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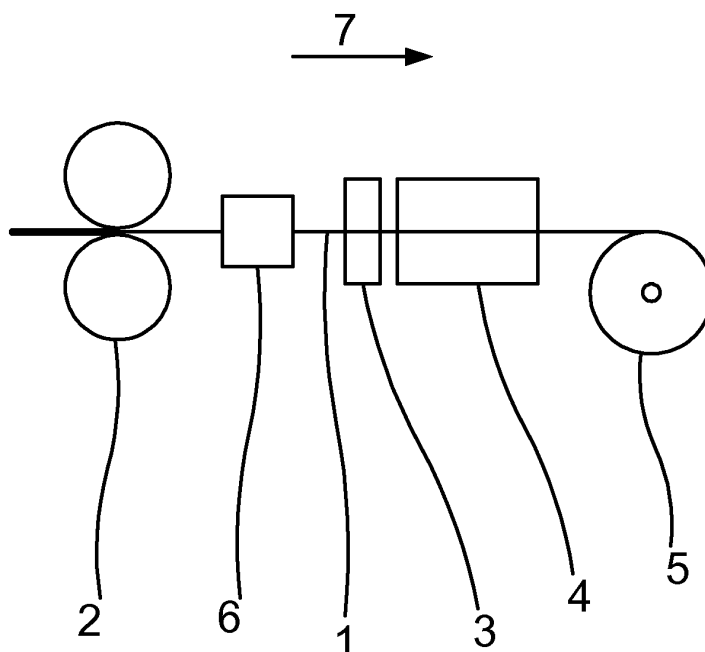
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(54) **Method for annealing metal strips**

(57) Method for use when hot rolling steel strips (1), where the strip (1) in a first step is hot rolled, in a second step is annealed, and where it finally is coiled for storage, transport or additional processing.

The invention is **characterised in that** the annealing is caused to take place in an annealing furnace (4) through which the strip (1) is transported after the hot rolling but before the coiling.

Fig. 1



Description

[0001] The present invention relates to hot rolling of steel strips. More precisely, the invention relates to a method for annealing of steel strips in connection with such hot rolling.

[0002] Today, strips of stainless steel are manufactured by rolling in for example Steckel type rolling mills, in which the strip is hot rolled in several steps between which steps the strip is coiled. Another type of rolling mills is those of tandem type, in which hot rolling takes place at several parallel stations. Typically, hot rolling takes place at a temperature of about 900°C - 1200°C, and is followed firstly by an annealing step at typically about 1100°C - 1200°C and thereafter by a pickling step.

[0003] Conventionally, strips have been let to cool down between hot rolling and annealing, and the strip has been reheated to the desired annealing temperature. This has resulted in an unnecessarily large energy consumption, as well as unnecessarily heavy material deterioration, among other things as a consequence of oxide scaling, and consequently leading to increased needs for cleaning and pickling.

[0004] In the article "Direktglühen - neue Strasse im Fertigungsverfahren von ferritischem, rostfreiem Stahl in Betrieb genommen", published in the journal GAS-WÄRME International (53) No. 7/2004, a method is disclosed in which the coiled steel strip is placed in an annealing furnace immediately following the last hot rolling step. Hereby, a large part of the thermal energy of the strip may be recovered for the annealing step.

[0005] However, it takes a non negligible period of time to heat such a steel strip coil from rolling temperature to annealing temperature, since heat conduction in the material is limited. Furthermore, during the heating process there are additional energy losses from which the material cannot benefit.

[0006] It is also possible to heat a rolled coiled strip by the use of induction heating. This is associated with smaller losses of energy. However, such heating is sensitive for the dimensions and geometry of the material, as well as for the distance between the heat source and the heated material, and plants for induction heating are also quite costly.

[0007] Moreover, in order for the handling of the coils between the rolling and the annealing not to unacceptably affect the rate of production, expensive logistics equipment is often required.

[0008] The present invention solves the above described problems.

[0009] Thus, the invention relates to a method for use when hot rolling steel strips, where the strip in a first step is hot rolled, in a second step is annealed, and where it finally is coiled for storage, transport or additional processing, and is **characterised in that** the annealing is caused to be performed in an annealing furnace through which the strip is transported after the hot rolling but before the coiling.

[0010] In the following, the invention will be described in detail, with reference to exemplifying embodiments of the invention and to the appended drawing, in which:

[0011] Figure 1 is an overview over a method according to the present invention.

[0012] A strip made of steel, preferably stainless steel, 1 is hot rolled in a hot rolling step 2. Preferably, the hot rolling takes place in a rolling mill of Steckel type, but it may also take place in a rolling mill of tandem type. The rolling temperature is conventional and typically lies between 900°C and 1200°C.

[0013] After the rolling, the strip 1 is transported, continuously and in the direction as indicated by the arrow 7, up to and through an annealing furnace 4, in which the strip 1 is annealed. According to a preferred embodiment, the annealing takes place at an essentially constant temperature of between 1100°C and 1200°C.

[0014] After annealing, the strip 1 is further transported to a coiling station 5, where the strip 1 is coiled on a roll for storage, transport or additional processing, such as a cold rolling step.

[0015] Thus, annealing is caused to be carried out on the not yet coiled strip 1. Hereby, higher efficiency and better use of resources in the heating of the strip 1 to annealing temperature is achieved. Furthermore, this heating is quicker than in case the coiled strip had been heated to annealing temperature. Only after annealing, the strip 1 is coiled at the coiling station 5.

[0016] According to a preferred embodiment, the annealing furnace 4 is heated by at least one oxyfuel burner. Preferably, the oxyfuel burner is driven with a gaseous fuel, such as natural gas or propane, and an oxidant with an oxygen content of at least 80 percentages by weight.

[0017] In case one or several such burners are used in an annealing furnace 4 of the type described herein, the addition advantage is achieved that the heating efficiency increases further in comparison to annealing furnaces being heated by conventional air burners, and the heating is energy efficient even at the elevated temperatures at which annealing is performed.

[0018] According to a preferred embodiment, the annealing furnace 4 is a tunnel furnace, and annealing of the strip 1 takes place continuously since the strip 1 is transported through the annealing furnace 4 with essentially constant velocity. Thus, the strip 1 may be moving all the time, with no operation interruptions, until it has been coiled at the coiling station 5.

[0019] According to a preferred embodiment, before annealing but after rolling, the strip 1 is caused to cool down from rolling temperature to a transformation temperature, at which precipitation and/or recrystallisation takes place in the material of the strip 1. According to a preferred embodiment, this transformation temperature is below about 400°C. This cooling down is performed in a conventional manner *per se* in a cooling down station 6.

[0020] According to a preferred embodiment, it is possible to temporarily refrain from the cooling down step by disconnecting the function of the cooling down station 6

from the process. In this way, cooling down may be performed only when necessary, depending on the material of the strip 1, desired final result, etc., however the cooling down function may be reconnected again when so is desired. In other words, an increased flexibility is achieved in the process, without adding any serious drawback as to its efficiency.

[0021] In order to quickly boost the temperature of the strip 1 before the annealing step and after the rolling step 2 or the cooling down step 6, according to a preferred embodiment one or several DFI burners are used in a preheating step 3. Preferably, the DFI burners are driven with a gaseous fuel, such as propane or natural gas, and an oxidant with an oxygen content of at least 80 percentages by weight.

[0022] According to a preferred embodiment, the strip 1 is heated so that it essentially reaches the desired annealing temperature before it leaves the preheating step 3. In this way, the strip 1 has the correct temperature even before it is brought into the annealing furnace 3, whereby annealing does not have to last longer than necessary.

[0023] In case a disconnectable cooling down step is used, according to the above said, according to a preferred embodiment the preheating step 3 is also arranged so that its power may be adapted to the temperature of the strip 1 at the entry into the preheating step 3. By way of example, this may be achieved by controlling the number of simultaneously switched on DFI burners, by controlling the power of the DFI burners, etc. In this way, a suitable preheating can be achieved, regardless of if a cooling down step is performed or not.

[0024] According to yet another preferred embodiment, the annealing furnace 4 itself comprises one or several DFI burners, of the type described above, that in combination with one or several oxyfuel burners achieve the annealing of the strip 1.

[0025] Hence, by using a method according to the present inventions, a cheap, fast and efficient annealing of hot rolled steel strips is achieved, with no unnecessary thermal losses. Moreover, the annealing is not sensitive for neither the dimensions and the geometrical design of the preheated material, nor the distance between the heat source and the material, which is the case when using for example induction heating.

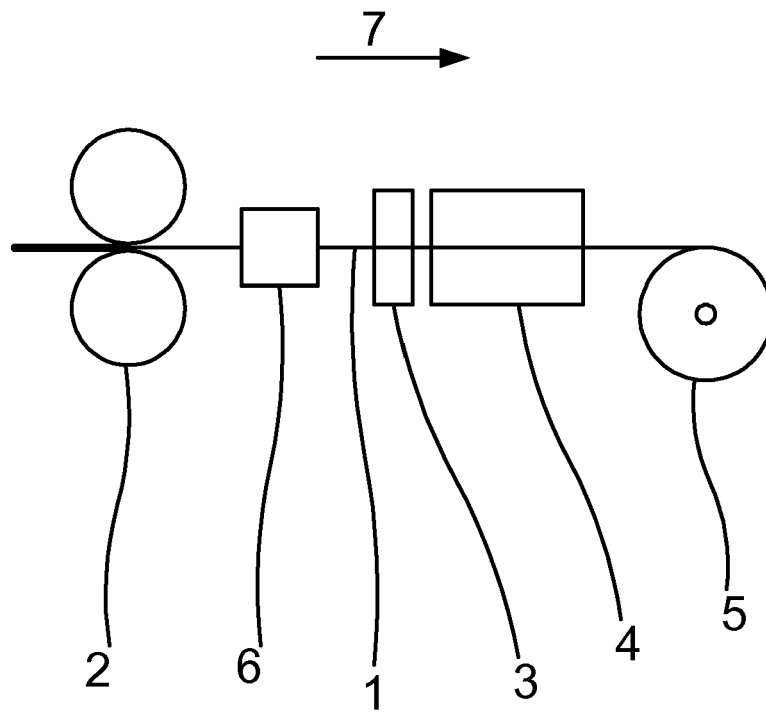
[0026] Furthermore, the extra processing step implied by having a separately arranged annealing furnace for coiled steel strips may be eliminated, which saves time as well as space, and which leads to increased production capacity, but also to diminished costs in terms of installation and maintenance.

[0027] Above, preferred embodiments have been described. However, it is apparent for the skilled person that many modifications may be made to the described embodiments without departing from the spirit of the invention. Thus, the invention shall not be limited by the described embodiments, but may be varied within the frame of the enclosed claims.

Claims

1. Method for use when hot rolling steel strips (1), where the strip (1) in a first step is hot rolled, in a second step is annealed, and where it finally is coiled for storage, transport or additional processing, **characterised in that** the annealing is caused to take place in an annealing furnace (4) through which the strip (1) is transported after the hot rolling but before the coiling.
2. Method according to claim 1, **characterised in that** the additional processing step is caused to be comprised of cold rolling.
3. Method according to claim 1 or 2, **characterised in that** the strip (1) is caused to be cooled down to a temperature below the transformation temperature for recrystallisation and/or precipitation of the material before the annealing.
4. Method according to any one of the preceding claims, **characterised in that** the annealing is caused to take place at an essentially constant temperature of between 1100°C and 1200°C.
5. Method according to any one of the preceding claims, **characterised in that** the rolling is caused to be performed in a rolling mill of Steckel type.
6. Method according to any one of the preceding claims, **characterised in that** the annealing furnace (4) is caused to be heated by at least one oxyfuel burner.
7. Method according to any one of the preceding claims, **characterised in that** the strip (1) is caused to be preheated by at least one DFI burner.
8. Method according to claim 7, **characterised in that** the strip (1) is caused to be preheated to the annealing temperature of the material.
9. Method according to claim 7 or 8, **characterised in that** the DFI burner is caused to be arranged along the transportation path of the strip (1) between the rolling step and the annealing step.
10. Method according to any one of the preceding claims, **characterised in that** the annealing furnace (4) is a tunnel furnace, and **in that** the annealing of the strip (1) is caused to be performed continuously by the strip (1) being transported through the annealing furnace (4) with a constant velocity.

Fig. 1





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Place of search Munich		Date of completion of the search 2 December 2008	Examiner Gavriliu, Alexandru
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