The invention discloses a continuous curing or drying installation for coated sheet metal strip. The installation comprises a continuous curing or drying oven, and downstream of it a cooling system. The cooling system comprises a number of consecutive cooling chambers along the direction of movement of the sheet metal strip. The cooling system comprises at least one fan. At least one of said at least one fans is provided for extracting air from in one cooling chamber, preferably from at the sheet metal strip, and for blowing the extracted air back onto the sheet metal strip in another cooling chamber than where the air has been extracted.
Continuous curing or drying installation for sheet metal strip

Description

Technical Field

[1] The invention relates to the field of treatment of sheet metal strip, and especially to a continuous drying or a curing oven followed by a cooling system for processing coated sheet metal strip. The invention describes continuous curing or drying installations for sheet metal strip, including cooling systems in it, as well as methods of operation of such installations. Examples of application are in the production process of grain oriented electrical steel, in the production process of non-grain oriented electrical steel and in producing coil coated sheet metal strips (made out of e.g. steel or aluminium).

Background Art

[2] Sheet metal strip can be coated in a continuous curing or drying installation. After - single or double sided - coating of the sheet metal strip, the coating is cured or dried in a continuous curing or drying installation. The sheet metal strip needs to be cooled inline after the drying or curing oven prior to coiling or reeling the sheet metal strip.

[3] The cooling is performed by means of cooling air in a cooling system installed downstream of the continuous curing or drying oven. In a range of specific prior art cooling systems several consecutive cooling chambers are provided along the length of the cooling system. The sheet metal strip goes consecutively through each of the cooling chambers. Each of the cooling chambers has a fan to extract air out of the cooling chamber from at the sheet metal strip and evacuates that air; and another fan is installed to blow fresh cooling air onto the sheet metal strip in that specific cooling chamber. Such cooling systems achieve highly efficient cooling.

[4] However, the installations and especially the cooling systems of the prior art have a number of drawbacks.
Disclosure of Invention

[5] The primary object of the invention is to provide improved continuous curing or drying installations that are solving drawbacks of prior art systems.

[6] According to a first aspect of the invention a continuous curing or drying installation for coated sheet metal strip is provided. The installation comprises a continuous curing or drying oven, and downstream of it a cooling system. The cooling system comprises a number of consecutive cooling chambers along the direction of movement of the sheet metal strip. The cooling system comprises at least one fan. At least one of the at least one fans is provided for extracting air from in one cooling chamber, preferably from at the sheet metal strip, and for blowing the extracted air back onto the sheet metal strip in another cooling chamber than from where the air has been extracted. Preferably, the same fan is provided for extracting air from in one cooling chamber, preferably from at the sheet metal strip, and for blowing the extracted air back onto the sheet metal strip in another cooling chamber than where the air has been extracted. Preferably, the installation comprises an inline coating station, for single or double sided coating of the sheet metal strip, whereby the continuous curing or drying oven is provided for curing and/or drying the coating applied in the coating station.

[7] Preferably, the cooling system is set up in such a way that cooling air can be blown from both sides of the sheet metal strip. It is preferred when fans for extracting air from at the sheet metal strip and for blowing the air back onto the sheet metal strip to cool it, are connected with both sides of the sheet metal strip, hence, that both sides are cooled by means of air that is extracted from at the sheet metal strip.

[8] Cooling systems according to the invention can be arranged for sheet metal strip that runs horizontally, and for sheet metal strip that runs vertically.
It is a benefit of the invention that efficient cooling of the sheet metal strip is achieved and thanks to the increased temperature of the extracted air when blowing it back onto the sheet metal strip, free water on dried and cured coatings is reduced. Free water can have negative effects on the quality of the coated sheet metal strip. This is especially critical in applications where magnesium oxide coatings have been applied in the production process of grain oriented electrical steel. Therefore, the invention allows to produce coated sheet metal strip of better quality.

Preferably, the fan is provided for blowing the extracted air back onto the sheet metal strip via a series of nozzles.

In a preferred embodiment a filter is installed in order to filter the air that is extracted by the fan from at the sheet metal strip. The filtration can be performed before the air is blown back by the fan onto the sheet metal strip. It is a benefit of this embodiment that it is prevented that dust (e.g. from the coating layer, e.g. from magnesium oxide comprising coatings) is blown back onto the sheet metal strip.

It is a possibility that multiple fans are used in the cooling system. Preferably, an arrangement with a filter or filtration system that is filtering extracted air prior to it being blown back on the sheet metal strip is provided for air that is extracted from the initial cooling chambers of the cooling system, e.g. in the first cooling chamber. This is particularly beneficial where coatings can set free dust, as is e.g. the case when the coating is comprising magnesium oxide as is used in grain oriented electrical steel. The filter system takes care of it that dust is evacuated and not blown back onto the sheet metal strip.

In a preferred embodiment the fan is provided for blowing a mixture of air onto the sheet metal strip. The mixture comprises air extracted by the fan from at the sheet metal strip and newly taken ambient air. With ambient air is meant air that is taking from inside the building in which the production line is installed, or air that is taken from outside. Preferably the amount of
newly take ambient air and the amount of extracted air can be controlled via appropriate means, e.g. to set the temperature of the air that is blown by the fan onto the sheet metal strip.

It is a benefit of this embodiment that the dust level of the cooling air can be controlled, as the air extracted from at the coated metal strip can contain dust from the coating.

It is another benefit that the temperature of the cooling air can be controlled, which can be set to reduce the moisture content of the coating of the sheet metal strip.

This way, the quality of the coating layer can be improved. This is e.g. of big importance when the coating on the sheet metal strip is a magnesium oxide comprising coating, as is e.g. used in grain oriented electrical steel (GOES).

[14] In a preferred embodiment, the fan is driven by a frequency controlled drive.

[15] In a preferred embodiment, the fan is provided for blowing the extracted air back onto the sheet metal strip in a cooling chamber upstream in the sheet metal strip production process from the cooling chamber where the fan is extracting air. By absorbing heat from the sheet metal strip, the extracted air is at a higher temperature than the ambient air. As the extracted air is blown back onto the sheet metal strip, it is at higher temperature than if "fresh" ambient air would be blown onto the sheet metal strip. In a further preferred embodiment, the effect of the increase of temperature is controlled, for control of the cooling ability of the cooling system, especially if the target temperature is low. This can particularly be the case in the last part of the cooling system. Therefore, it is preferred to use a cooling system, wherein the fan is blowing the air onto the sheet metal strip upstream in the process from where the fan is extracting air.

[16] Alternatively, the fan can be provided for blowing the extracted air onto the sheet metal strip in a cooling chamber downstream in the sheet metal strip production process from the cooling chamber where the fan is extracting air. It is a benefit of this embodiment that free water in the coating layer is
better prevented, which is important in magnesium oxide comprising coatings on grain oriented electrical steel.

[17] In yet an embodiment, additional fans are provided that extract air from at the sheet metal strip and of which the extracted air is evacuated without being blown back onto the sheet metal strip. Preferably, such fans for extracting air from at the sheet metal strip and for evacuating it are located at the entrance of the sheet metal strip into the cooling system. This embodiment ensures that dust (e.g. from the coating layer) is evacuated from the coating layer and out of the production process in an effective way.

[18] In yet an embodiment, extra fans are provided for blowing fresh ambient air (meaning air that is not extracted by a fan from at the sheet metal strip, but which is taken from inside or from outside the building) onto the sheet metal strip. It is beneficial when the extra fan or fans for blowing fresh ambient air in the cooling chambers are located at the exit of the cooling system, e.g. in the last cooling chamber. This embodiment ensures an increased efficiency of the cooling.

It is also especially useful for increased cooling efficiency when extra fans for blowing fresh cooling air are provided in cooling chambers at the entry (e.g. in the first cooling chamber) where the sheet metal strips enters the cooling system. Where extra fans are installed in the cooling system for only blowing fresh ambient air onto the sheet metal strip, preferably also additional fans are installed for only extracting air from at the sheet metal strip (and which are not blowing the air they extract back onto the sheet metal strip).

[19] In an embodiment, the cooling system comprises at least four consecutive cooling chambers. A fan is provided for blowing fresh cooling air onto the sheet metal strip in the last cooling chamber. A fan is provided for extracting and evacuating air from inside the first cooling chamber. Preferably a fan is provided for extracting cooling air from in the last cooling chamber and for blowing it into the one but last cooling chamber.
In an embodiment of the invention, at least three fans are provided for extracting air, each from a different cooling chamber, and for blowing the air back into another cooling chamber than from where the air has been extracted.

In a preferred embodiment, the cooling system comprises a fan for extracting air from one cooling chamber and which is arranged to blow the air extracted by it into another cooling chamber, and is provided with a bypass to evacuate air instead of blowing it into that another cooling chamber. It is a benefit of this embodiment that a flexible cooling system can be built. It is possible to shut off one (or more) of the cooling chambers if one (or more) fans are provided with such a bypass.

According to a second aspect of the invention a method is claimed for the continuous curing or drying of coated sheet metal strip using an installation as described in the first aspect of the invention.

In a preferred embodiment, the sheet metal strip enters the cooling system at a temperature of more than 100°C (preferably at between 120°C and 250°C, more preferably between 120°C and 180°C, for grain oriented electrical steel; or e.g. at between 160°C to 300°C for non-grain oriented electrical steel or in coil coating), and preferably below 250°C. Preferably, the sheet metal strip is cooled by means of the cooling system to a temperature of less than 90°C, preferably to a temperature between 40°C and 90°C and even more preferably to a temperature between 65°C and 80°C.

Preferably, the sheet metal strip is coiled after being cooled by means of the cooling system.

The continuous curing or drying installation of the first aspect of the invention and the method of the second aspect of the invention can advantageously be used for processing sheet metal strip of grain oriented electrical steel (GOES), non-grain oriented electrical steel (NGOES) or
sheet metal strip, of e.g. steel or aluminum, after coating it. Coatings can be magnesium oxide comprising coatings such as used in the production of GOES. Coatings can also be water based or solvent based lacquer coatings such as used in coil coating sheet metal strip, e.g. steel or aluminum. Typical width of sheet metal strip that is treated is between 0.75 meter and 1.60 meter. Typical line speeds are in the range of 80 - 120 meter per minute.

**Brief Description of Figures in the Drawings**

[26] Figure 1 shows a continuous curing or drying installation according to the first aspect of the invention.

[27] Figure 2 shows an embodiment of the invention in which the air extracted from at the sheet metal strip is filtered.

[28] Figure 3 shows an embodiment of the invention in which a mixture or fresh ambient air and air extracted from at the sheet metal strip is blown onto the sheet metal strip to cool it.

**Mode(s) for Carrying Out the Invention**

[29] Figure 1 shows a continuous curing or drying installation according to the invention. Sheet metal strip 110 is coated, e.g. in the continuous curing or drying installation via a suitable coating station. The coating is dried and or cured in a continuous oven 120. With a continuous oven is meant that the sheet metal strip is running through the oven during which the coating is dried and or cured. The continuous oven can be any oven as known in the art, e.g. a hot air oven or an infrared oven comprising infrared emitters (e.g. gas fired infrared emitters) as known in the art.

The cooling system of the example comprises five consecutive cooling chambers 131, 132, 133, 134, 135. Fan 140 takes fresh ambient air and blows it through nozzles (not show on the figure) onto the sheet metal strip 110 in the last cooling chamber 135. Four fans 145 extract air from at the sheet metal strip 110 in the four last cooling chambers 132, 133, 134, 135 and each blow the extracted air through nozzles (not shown in the figure) onto the sheet metal strip 110 in the cooling chamber 131, 132, 133, 134.
that preceeds the cooling chamber where the cooling air has been extracted. In the first cooling chamber 131 a fan 147 is installed that is extracting air from at the sheet metal strip 110 and which is evacuating the extracted air.

At the exit of the cooling system, the sheet metal strip 110 can be reeled in a coiling station 190.

[30] Preferably, the cooling is performed from both sides of the sheet metal strip (figure 1 is only showing the cooling on one side). Fans can be installed at both sides of the sheet metal strip. Alternatively, a fan installed at one side of the sheet metal strip can, via appropriate ducting or piping, extract air from at both sides of the sheet metal strip from in one cooling chamber; and blow the air back to the sheet metal sheet at both sides of the sheet metal strip in another cooling chamber.

[31] Figure 2 shows a detail of an embodiment of the invention. Air 205 is extracted from at the surface of sheet metal strip 210 via a hood 220 from in a first cooling chamber 207. The air is transported via piping 225 and lead through a filter 230. The filter has the function to remove dust out of the air, e.g. dust from the coating applied onto the sheet metal strip 210. A fan 240 realizes the extraction of air 205 and blows the air through further piping 235 through a hood 240 by means of nozzles 250 on the sheet metal strip in a second cooling chamber 209 downstream from where the air is extracted.

[32] Figure 3 shows an alternative embodiment of the invention. Air 305 is extracted from at the surface of sheet metal strip 310 via a hood 320 from in a first cooling chamber 307. The air is transported via piping 325. Fresh ambient air 315 is taken (from inside or from outside the building) and mixed with the extracted air 305. The air mixture is transported via the action of fan 340, through piping 335. The air mixture 337 is blown onto the sheet metal strip 310 in a second cooling chamber 309 via a hood 340 and nozzles 350.
[33] The invention has shown to improve the quality of the coated sheet metal strip. Application of the invention has shown to reduce free water on dried and cured coatings. A number of embodiments of the invention have shown further improved coating quality, via a reduction of dust in the coatings.

[34] A number of examples and embodiments have been described. Combination of elements from examples and/or from embodiments may be made without departing from the scope of the invention.
Claims

1. Continuous curing or drying installation for coated sheet metal strip, 
   comprising a continuous curing or drying oven, and downstream of said 
   continuous curing or drying oven a cooling system, 
   - wherein said cooling system comprises a number of consecutive cooling 
     chambers along the direction of movement of the sheet metal strip, 
   - wherein said cooling system comprises at least one fan, 
   wherein at least one of said at least one fans is provided for extraction of air 
   from in one cooling chamber and for blowing the extracted air back onto the 
   sheet metal strip in another cooling chamber than where the air has been 
   extracted.

2. Continuous curing or drying installation as in claim 1, wherein said at least one 
   of said at least one fans is provided for blowing said extracted air back onto 
   said sheet metal strip via a series of nozzles.

3. Continuous curing or drying installation as in any of the preceding claims, 
   wherein a filter is provided, wherein said filter is installed in order to filter said 
   air that is extracted by said fan from at said sheet metal strip, and wherein said 
   filtration is performed before said air is blown by said fan onto said sheet metal 
   strip.

4. Continuous curing or drying installation as in any of the preceding claims, 
   wherein said fan is provided for blowing a mixture of said extracted air and 
   newly taken ambient air onto said sheet metal strip in order to cool said sheet 
   metal strip.

5. Continuous curing or drying installation as in any of the preceding claims, 
   wherein said fan is driven by a frequency controlled drive.

6. Continuous curing or drying installation as in any of the preceding claims, 
   wherein said fan is provided for blowing said air back onto said sheet metal
strip in a cooling chamber downstream in the cooling system from the cooling chamber where said fan is extracting said air.

7. Continuous curing or drying installation as in claims 1 - 5, wherein said fan is provided for blowing said air onto said sheet metal strip in a cooling chamber upstream in the cooling system from the cooling chamber where said fan is extracting said air.

8. Continuous curing or drying installation as in any of the preceding claims,
   - wherein the cooling system comprises at least four consecutive cooling chambers
   - wherein a fan is provided for blowing fresh cooling air the sheet metal strip in the last cooling chamber,
   - wherein inside the first cooling chamber a fan is provided for extraction and evacuation of air.

9. Continuous curing or drying installation as in claim 8, wherein a fan is provided for extracting cooling air from in the last cooling chamber and blowing it into the one but last cooling chamber.

10. Continuous curing or drying installation as in any of the preceding claims, wherein at least three fans are provided for extracting air each from in a different cooling chamber, and for blowing it back into another cooling chamber than where the air has been extracted.

11. Continuous curing or drying installation as in any of the preceding claims, wherein a fan is provided for extraction of air from in one cooling chamber and for blowing the air extracted by it into another cooling chamber, and wherein said fan is provided with a bypass to evacuate air instead of blowing it into said another cooling chamber.

12. Method for continuous curing or drying coated sheet metal strip using an installation as in any of the preceding claims.
13. Method as in claims 11 or 12, wherein
   the sheet metal strip enters the cooling system at a temperature of more than
   100°C.

14. Method as in claims 11 - 13 wherein the sheet metal strip is cooled by means
   of said cooling system to a temperature of less than 90°C.
**INTERNATIONAL SEARCH REPORT**

**International application No**
PCT/EP2013/060063

**A. CLASSIFICATION OF SUBJECT MATTER**

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**ADD.**

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**According to International Patent Classification (IPC) or to both national classification and IPC**

**B. FIELDS SEARCHED**

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**Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched**

**Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)**

**EPO-Internal, WPI Data**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**Further documents are listed in the continuation of Box C.**

**See patent family annex.**

**Date of the actual completion of the international search**

15 July 2013

**Date of mailing of the international search report**

24/07/2013

**Name and mailing address of the ISA/IB**

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HT Rijswijk
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**Authorized officer**

Ri schard, Marc
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