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(54) IMPROVEMENTS IN OR RELATING TO PLANTS FOR TREATING ROLLED STEEL PRODUCTS

(71) We, CENTRE DE RECHERCHES METALLURGIQUES — CENTRUM VOOR RESEARCH IN DE METALLURGIE, of 47 Rue Montoyer, Brussels, Belgium, a Belgian body corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a plant for treating a rolled steel product, such as concrete reinforcing rod or bar (referred to simply as "rod" below), in order to improve its quality.

The main qualities required by users of steel rods are, among other things, as high as possible a yield stress for the kind of steel used, as well as satisfactory weldability, fatigue strength, and ductility for the use to which the rod is to be put. On the other hand, in order to improve weldability and ductility of a steel, it is necessary to decrease its carbon and manganese content, which concurrently results in a decrease of its tensile strength. To remedy this drawback, the steel can undergo a suitable cooling treatment, preferably directly applied while the steel emerges from the rolling mill, which permits the yield stress of the rod to be raised to a certain extent.

When the rod (particularly concrete reinforcing rod) is cooled by convection or radiation, the way in which the rolled product cools depends almost entirely on the diameter of the rod so that, for a rod of a given diameter, it is necessary to make use of other procedures for completing the mere cooling action in order to modify its yield stress, which results in an increase of the cost of the product.

To avoid the above-mentioned drawback, without increasing the carbon and manganese content of the steel up to an unacceptable value from the weldability viewpoint,

the applicants have already suggested a process for treating rods in which a rod undergoes surface quenching at the exit of the finishing stand of a rolling mill by means of a suitable cooling fluid; the conditions of cooling are adjusted so that, at the outlet of the quenching zone, the core of the rod remains at a temperature sufficient to allow, during subsequent air cooling, tempering of the surface quenched layer, and transformation of austenite into ferrite and carbides in the central part of the rod. Depending upon the conditions in which this process is performed, the surface layer, due to quenching of the rod, is formed of martensite or bainite.

In practice, the desired cooling of the rod is obtained by appropriately choosing the cooling apparatuses such as, for example, sprayers, and by suitably adjusting their extent and their position.

In order to be able to increase the efficiency of the cooling apparatus, we have found it important to be able to ensure that in the cooling zones the rod is in fact sprayed in the desired manner with the cooling liquid, and that between the cooling zones and after the last of these zones, the rod is prevented from contacting the liquid; otherwise the structure or structures of the rod are liable to follow an evolution which would no longer allow the desired properties to be obtained.

The present invention provides a plant for treating a rolled steel product, comprising, in combination with a rolling mill, in sequence, a quenching apparatus through which the rolled steel product passes from the outlet of the rolling mill, cutting means for cutting the product, and a still-air cooling area, the quenching apparatus having cooling means for directing cooling liquid onto the rolled product passing through the quenching apparatus and having liquid removal means for mechanically removing

cooling liquid from the rolled product passing through it.

There are preferably a plurality of cooling zones with high heat transfer coefficient in the quenching apparatus, the cooling liquid being mechanically removed from the product after each cooling zone.

The quenching apparatus preferably includes two ducts (or more) spaced apart one after the other on a common axis, an enlarged extension of one duct enveloping an annular passage defined between adjacent ends of the ducts, and means for supplying fluid under pressure to the annular passage. Depending on the nature of the fluid and its direction and velocity, this arrangement can function as a means for carrying the product through the apparatus or as means for limiting the amount of liquid carried along by the product and/or as cooling means.

For instance, the upstream duct is convergent in the direction of displacement of the product, the downstream end of the upstream duct having an internal diameter which is at most equal to the internal diameter of the upstream end of the downstream duct, the upstream end of the downstream duct having the enlarged extension enveloping both the said annular passage and the downstream end of the upstream duct. In this case, the fluid leaves the annular passage in the direction of displacement of the product and therefore carries it along. The fluid may be the cooling liquid.

As another example, the downstream duct may be divergent in the direction of displacement of the product, the upstream end of the downstream duct having an internal diameter which is at least equal to the internal diameter of the downstream end of the upstream duct, and the downstream end of the upstream duct having the enlarged extension enveloping both the said annular passage and the upstream end of the downstream duct. In this case, the fluid leaves the annular passage in a direction opposite to the direction of displacement of the product and, if its velocity is high enough, it will act as a jet-breaker preventing any cooling liquid from being carried along with the rod, even if the fluid is itself the cooling liquid.

Preferably, the liquid removal means comprises a series of scrapers which is constituted by a helical wire with spaced turns, the helical wire being arranged with the axis of the helix substantially horizontal.

Other suitable liquid removal means comprise a support for brushing means permitting contact between the brush and the product and also ensuring inclination of the brush with respect to the direction of displacement of the product, and drive means

for rotating the support about the longitudinal axis of the product.

The overall length of the quenching apparatus (cooling apparatus with high heat transfer coefficient) is preferably 0.5 V to 2 V metres, where V is the speed, in m/s, of the rolled product emerging from the last stand of the rolling mill.

The cooling means preferably comprises a series of ducts through which the cooling product passes, the ducts having orifices for cooling liquid, the width e of the annular space between two successive ducts being greater than $S/2D$, where D is the inner diameter of the downstream duct and S is the total area of the orifices of the upstream duct, e also being smaller than $3S/2D$.

The quenching apparatus thus conceived is effective in that it ensures the same removal of heat with an overall length reduced by almost 50% with respect to sprayers in which the successive ducts are spaced from one another by a distance substantially equal to the length of the ducts themselves. Preferably, the quenching apparatus described above has a specific cooling-liquid flow rate (the flow rate per unit surface area of the length of rolled product located in the apparatus) of 10 to 20 ml/s/cm².

An alternative cooling means comprises a helical pipe with spaced turns having at the inner side a plurality of orifices orientated towards its axis.

The means for carrying the product along its path in the treating plant for rolled products can comprise rollers. In a particularly advantageous embodiment of the plant the rollers are arranged in the quenching apparatus, for example located between devices for directing cooling liquid.

The means for cutting the rolled product at the outlet of the quenching zone can comprise a shears powerful enough to cut the rolled product at low temperature. (The temperature of the rolled product is heterogeneously distributed through its cross-section.)

The still-air cooling area can be a conventional air cooling area such as is generally used in rod rolling mill installations.

The invention will be described further, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 schematically shows part of a conventional rolling installation;

Figure 2 schematically shows part of a rolling mill and a plant for treating the rolled product;

Figure 3 is an axial section through a cooling device;

Figure 4 schematically shows a rolling mill and plant for treating the rolled product;

Figure 5 is a side view, partly in section,

of a brushing device;

Figure 6 is an axial section through a conveying and/or cooling device;

Figure 7 is an axial section through a cooling device; and

Figure 8 is an axial section through a jet-breaker.

Figure 1 shows the end part of a conventional rod rolling mill; its last four stands 14, 15, 16, and 17 are illustrated. At the outlet of the last stand 17, a switching device 1 diverts the rolled rods towards one of two output lines, each of which has shears 2. Between the switching device 1 and the shears 2 the rolled product is conveyed by beds of rollers located in the region 3. The product passes from the shears 2 to a still-air cooling area.

Figure 2 shows an example of a plant for quenching the surface of a rolled product, the plant being developed from the conventional installation of Figure 1. In lieu of the last stand 17 of the rolling mill, there is a quenching apparatus comprising water-cooling devices 4 through which the rolled product passes. At the outlet of the quenching apparatus, there is again a switching device 1 followed by two parallel product lines across which two rotary shears 2 are located. The plant also includes means (not shown in Fig. 1) for removing water from the product, as will be described below.

Figure 3 shows a detail of a high heat transfer coefficient cooling device which can be used as one of the devices 4 shown in Fig. 2. It comprises two co-axial ducts 5, 8 through which passes the rolled product 7 to be quenched. The inner duct 5 is formed with orifices 6 for directing atomized cooling liquid onto the product 7. The outer duct 8, together with the inner duct 5, forms an annular chamber 9 closed at both its ends and containing a quenching liquid supplied through an inlet 10. One end 11 of the inner duct 5 defines an inlet for the rolled product and is flared to facilitate introduction of the product.

Figure 4 diagrammatically shows a rod rolling mill in combination with a plant for treating the rolled product. At the outlet of the last stand of the rolling mill, there is a quenching apparatus comprising three cooling devices 4, in which quenching of the surface of the rolled product takes place. The quenching apparatus is 20 m long; thus for a rod output rate of 15 m/s a quenching duration of 1.33 s is ensured. The quenching apparatus comprises a series of cooling devices with a specific flow rate of 15 ml/s/cm², i.e. a total flow rate of 678 m³/h for rod with a diameter of 20 mm. The cooling apparatus is followed by the switching device 1 arranged to divert the rolled product to one of two lines for removing the liquid by means which are not shown in Fig. 4 but

which are described below. The shears 2 cut the rolled product into lengths of a given size, the lengths being sent to a still-air cooling area 12 before entering a conventional finishing zone 13.

When the rolling mill installation has two "lines", it can be arranged in various ways dictated by production or available space requirements. According to a first example, the last stand of the rolling mill is followed by a single quenching apparatus located before a switching device; this device diverts the rolled product toward either of two beds of rollers, each of which conveys the product to shears; at the outlet of the shears, the rods are conveyed to an air cooler associated with each shears and then to the finishing zone (see Figure 2). According to a second example of the plant, a switching device is located at the outlet of the rolling mill and is arranged to divert the rolled product towards either of two quenching apparatuses in which surface quenching of the product takes place, the two quenching apparatuses being then arranged in parallel, each quenching apparatus being also followed by shears, a still-air cooling area, and a finishing zone.

When the treatment plant (according to the second example) has two high heat transfer coefficient cooling apparatuses arranged in parallel, it is advantageous for each quenching apparatus to comprise two sections having liquid atomizing device which are separately controlled. In such conditions, the upstream sections (which are closer to the switching device) are permanently supplied with cooling liquid; the downstream section of each quenching apparatus is not then supplied when the rod is passing through the other quenching apparatus. The control of the downstream sections is ensured, for example, by the cell controlling the switching device. It is thus possible to obtain a considerable economy in water consumption.

Another possible position for the switching device is immediately before the still-air cooling area.

Figure 5 shows a brushing device for removing the cooling liquid from the rolled product in the above-described installations. A rod 18 to be dried is displaced in the direction indicated by an arrow 19. A sleeve 20 is co-axial with the rod, and is supported by two bearings 21 and 22 in which it can rotate when driven by a race pulley 23 keyed on the sleeve 20, the pulley 23 being rotated by a belt 24, a pulley 25, and a motor 26. The sleeve 20 carries at its end 27, projecting from the bearing 22, a brush-holder 28 which is keyed on the sleeve 20 and bears two brushes 29 and 30. Bristle bundles 31 and 32 are adjusted and directed against the rod in the way referred to above.

It should be noted that the brushes 29 and 30 are 180° apart about the rod and extend substantially in the same plane.

Figure 6 shows a conveying and/or cooling device for the rod, particularly when passing through the quenching apparatus. An upstream duct 33 is convergent in the direction of displacement of the rod (indicated by the arrow) and is enveloped by the enlarged upstream inlet of a duct 35. Between the two ducts 33, 35 an annular passage 36 is formed, through which water supplied to the space 37 through an opening 38 enters the device for conveying the rod which passes through the two ducts.

Figure 7 diagrammatically shows a cooling device for use instead of one or more of the cooling devices 4 in the quenching apparatus of an installation as described above. This device comprises a cylindrical duct 39 through which a rod to be quenched passes (as indicated by the arrow). The upstream end of the duct has an enlarged convergent-divergent end 40 whose neck portion 41 is arranged to guide the rod. The downstream end of the duct 39 has a guide ring 42. The duct has an inlet 43 for supplying a quenching liquid, for example water, to the inside of the device.

Figure 8 shows a jet-breaker (similar to the conveying device of Fig. 6 in reverse). Co-axial ducts 44 and 45 form therebetween an annular space 46 through which water under pressure is supplied to the device. The rod is displaced (as indicated by the arrow) through the device in a direction opposite to that of the water jet. The duct 44 has an upstream flared enlarged end 47 whereas the duct 45 is divergent in the direction towards its downstream orifice; a flared guide duct (not shown) is arranged at the outlet of the duct 45. The water jet, owing to its velocity, limits the amount of water carried along by the rod.

WHAT WE CLAIM IS:—

1. A plant for treating a rolled steel product, comprising, in combination with a rolling mill, in sequence, a quenching apparatus through which the rolled steel product passes from the outlet of the rolling mill, cutting means for cutting the product, and a still-air cooling area, the quenching apparatus having cooling means for directing cooling liquid onto the rolled product passing through the quenching apparatus and having liquid removal means for mechanically removing cooling liquid from the rolled product passing through it.

2. A plant as claimed in claim 1, in which the quenching apparatus includes two ducts spaced apart one after the other on a common axis, an enlarged extension of one duct enveloping an annular passage defined

between adjacent ends of the ducts, and means for supplying fluid under pressure to the annular passage.

3. A plant as claimed in claim 2, in which the upstream duct is convergent in the direction of displacement of the product, the downstream end of the upstream duct having an internal diameter which is at most equal to the internal diameter of the upstream end of the downstream duct, the upstream end of the downstream duct having the enlarged extension enveloping both the said annular passage and the downstream end of the upstream duct.

4. A plant as claimed in claim 2, in which the downstream duct is divergent in the direction of displacement of the product, the upstream end of the downstream duct having an internal diameter which is at least equal to the internal diameter of the downstream end of the upstream duct, and the downstream end of the upstream duct having the enlarged extension enveloping both the said annular passage and the upstream end of the downstream duct.

5. A plant as claimed in any of claims 1 to 4, in which the liquid removal means comprises a series of scrapers which is constituted by a helical wire with spaced turns, the helical wire being arranged with the axis of the helix substantially horizontal.

6. A plant as claimed in any of claims 1 to 4, in which the liquid removal means comprises a support for brushing means permitting contact between the brush and the product and also ensuring inclination of the brush with respect to the direction of displacement of the product, and drive means for rotating the support about the longitudinal axis of the product.

7. A plant as claimed in any of claims 1 to 6, in which the overall length of the quenching apparatus is $0.5V$ to $2V$ metres, where V is the speed, in m/s, of the rolled product emerging from the last stand of the rolling mill.

8. A plant as claimed in any of claims 1 to 7, in which the cooling means comprises a series of ducts through which the product passes, the ducts having orifices for cooling liquid, the width e of the annular space between two successive ducts being greater than $S/2D$, where D is the inner diameter of the downstream duct and S is the total area of the orifices of the upstream duct, e also being smaller than $3S/2D$.

9. A plant as claimed in any of claims 1 to 7, in which the cooling means com-

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2. A plant as claimed in claim 1, in which the quenching apparatus includes two ducts spaced apart one after the other on a common axis, an enlarged extension of one duct enveloping an annular passage defined

between adjacent ends of the ducts, and means for supplying fluid under pressure to the annular passage.

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6. A plant as claimed in any of claims 1 to 4, in which the liquid removal means comprises a support for brushing means permitting contact between the brush and the product and also ensuring inclination of the brush with respect to the direction of displacement of the product, and drive means for rotating the support about the longitudinal axis of the product.

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8. A plant as claimed in any of claims 1 to 7, in which the cooling means comprises a series of ducts through which the product passes, the ducts having orifices for cooling liquid, the width e of the annular space between two successive ducts being greater than $S/2D$, where D is the inner diameter of the downstream duct and S is the total area of the orifices of the upstream duct, e also being smaller than $3S/2D$.

9. A plant as claimed in any of claims 1 to 7, in which the cooling means com-





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orientated towards its axis.

10. A plant for treating a rolled steel
5 product, substantially as described herein
with reference to Figures 2 to 8 of the ac-
companying drawings.

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