigkeit auf die obere Fläche (1') des Stahlbands (1) und auf die untere Fläche (1'') des Stahlbands (1) gesprüht wird, während das Stahlband (1) in dem weiteren Sprühbereich der weiteren Behandlungsstation (31) ist,
- in einem vierten Schritt das Stahlband (1) in die weitere Behandlungsflüssigkeit eingetaucht wird, während das Stahlband (1) in dem weiteren Eintauchbereich der weiteren Behandlungsstation (31) ist,

wobei während des Behandelns des Stahlbands (1) die weitere Behandlungsflüssigkeit fortlaufend aus der weiteren allgemeinen Sammeleinrichtung (51) und durch sowohl den weiteren Sprühbereich als auch den weiteren Eintauchbereich der weiteren Behandlungsstation (31) gepumpt wird, wobei das Sprühen der weiteren Behandlungsflüssigkeit auf die obere und die untere Fläche (1', 1'') des Stahlbands (1) unter Verwendung der weiteren Sprühdüsen bereitgestellt wird, wobei der dritte und der vierte Schritt dem ersten und dem zweiten Schritt vorangehen oder dem ersten und dem zweiten Schritt folgen.

12. Verfahren nach einem der Ansprüche 7 bis 11, wobei die Behandlungsflüssigkeit und/oder die weitere Behandlungsflüssigkeit
 - Salzsäure in einer Konzentration im Bereich von und einschließlich 150 g/l bis und einschließlich 250 g/l und
 - FeCl_3 in einer Konzentration im Bereich von und einschließlich 10 g/l bis und einschließlich 35 g/l, insbesondere in einer Konzentration im Bereich von und einschließlich 15 g/l bis und einschließlich 30 g/l oder insbesondere in einer Konzentration im Bereich von und einschließlich

19 g/l bis und einschließlich 26 g/l, und
 -- FeCl_2 in einer Konzentration im Bereich von
 und einschließlich 30 g/l bis und einschließlich
 300 g/l, insbesondere in einer Konzentration im
 Bereich von et/ou 30 g/l bis et/ou
 60 g/l ou dans une concentration
 im Bereich von et/ou 130 g/l bis et/ou
 180 g/l ou dans une concentrati-
 on im Bereich von et/ou 230 g/l bis
 et/ou 300 g/l,

umfasst.

Revendications

1. Système pour le traitement d'une bande d'acier (1), en particulier pour un traitement de décapage de la bande d'acier, au moyen d'un liquide de traitement dans une station de traitement (3), le système comprenant la station de traitement (3), la station de traitement (3) comprenant un bac de traitement (4) pourvu d'une section de pulvérisation (13), d'une section d'immersion (14) et la station de traitement (3) comprenant un moyen de récupération commun (5) pour le liquide de traitement, le moyen de récupération commun (5) pour le liquide traitement à la fois de la section de pulvérisation (13) et de la section d'immersion (14) étant un moyen de récupération (5) séparé du bac de traitement (4) de la station de traitement (3), la bande d'acier (1) étant constituée d'acier ordinaire et étant une bande d'acier continue (1) qui est orientée pratiquement horizontalement, à la fois dans ses directions longitudinale et transversale, la bande d'acier (1) ayant une surface supérieure (1') et une surface inférieure (1''), le système étant conçu pour transporter la bande d'acier (1) en continu dans la station de traitement (3) dans une direction de transport, la direction de transport étant parallèle à la direction longitudinale de la bande d'acier (1), de façon telle que

- le liquide de traitement est pulvérisé sur la surface supérieure (1') de la bande d'acier (1) et sur la surface inférieure (1'') de la bande d'acier (1) alors que la bande d'acier (1) est dans la section de pulvérisation (13) de la station de traitement (3),
- la bande d'acier (1) est immergée dans le liquide de traitement alors que la bande d'acier (1) est dans la section d'immersion (14) de la station de traitement (3),

le système étant conçu de façon telle que le liquide de traitement est pompé en continu à partir du moyen de récupération commun (5) et pour l'amener à passer à la fois dans la section de pulvérisation (13) et dans la section d'immersion (14) de la station de

traitement (3), le système comprenant des buses de pulvérisation (15) de façon telle que le liquide de traitement est pulvérisé sur les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) à l'aide des buses de pulvérisation (15).

2. Système selon la revendication 1, dans lequel la section de pulvérisation (13) comprend une longueur de pulvérisation efficace parallèlement à la direction longitudinale de la bande d'acier (1) de façon telle que les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) reçoivent le liquide de traitement alors qu'elles sont situées sur la longueur de pulvérisation efficace, dans lequel la section d'immersion (14) comprend une longueur d'immersion efficace parallèlement à la direction longitudinale de la bande d'acier (1) de façon telle que la bande d'acier (1) est immergée, avec ses surfaces supérieure et inférieure (1', 1''), dans le liquide de traitement alors qu'elle est située sur la longueur d'immersion efficace, la longueur de pulvérisation efficace et la longueur d'immersion efficace étant prévues pour avoir un rapport entre 30:70 et 70:30 inclus, en particulier un rapport de 50:50.
3. Système selon l'une des revendications 1 à 2, dans lequel, le long de la direction de transport de la bande d'acier (1), la section de pulvérisation (14) est située en amont ou en aval par rapport à la section d'immersion (15).
4. Système selon l'une des revendications 1 à 3, le système comprenant, outre le liquide de traitement dans la station de traitement (3), un autre liquide de traitement dans une autre station de traitement (31), l'autre station de traitement (31) comprenant un autre bac de traitement (41) pourvu d'une autre section de pulvérisation et d'une autre section d'immersion et l'autre station de traitement (31) comprenant un autre moyen de récupération commun (51) pour l'autre liquide de traitement, le système étant conçu de façon telle que la bande d'acier (1) est transportée en continu dans l'autre station de traitement (31) dans la direction de transport de façon telle que
 - l'autre liquide de traitement est pulvérisé sur la surface supérieure (1') de la bande d'acier (1) et sur la surface inférieure (1'') de la bande d'acier (1) alors que la bande d'acier (1) est dans l'autre section de pulvérisation de l'autre station de traitement (31),
 - la bande d'acier (1) est immergée dans l'autre liquide de traitement alors que la bande d'acier (1) est dans l'autre section d'immersion de l'autre station de traitement (31),

le système étant conçu de façon telle que l'autre li-

guide de traitement est pompé en continu à partir de l'autre moyen de récupération commun (51) et pour l'amener à passer à la fois dans l'autre section de pulvérisation et dans l'autre section d'immersion de l'autre station de traitement (31), le système comprenant d'autres buses de pulvérisation de façon telle que l'autre liquide de traitement est pulvérisé sur les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) à l'aide des autres buses de pulvérisation.

5. Système selon l'une des revendications 1 à 4, le système comprenant, outre le liquide de traitement dans la station de traitement (3) et l'autre liquide de traitement dans l'autre station de traitement (31), un troisième liquide de traitement dans une troisième station de traitement (32), la troisième station de traitement (32) comprenant un troisième bac de traitement (42) pourvu d'une troisième section de pulvérisation et d'une troisième section d'immersion et la troisième station de traitement (32) comprenant un troisième moyen de récupération commun (52) pour le troisième liquide de traitement.

6. Système selon l'une des revendications 1 à 5, dans lequel le liquide de traitement et/ou l'autre liquide de traitement et/ou le troisième liquide de traitement comprennent

- de l'acide chlorhydrique en une concentration allant de 150 g/l inclus à 250 g/l inclus et
- du FeCl_3 en une concentration allant de 10 g/l inclus à 35 g/l inclus, en particulier en une concentration allant de 15 g/l inclus à 30 g/l inclus ou en particulier en une concentration allant de 19 g/l inclus à 26 g/l inclus, et
- du FeCl_2 en une concentration allant de 30 g/l inclus à 300 g/l inclus, en particulier en une concentration allant de 30 g/l inclus à 60 g/l inclus ou en une concentration allant de 130 g/l inclus à 180 g/l inclus ou en une concentration allant de 230 g/l inclus à 300 g/l inclus.

7. Procédé pour le traitement d'une bande d'acier (1), en particulier pour un traitement de décapage de la bande d'acier (1), au moyen d'un liquide de traitement dans une station de traitement (3), la station de traitement (3) comprenant un bac de traitement (4) pourvu d'une section de pulvérisation (13) et d'une section d'immersion (14) et la station de traitement (3) comprenant un moyen de récupération commun (5) pour le liquide de traitement, dans lequel le moyen de récupération commun (5) pour le liquide de traitement à la fois de la section de pulvérisation (13) et de la section d'immersion (14) est un moyen de récupération (5) séparé du bac de traitement (4) de la station de traitement (3), dans lequel la bande d'acier (1) est constituée d'acier ordinaire et est une

bande d'acier continue (1) qui est orientée pratiquement horizontalement, à la fois dans ses directions longitudinale et transversale, dans lequel la bande d'acier (1) a une surface supérieure (1') et une surface inférieure (1''), le procédé comprenant le transport de la bande d'acier (1) en continu dans la station de traitement (3) dans une direction de transport (2), la direction de transport étant parallèle à la direction longitudinale de la bande d'acier (1), de façon telle que

- dans une première étape, le liquide de traitement est pulvérisé sur la surface supérieure (1') de la bande d'acier (1) et sur la surface inférieure (1'') de la bande d'acier (1) alors que la bande d'acier (1) est dans la section de pulvérisation (13) de la station de traitement (3),
- dans une seconde étape, la bande d'acier (1) est immergée dans le liquide de traitement alors que la bande d'acier (1) est dans la section d'immersion (14) de la station de traitement (3),

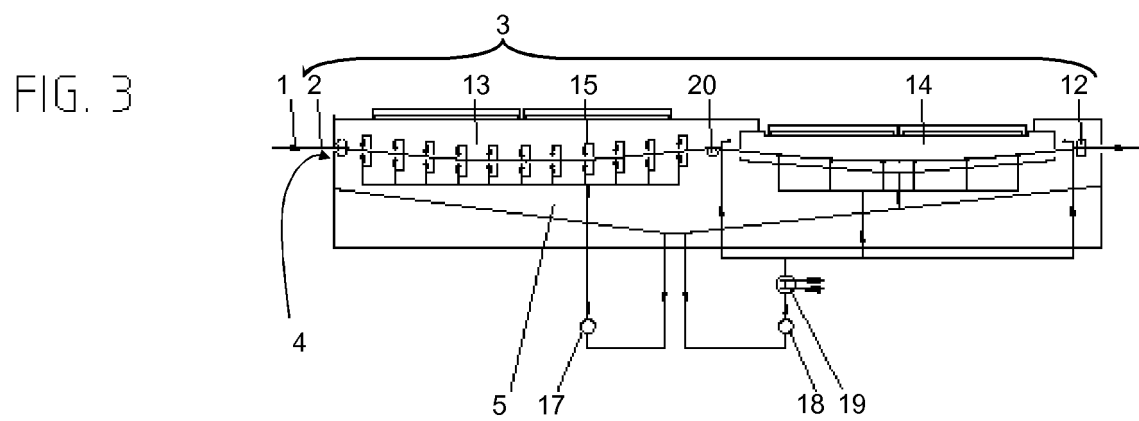
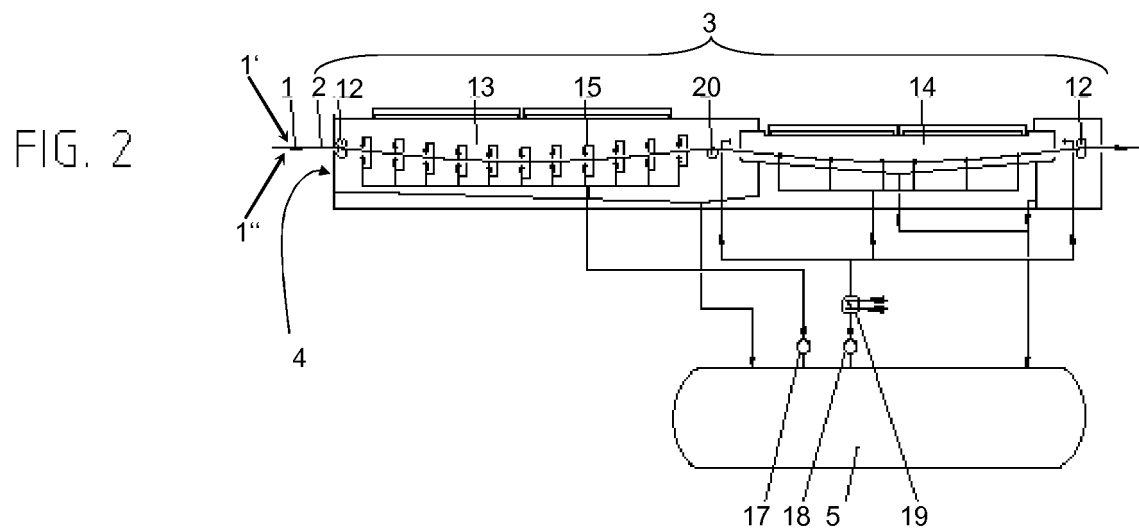
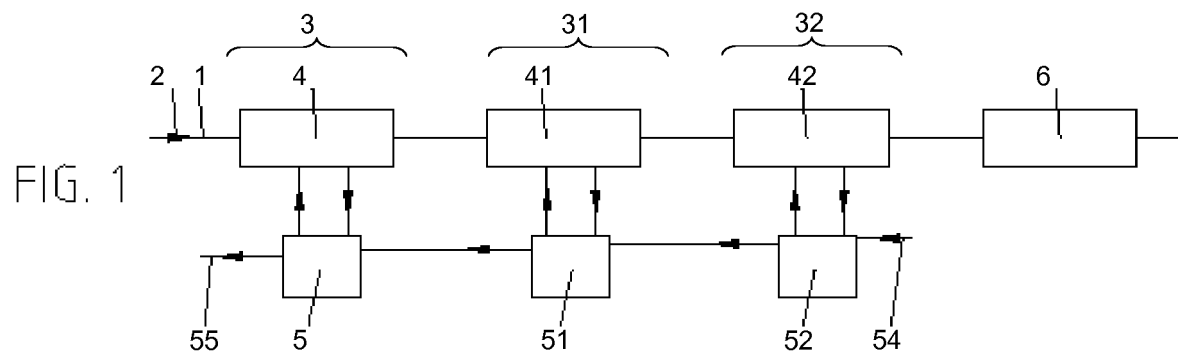
dans lequel, pendant le traitement de la bande d'acier (1), le liquide de traitement est pompé en continu à partir du moyen de récupération commun (5) et pour l'amener à passer à la fois dans la section de pulvérisation (13) et dans la section d'immersion (14) de la station de traitement (3), dans lequel la pulvérisation du liquide de traitement sur les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) est assurée par des buses de pulvérisation (15).

8. Procédé selon la revendication 7, dans lequel la section de pulvérisation (13) comprend une longueur de pulvérisation efficace parallèlement à la direction longitudinale de la bande d'acier (1) de façon telle que, pendant la première étape, les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) reçoivent le liquide de traitement alors qu'elles sont situées sur la longueur de pulvérisation efficace, dans lequel la section d'immersion (14) comprend une longueur d'immersion efficace parallèlement à la direction longitudinale de la bande d'acier (1) de façon telle que, pendant la seconde étape, la bande d'acier (1) est immergée, avec ses surfaces supérieure et inférieure (1', 1''), dans le liquide de traitement alors qu'elle est située sur la longueur d'immersion efficace, la longueur de pulvérisation efficace et la longueur d'immersion efficace étant prévues pour avoir un rapport entre 30:70 et 70:30 inclus, en particulier un rapport de 50:50.
9. Procédé selon l'une des revendications 7 à 8, dans lequel la longueur de pulvérisation efficace, et donc le rapport de la longueur de pulvérisation efficace à la longueur d'immersion efficace, est amenée à varier par activation de seulement une partie des buses

de pulvérisation (15).

10. Procédé selon l'une des revendications 7 à 9, dans lequel, le long de la direction de transport de la bande d'acier (1), la section de pulvérisation (14) est située en amont ou en aval par rapport à la section d'immersion (15). 5
11. Procédé selon l'une des revendications 7 à 10, le procédé comprenant, outre l'utilisation du liquide de traitement dans la station de traitement (3), l'utilisation d'un autre liquide de traitement dans une autre station de traitement (31), l'autre station de traitement (31) comprenant un autre bac de traitement (41) pourvu d'une autre section de pulvérisation et d'une autre section d'immersion et l'autre station de traitement (31) comprenant un autre moyen de récupération commun (51) pour l'autre liquide de traitement, 10
- le procédé comprenant le transport de la bande d'acier (1) en continu dans l'autre station de traitement (31) dans la direction de transport de façon telle que 20
- dans une troisième étape, l'autre liquide de traitement est pulvérisé sur la surface supérieure (1') de la bande d'acier (1) et sur la surface inférieure (1'') de la bande d'acier (1) alors que la bande d'acier (1) est dans l'autre section de pulvérisation de l'autre station de traitement (31), 25 30
 - dans une quatrième étape, la bande d'acier (1) est immergée dans l'autre liquide de traitement alors que la bande d'acier (1) est dans l'autre section d'immersion de l'autre station de traitement (31), 35
- dans lequel, pendant le traitement de la bande d'acier (1), l'autre liquide de traitement est pompé en continu à partir de l'autre moyen de récupération commun (51) et pour l'amener à passer à la fois dans l'autre section de pulvérisation et dans l'autre section d'immersion de l'autre station de traitement (31), dans lequel la pulvérisation de l'autre liquide de traitement sur les surfaces supérieure et inférieure (1', 1'') de la bande d'acier (1) est assurée par d'autres buses de pulvérisation, dans lequel les troisième et quatrième étapes précèdent les première et deuxième étapes ou suivent les première et deuxième étapes. 40 45 50
12. Procédé selon l'une des revendications 7 à 11, dans lequel le liquide de traitement et/ou l'autre liquide de traitement comprennent 55
- de l'acide chlorhydrique en une concentration allant de 150 g/l inclus à 250 g/l inclus et
 - du FeCl_3 en une concentration allant de 10 g/l inclus à 35 g/l inclus, en particulier en une con-

centration allant de 15 g/l inclus à 30 g/l inclus ou en particulier en une concentration allant de 19 g/l inclus à 26 g/l inclus, et
- du FeCl_2 en une concentration allant de 30 g/l inclus à 300 g/l inclus, en particulier en une concentration allant de 30 g/l inclus à 60 g/l inclus ou en une concentration allant de 130 g/l inclus à 180 g/l inclus ou en une concentration allant de 230 g/l inclus à 300 g/l inclus.



REFERENCES CITED IN THE DESCRIPTION

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