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(54) **Method for rolling a metal strip or foil**

(57) The invention relates to a method for rolling a metal foil or strip comprising the following steps:
- passing a metal strip or foil (12) through a pair of interacting work rolls (13) of a rolling mill (10) in order to per-

form reduction in thickness of the metal strip or foil (12),
and
- herein utilizing liquid air as a cryogenic coolant.

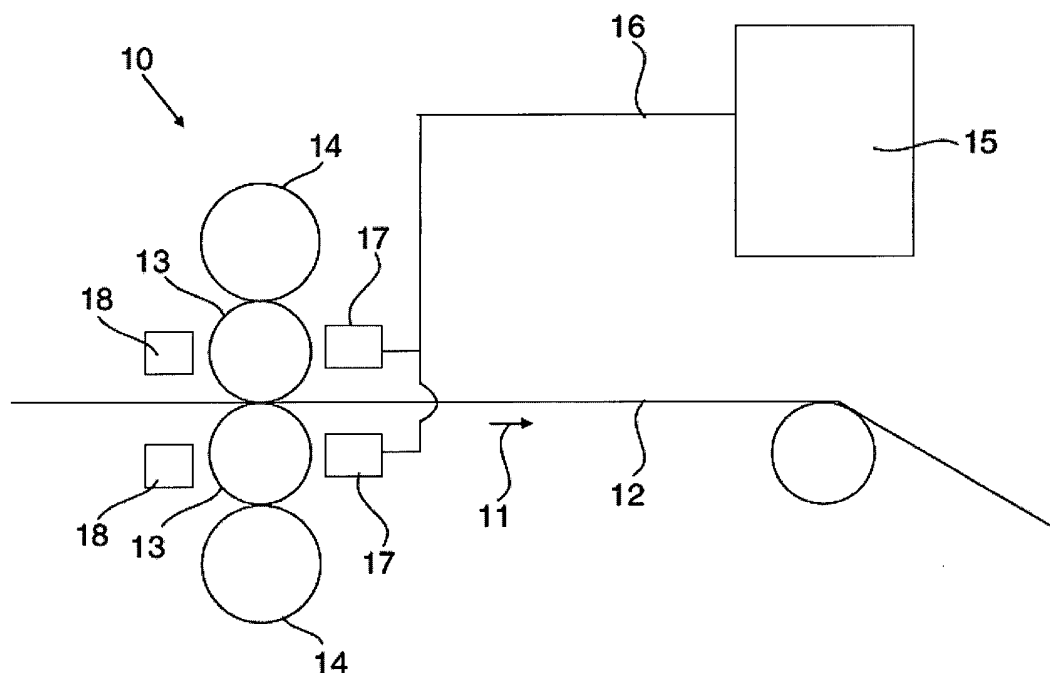


Fig.1

Description

[0001] The invention relates to the field of roll cooling for rolling mills, especially aluminium strip or foil rolling mills.

[0002] Aluminium rolling in rolling mills requires lubrication in order to achieve an acceptable finish of the strip, especially at higher reductions. Also, the rolling process generates a large amount of heat, which must be dissipated in order to prevent the equipment, especially the rolls of the rolling mill, and/or the aluminium strip being rolled from overheating. Thus, efficient cooling of the rolls is required.

[0003] It is known to use water based emulsions as rolling coolant and lubricant. Herein, it is necessary that the water is fully removed from the aluminium strip immediately after rolling, as otherwise stains are created, which are difficult to remove.

[0004] It is also known to use kerosene as lubricant and coolant.

[0005] As the use of kerosene has significant fire safety issues, it is also known to use cryogenic gases or liquids as a coolant in industrial rolling processes. This is discussed for example in PCT/GB2009/051590. The term cryogenic shall refer to substances which are normally gases at room temperature, but are maintained in liquid state by suitable control of temperature and pressure.

[0006] PCT/GB2009/051590 especially describes the use of cryogenic nitrogen. Use of nitrogen as a coolant can, however, lead to an oxygen deficiency in the vicinity of the rolling mill. In order to eliminate safety risks for an operator at such a mill in connection therewith, elaborate safety measures are required. For example, in order to prevent a build-up of gases, which reduce oxygen levels in operator access areas around the mill, PCT/GB2009/051590 suggests provision of a construction comprising an inner chamber and an outer chamber provided with extraction points and valves, by means of which it is attempted to control the extraction rate of the inner chamber to ensure that the outer chamber is always held at a negative pressure compared to the operator areas, thus minimizing gas emissions from the outer chamber, ensuring the safety of the mill operator.

[0007] This double chamber construction is considered to be expensive to provide and maintain.

[0008] The object of the invention is thus to be able to provide a simplified construction for the above discussed rolling mills. This object is achieved by utilizing a method according to claim 1.

[0009] Advantageous embodiments are the subject matter of the dependent claims.

[0010] With the method according to the invention, any danger of a reduction of oxygen levels in the vicinity of a rolling mill can be avoided, as the liquid air used as cryogenic coolant has the same chemical composition as the ambient air. Thus, elaborate constructions for containing coolants subsequently to their usage are not necessary.

[0011] Advantageously, liquid air is directed to one or more of a plurality of zones on the surface of at least one of the work rolls through which the metal strip is passed via cryogenic fluid applicators. For example, this plurality of zones may be provided along the width of the work rolls (thus also along the width of the metal strip passing through the work rolls), so that an effective control of the cooling process is possible.

[0012] Expediently, the metal strip or foil is coated with a lubricant before being passed through the work rolls.

[0013] It is especially advantageous to provide the liquid air used for the method according to the invention by means of a liquefaction unit, especially an on-site liquefaction unit. A liquefaction unit is, essentially, a simplified version of an air separation unit, in which ambient air is initially cooled down into temperatures, at which it liquefies. Subsequent means for separation of liquified air into its individual components are, according to the invention, not necessary. Liquefaction units can be provided in a cost effective manner, so that especially the on-site combination of a rolling mill employing the method of the invention and a liquefaction unit is advantageous, taking into account the large amounts of cryogenic coolant needed.

[0014] It is also possible to provide the liquid air as synthetic liquid air by mixing liquid oxygen with liquid nitrogen as well as, if desired, with other air components, such as carbon dioxide.

[0015] The method of the invention is advantageously used in connection with the rolling of aluminium strips or foils.

[0016] The invention will now be further described with reference to the appended figures. Herein,

Figure 1 shows a schematically simplified side view of a rolling mill, with which the method of the invention can be implemented; and

Figure 2 shows a schematically simplified side view showing an additional preferred feature of the rolling mill according to Figure 1.

[0017] In Figure 1 there is shown schematically a preferred embodiment of a rolling mill 10, with which the method according to the invention can be implemented. A preferred feature of rolling mill 12 is presented in Figure 2.

[0018] Herein, an aluminium strip or foil 12 passes through the rolling mill from left to right (indicated by arrow 11). Interacting mill rolls 13 and back up rolls 14 are provided to perform the reduction in thickness of the strip 12, as is known in the art. Before entering the region between work rolls 3, a lubricant is applied to strip 12, preferably on both sides.

[0019] A cryogenic storage and delivery system 15 supplies cryogenic coolant to coolant applicators 17, for example via insulated and protected feed pipes 16. System 15 is preferably implemented as an on-site a lique-

faction unit.

[0020] The coolant applicators 17 can be divided into separate zones across the width of the strip 12 in order to apply different or variable cooling effects across the width of the rolls, for example to provide a flatness control for the strip 12.

[0021] It is advantageous to also provide heating devices 18 on the entry side of the mill. These heating devices 18 may be provided anywhere of the vicinity of the work rolls 13, taking into account mill size, space and heating effect.

[0022] The heating devices 18 can also be divided into separate zones over the width of the strip 12 or the rolls 13 in order to apply corresponding separate heating effects.

[0023] As is also well known in the art, a (not shown) control system is used to ensure that the metal rolling process provides the desired properties to the strip 12, especially regarding thickness and/or flatness.

[0024] It is advantageous to direct the cryogenic coolant to an area designated 21 in Figure 2. This area can be referred to the "arc" area, as opposed to an area 24 adjacent to where the strip comes into contact with the rolls 13, referred to as "wedge area", of work rolls 13 in order to effectively limit application of cryogenic coolant to area 21, shields 22 can be provided, as shown in Figure 2. Depending on the position of coolant applicators 17, arc area 21 may be longer or shorter, as well as in a different circumferential position as compared to the one shown in Figure 2 by way of example only.

[0025] According to the invention, liquid air is used as cryogenic coolant, i.e. liquid air is applied to the metal sheet 12 by means of cryogenic cooling applicators 17.

[0026] As the composition of liquid air corresponds to that of the surrounding (gaseous) air, there is no danger of any reduction of oxygen levels in the vicinity of the mill. Thus, according to the invention, there is no need to provide elaborate protection chambers and corresponding valve systems to protect an operator in the vicinity of the mill.

[0027] Also, equipment for monitoring any oxygen deficiencies in the vicinity of the mill can be omitted.

[0028] Utilization of liquid air also assists in providing a dry internal atmosphere in the vicinity of the mill, thereby reducing the risk of any icing inside the mill. During the liquefaction of air all water is removed and the liquefied air contains essentially not water. Thus, use of liquefied or liquid air for the cooling inside the mill will not create any icing. The main advantage over liquid nitrogen is safety. Liquid nitrogen also contains no water, but use of it inside the mill without any safety precautions will be extremely dangerous in the surroundings, and especially to the operators working at the mill. Therefore by using air, all of the extra safety precautions can be avoided.

[0029] There are two preferred methods of providing cryogenic air for the cryogenic storage and delivery system 5. Firstly, it is possible to provide cryogenic oxygen and cryogenic nitrogen in separate tanks. By mixing the

contents of these tanks, synthetic liquid air can be provided. This mixture is then led into the feed pipes 16 and to the coolant applicators 17 as described above.

[0030] It is also possible to provide cryogenic air by using an air liquefaction unit (as already mentioned above), which serves to cool gaseous air down to temperatures, at which it liquifies. This method is especially preferred, as typical quantities of cryogenic coolant required by a rolling mill justify an on-site production unit.

Claims

1. Method for rolling a metal foil or strip comprising the following steps:
 - passing a metal strip or foil (12) through a pair of interacting work rolls (13) of a rolling mill (10) in order to perform reduction in thickness of the metal strip or foil (12), and
 - herein utilizing liquid air as a cryogenic coolant.
2. Method according to claim 1, wherein liquid air is directed to one or more of a plurality of zones on the surface of at least one of the work rolls (13) via at least one cryogenic fluid applicator (17).
3. Method according to claim 1 or 2, wherein the metal strip or foil (12) is coated with a lubricant before being passed through the work rolls (13).
4. Method according to any one of the preceding claims, wherein the liquid air is provided by means of a liquefaction unit (15), especially an on-site liquefaction unit.
5. Method according to any one of preceding claims 1 to 3, wherein the liquid air is provided as synthetic liquid air by mixing liquid oxygen with liquid nitrogen.
6. Method according to any one of the preceding claims, wherein application of the cryogenic fluid and/or the lubricant is controlled by means of a control device.
7. Method according to any one of the preceding claims, wherein the metal strip or foil (12) is an aluminium strip or foil.
8. Usage of liquid air as cryogenic coolant in roll cooling of metal strips or foils, especially aluminium strips or foils.

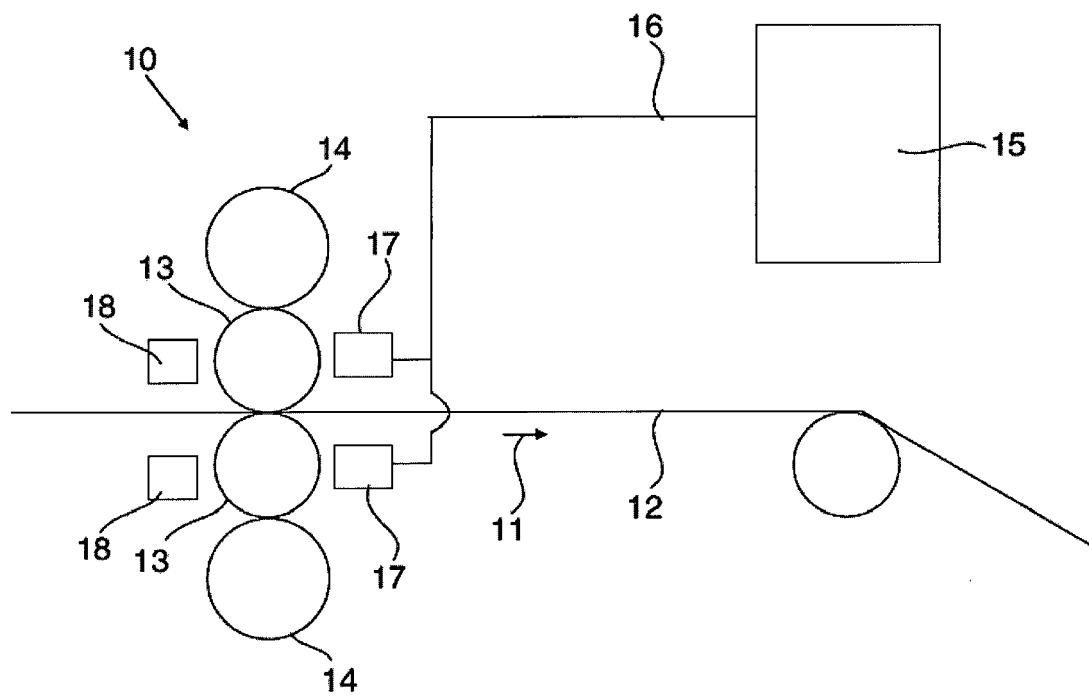


Fig.1

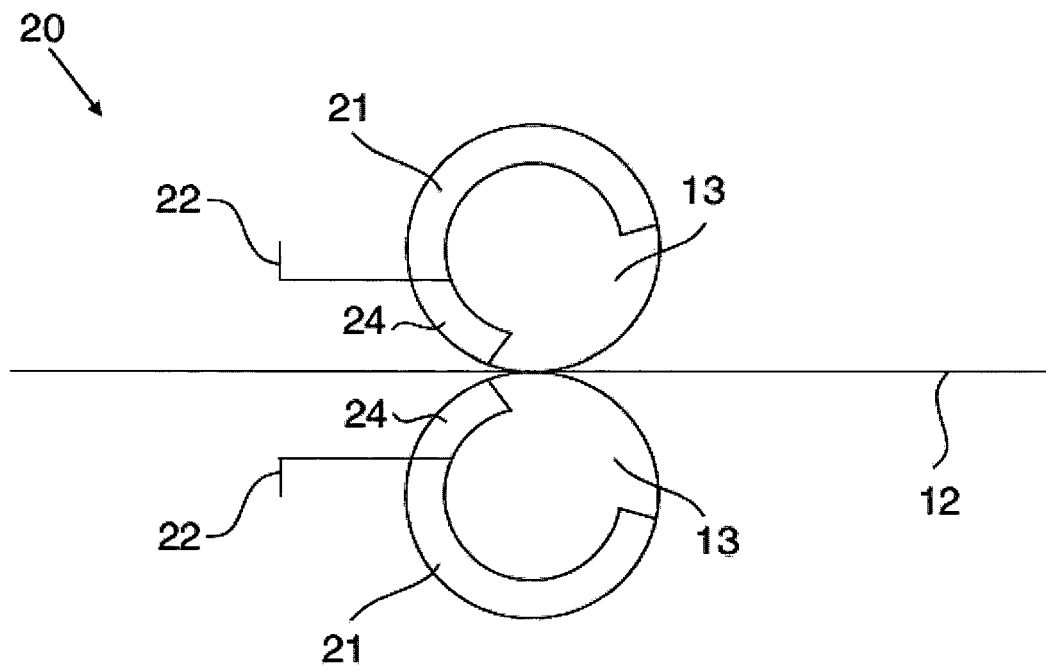


Fig.2



EUROPEAN SEARCH REPORT

Application Number
EP 14 00 0439

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2005 001806 A1 (AIR LIQUIDE DEUTSCHLAND GMBH [DE]) 20 July 2006 (2006-07-20) * paragraph [0030] - paragraph [0037] *	1-8	INV. B21B45/02
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			TECHNICAL FIELDS SEARCHED (IPC)
			B21B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 June 2014	Examiner Frisch, Ulrich
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 00 0439

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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25-06-2014

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REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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