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(54) **HEAT PIPE ASSISTED STRIP HEAT TREATMENT**

WÄRMEBEHANDLUNG VON BANDSTAHL MIT HILFE EINES HEIZROHRS

TRAITEMENT THERMIQUE DE BANDE ASSISTÉ PAR UN CALODUC

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WO-A1-2009/007362 JP-A- 57 164 932

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a method of processing a strip following a strip path by heating or cooling wherein the strip is brought into contact with a roller wherein the roller comprises a heat pipe, wherein the roller simultaneously heats a first strip and cools a second strip. Such a method may be practised on a steel strip, for example in a strip processing line such as a continuous annealing line. The invention further relates to an apparatus for carrying out said method and the use thereof.

[0002] An object of the invention is to develop a method and installation that will be much more energy efficient, while delivering similar or better process conditions and controllability. According to the invention extensive heat recovery is feasible.

BACKGROUND OF THE INVENTION

[0003] The use of heat conductive rollers in heating or cooling in processing lines per se is known. Patent application WO2009/007362 discloses a system where a strip surrenders its heat to the rolls and is thereby cooled. The rolls revolve and surrender their heat to a cold strip the footprint of which largely or fully overlaps that of the hot strip, the strip contacting the roller over the same part of its width corresponding with the footprint-overlap, but at another portion of the roller's circumference.

[0004] The heat conductive roller with integrated heat pipe used in an arrangement according to WO2009/007362 referred to above has the advantage that it is simple and the strip direction only needs to be reversed on a turn roll. The disadvantages are that the heat is transported mostly by conduction so the smoothening effects for temperature gradients across the strip width is limited. The heat and cool cycle for the roll shell in each revolution will also result in a high fatigue load due to thermal expansion and contraction.

[0005] This concept is improved according to EP180851. Here the rolls are filled with a working fluid in order to act as a so called heat pipe. This achieves the effect that any temperature gradients developing across the width of the strip will be passed from the cooling side to the heating side will be smoothened.

[0006] A heat pipe per se is known from <http://www.cheresources.com/htpipes.shtml>.

SUMMARY OF THE INVENTION

[0007] The invention provides in fact another type of heat exchanging process for strip in a processing line. According to the invention, the dimensions of the roller and the lay-out of the strip paths are chosen such that the footprint on the roller of the first strip to be heated and the footprint on the roller of the second strip to be cooled, do not overlap. This means that the roller has a width of more than the sum of the width of the hot strip to be cooled down and the width of the cold strip to be heated up so as to enable the roll to simultaneously act with the two strip parts that essentially run side by side.

[0008] According to the invention the hot strip surrenders its heat to a roll through the roll shell to a working fluid that is contained in a heat pipe integrated in the roll, causing evaporation of the working fluid in the relevant part of the roller hereinafter named evaporator zone. The working fluid vapour flows to the cooler part of the roller, hereinafter named the condenser section and condenses there. The condensation heat is passed through the roll shell to heat the cold strip that cooperates with the complementary part of the roll. Both the evaporator and condenser sections of the heat pipe are located in a single cylindrical shell part of one and the same roller, so that there necessarily is an offset between the strips. For the avoidance of doubt it should be understood that the heat pipe extends essentially along the axial length of the roller having a length of more than the sum of a first strip width to be heated and a second strip width to be cooled.

[0009] It will be clear that the strip to be heated and the strip to be cooled may be part of the same uncut strip, in which case the line arrangement will have to be such that the strip is turned and led so as to be running side by side with itself at the roller in question.

[0010] For example, in a continuous annealing line according to the invention the heat that is continuously extracted in the cooling section of a continuous annealing line is re-used to heat the strip up to soaking temperature, see also Figure 1. If a process according to the invention is put into practice, the design of such an installation will have to be adapted by having the cooling section and the heating section of such a line in adjacent locations.

[0011] Experiments show that practising the invention allows heat flux densities that exceed those of the conventional current state of the art radiant tube heated processing lines. The larger heat flux densities enable compact installations.

[0012] It has turned out that, compared to a conventional continuous annealing line, a reduction in fuel consumption of more than 30 - 50 %, even up to 70% is feasible. Also, CO₂ emissions may be greatly reduced. Typically, possible

savings (at early 2009 prices in W-Europe) in an average steel strip continuous annealing line are in excess of 2.5 M€/a for a 1 Mton/a installation.

[0013] The advantage of operating according to the invention is that the heat is transported in near steady state, which drastically reduces the fatigue load on the heat pipe shell. In addition, temperature gradients across the strip width will not be transferred to the reverse side, because of the separation of heating and cooling sections of the cylinders. Strip reversal and/or offset can be realised using gas cushion or roller offset sections.

[0014] In conventional furnaces the strip is heated up by heating up the furnace to temperatures well above the desired strip temperature. The high temperature difference between furnace and strip is the force in driving the heat into the strip at an acceptable rate. Because the furnace refractory and radiant tubes have a large heat content compared to the strip, changes in line speed will immediately lead to a changed strip temperature. To prevent this the conventional line must preferably be kept at a constant speed. This is established by implementing looper towers at the entry and exit, so that the line speed at entry and exit can be varied without changing the line speed inside the furnace. This flexibility in line speed at entry and exit is required to weld together coils at the entry, creating a continuous strip, and separating them again at the exit.

[0015] For the heat pipe concept the heat pipe fluid temperatures are very close to the strip temperatures. Due to these only slight temperature differences, overheating in case of speed changes and line stops will be very limited to only a couple of degrees. Looper towers are therefore not required, which greatly reduces capital expenditure to build such a line as well as maintenance cost.

[0016] The heat densities that can be achieved with heat pipes are substantially higher than in conventional lines. The exposed strip lengths to heat up and cool down the strip can therefore be much smaller than in conventional furnaces allowing again an installation that can be more compact resulting in lower capital expenditure and operating cost.

BRIEF DESCRIPTION OF THE DRAWING

[0017] The invention is illustrated in the drawings comprising

figure 1 showing schematically the heat transfer from a cooling section of a steel strip continuous annealing line to the heating section;

figure 2 showing a strip heating and cooling processing line roller arrangement according to the invention in side view;

figure 3 schematically showing the arrangement shown in figure 2 seen from above.

[0018] In continuous heat treatment installations for strip, the strip is paid off at the start of the line, heated, soaked, cooled, over-aged and recoiled at the end of the line. The current state of the art in this type of heat treatment is that the strip is heated using one or more gas fired furnaces with possibly additional capacity installed in an inductive heating section. The strip is maintained at a high temperature for a limited time to anneal, after which the strip is cooled using a convective cooling system with protective gas and possibly a final cooling in the form of a quench.

[0019] Basically all energy inserted into the strip in the heating section needs to be extracted again in the cooling sections of the installation.

[0020] Because the amounts of heat to be inserted and extracted from the strip are almost exactly matched and because the heating and cooling sections are in close proximity, the present invention is ideally suited to be applied in such an installation.

[0021] The invention enables transport of heat with an apparent conductivity greater than copper, the most efficient industrial conductor material applied today, provides an installation that will be much more energy efficient, while delivering similar or better process conditions and controllability.

[0022] In fig. 2 an example for a cycle at 600°C is shown where a strip is paid off and fed via a roller 9 into a roller arrangement consecutively passing roller 16 at 150 °C, roller 15 at 240 °C, roller 14 at 330 °C, roller 13 at 420 °C, roller 12 at 510 °C and roller 11 at 600 °C.

[0023] Subsequently the strip is led via a roller 9 to a heater 10, then travels to a soaking section, is reversed and offset, to return to roller denoted as 1 having a temperature of also 600 °C, roller 1 being the other side of roller 11, as can be seen in the top view of fig. 3. It should be understood that roller 1 and roller 11 are complementary parts of one and the same roller 1, 11 comprising one shared heat pipe. The same applies to the roller parts 2 12, 3 13, 4 14, 5 15 and 6 16 respectively.

[0024] Subsequently the strip passes roller 2 at 510 °C and roller 3 at 420 °C. Then the strip is subjected to over-aging at roller 7 at 420 °C, cooled and passed on to roller 4 at 330 °C.

[0025] Finally the strip passes roller 5 at 240 °C, roller 6 at 150 °C, roller 9 and cooling section 8 whereafter it travels towards the coiler.

[0026] To summarise, the roller halves 16, 15, 14, 13, 12 and 11 are to be regarded as heat pipe condenser sections that heat the strip from 150°C to 600 °C and the roller halves 1, 2, 3, 4, 5 and 6 as heat pipe evaporator sections that

cool the strip down from 600 °C to 150 °C.

[0027] The complete temperature cycle for strip, nickel plated strip and tin plate processing can be achieved with a minimum of four working fluids, namely water, mercury, sodium and Thermex®, wherein Thermex® comprises a mixture of propylene glycol, dipotassium phosphate and deionised water. Another working fluid that can be used is Dowtherm A®, which is a diphenyl oxide/biphenyl blend.

[0028] The working temperature for these four media, ranges from 30°C up to 1200°C (Table 1). This is more than sufficient for processing low carbon steel up to and beyond normalization temperature and for annealing and normalising a nickel plated strip, having a normalisation temperature of up to 1050°C. Caesium or potassium can be added as working fluids to keep normal operation pressures limited.

[0029] The strip temperature drops over each roller in the cooling pass fuels an equal temperature rise of the same roll in the heating pass. Because of this effect only the final heating and final cooling need to be done in a conventional way.

Table 1: Heat pipe media for 30-1200°C range.

Medium	Melting point	Boiling point (atmospheric)	Useful range	
	[°C]	[°C]	[°C]	
Water	0	100	30	200
Thermex ®	12	257	150	350
Mercury	-39	361	250	650
Sodium	98	892	600	1200
To prevent the deterioration of the working liquid over time due to reaction with a heat pipe container material or contaminants present on an inner surface of the container material, it is preferred to use stainless steel container materials in the presence of Thermex®, mercury and sodium, whereas in the presence of water, mild steel or copper container materials are preferred.				

Claims

1. Method of processing a strip following a strip path by heating or cooling wherein the strip is brought into contact with a roller wherein the roller comprises a heat pipe, wherein the roller simultaneously heats a first strip and cools a second strip, **characterised in that** the dimensions of the roller and the lay-out of the strip paths are chosen such that the footprint of the first strip on the roller and the footprint of the second strip on the roller do not overlap.
2. Method of processing a strip according to claim 1, wherein the first strip and the second strip are part of the same uncut strip.
3. Method of processing a strip according to claim 1 or claim 2, wherein the strip is processed in a continuous annealing line.
4. Method of processing a strip according to any one of the preceding claims, wherein the first strip is heated to a temperature in the range of 150°C to 1050°C, preferably in the range of 150°C to 600°C.
5. Method of processing a strip according to any one of the preceding claims, wherein the second strip is cooled to a temperature in the range of 1050°C to 150°C, preferably in the range of 600°C to 150°C.
6. Method of processing a strip according to any one of the preceding claims, wherein the strip is a steel strip, a nickel plated strip or a tin plate.
7. A strip processing apparatus, which comprises a roller and an integrated heat pipe, the heat pipe comprising a working fluid, an evaporation section for evaporating the working fluid and a condensation section for condensing the evaporated working fluid, wherein the heat pipe extends essentially along the axial length of the roller having a length of more than the sum of a first strip width to be heated and a second strip width to be cooled.
8. The use of the strip processing apparatus according to claim 7 in a continuous annealing line.

Patentansprüche

1. Verfahren zur Verarbeitung eines Bands das eine Bandbahn durch Erwärmen oder Kühlen folgt, wobei das Band mit einer Walze in Kontakt gebracht wird, wobei die Walze ein Heizrohr umfasst, wobei die Walze simultan ein erstes Band erwärmt und ein zweites Band kühlt, **dadurch gekennzeichnet, dass** die Abmessungen der Walze und das Layout der Bandbahnen derart gewählt werden, dass sich das Profil des ersten Bands auf der Walze und das Profil des zweiten Bands auf der Walze nicht überlappen.
2. Verfahren zur Verarbeitung eines Bands gemäß Anspruch 1, wobei das erste Band und das zweite Band Teil des gleichen nicht zerschnittenen Bands sind.
3. Verfahren zur Verarbeitung eines Bands gemäß Anspruch 1 oder Anspruch 2, wobei das Band in einer Durchlaufglühanlage verarbeitet wird.
4. Verfahren zur Verarbeitung eines Bands nach einem der vorhergehenden Ansprüche, wobei das erste Band auf eine Temperatur im Bereich von 150°C bis 1050°C, vorzugsweise im Bereich von 150°C bis 600°C erwärmt wird.
5. Verfahren zur Verarbeitung eines Bands nach einem der vorhergehenden Ansprüche, wobei das zweite Band auf eine Temperatur im Bereich von 1050°C bis 150°C, vorzugsweise im Bereich von 600°C bis 150°C gekühlt wird.
6. Verfahren zur Verarbeitung eines Bands gemäß einem der vorhergehenden Ansprüche, wobei das Band ein Stahlband, ein vernickeltes Band oder ein Zinnblech ist.
7. Bandverarbeitungsvorrichtung, die eine Walze und ein integriertes Heizrohr umfasst, wobei das Heizrohr ein Arbeitsfluid, einen Verdampfungsabschnitt zum Verdampfen des Arbeitsfluids und einen Kondensationsabschnitt zum Kondensieren des verdampften Arbeitsfluids umfasst, wobei sich das Heizrohr im Wesentlichen entlang der axialen Länge der Walze erstreckt, wobei die Walze eine Länge von mehr als der Summe einer ersten zu erwärmenden Bandbreite und einer zweiten zu kühlenden Bandbreite aufweist.
8. Verwendung der Bandverarbeitungsvorrichtung gemäß Anspruch 7 in einer Durchlaufglühanlage.

Revendications

1. Procédé de traitement d'une bande en suivant un trajet de bande par chauffe ou refroidissement, dans lequel la bande est amenée en contact avec un rouleau dans lequel le rouleau comporte un caloduc, dans lequel le rouleau chauffe une première bande tout en refroidissant simultanément une seconde bande, **caractérisé en ce que** les dimensions du rouleau et le tracé des trajets de bande sont choisis de telle manière que l'empreinte de la première bande sur le rouleau et l'empreinte de la seconde bande sur le rouleau ne se chevauchent pas.
2. Procédé de traitement d'une bande selon la revendication 1, dans lequel la première bande et la seconde bande font partie de la même bande non coupée.
3. Procédé de traitement d'une bande selon la revendication 1 ou 2, dans lequel la bande est traitée sur une ligne de recuit continu.
4. Procédé de traitement d'une bande selon l'une quelconque des revendications précédentes, dans lequel la première bande est chauffée à une température dans la fourchette de 150° C à 1050° C, de préférence dans la fourchette de 150° C à 600° C.
5. Procédé de traitement d'une bande selon l'une quelconque des revendications précédentes, dans lequel la seconde bande est refroidie à une température dans la fourchette de 1050° C à 150° C, de préférence dans la fourchette de 600° C à 150° C.
6. Procédé de traitement d'une bande selon l'une quelconque des revendications précédentes, dans lequel la bande est une bande d'acier, une bande nickelée ou une tôle de fer blanc.
7. Dispositif de traitement d'une bande, qui comporte un rouleau et un caloduc intégré, le caloduc comportant un fluide

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de travail, une section d'évaporation destinée à l'évaporation du fluide de travail et une section de condensation destinée à la condensation du fluide de travail évaporé, dans lequel le caloduc s'étend essentiellement le long de la longueur axiale du rouleau ayant une longueur supérieure à la somme de la largeur d'une première bande devant être chauffée et de la largeur d'une seconde bande devant être refroidie.

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8. Utilisation du dispositif de traitement d'une bande selon la revendication 7 sur une ligne de recuit continu.

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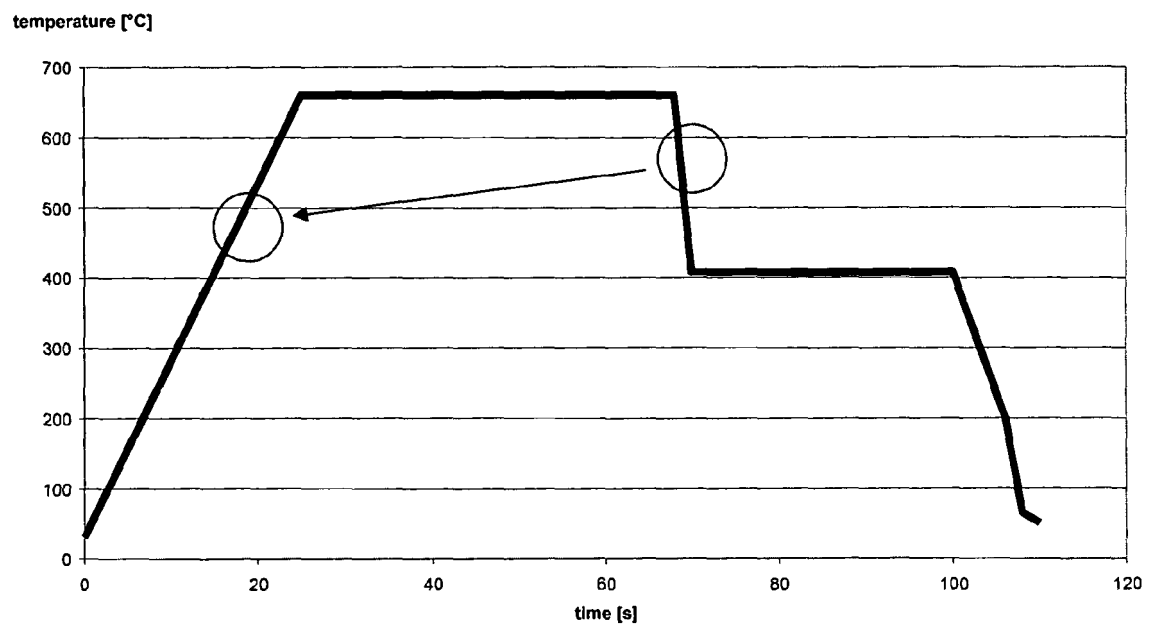


Fig. 1

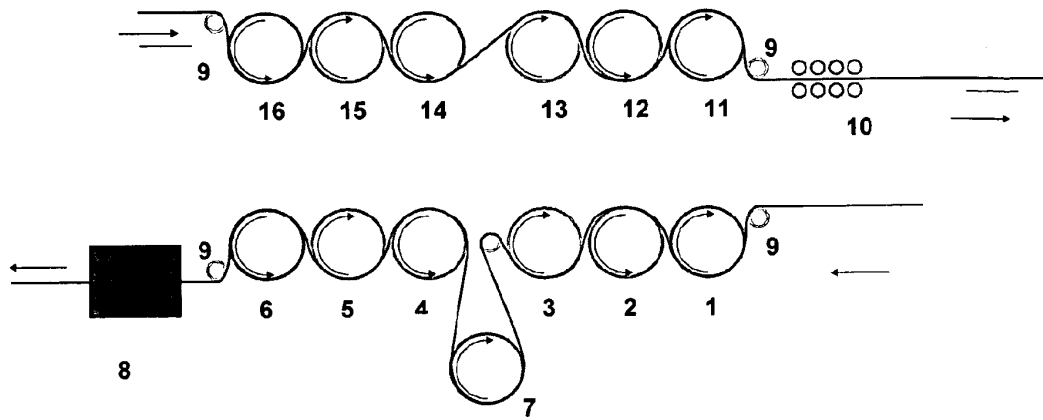


Fig. 2

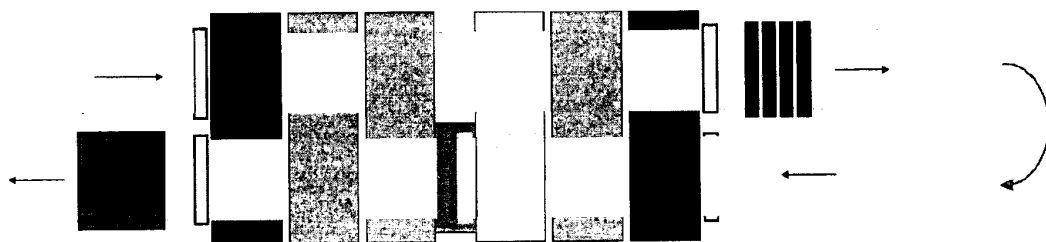


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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