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(54) IMPROVEMENTS IN OR RELATING TO ROLLING OF BILLETS

(71) We, SACK G.m.b.H. formerly Maschenenfabrik Sack G.m.b.H., a Joint Stock Company organised under the laws of Germany (Fed. Rep.), of Wahlerstrasse, 4000 Düsseldorf-Rath, Germany (Fed. Rep.), 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:—

This invention relates to a method of and apparatus for rolling a slab to form a billet.

It has previously been proposed to reduce the cross-section of a slab with elongation by means of powerful repeated edging passes acting on its narrow sides and between the edging passes the slab is subjected to a rolling operation on its broad sides. A known rolling method with these features, in which the actual shaping of the rolled stock is intended to take place solely by powerful edging passes, is intended to prevent local spreading, which leads to a so-called "dog's bone" configuration, due to a certain relationship between the diameter of the edging or working rolls and the width of the slab (German Offenlegungsschrift 2,254,676).

It was recognised that the undesirable "dog's bone" configuration with enlarged edge regions of the slab cannot be eliminated solely by a large diameter of the edging rolls, by which a large contact area is provided at the time of rolling, in order to allow the rolling pressure to act on the central region of the slab. In the case of relatively narrow slabs, a large diameter of the edging rolls may be successful in this respect, but not in the case of very wide slabs, such as are produced as continuously cast slabs.

According to a first aspect of the present invention there is provided a method of rolling a slab to form a billet, comprising the steps of introducing a slab of substantially uniform, rectangular cross-section defined by a pair of opposed slab faces interconnected by a pair of opposed slab edges to a rolling apparatus comprising first and second sets of opposing face-working rolls and a set of opposing edge-working rolls disposed intermediate said sets of face-working rolls, maintaining a reducing temperature gradient from the centre-line of said slab outwardly thereof to impart greater deformation resistance to the edge regions than the central portion of said slab, and alternately applying deformation forces by means of said edge-working rolls and said first and second sets of face-working rolls to effect longitudinal elongation of said slab and alternately effect material deformation of the slab mainly in the central portion thereof to yield a bulged-shape cross-section due to application of a deformation force between said edge-working rolls and to at least restore said slab to a substantially rectangular cross-section by elimination of said bulged shape due to application of a deformation force to face-working rolls next adjacent said edge-working rolls in the direction of travel of said slab.

According to a second aspect of the present invention there is provided apparatus for rolling a slab to form a billet comprising means for introducing a slab of substantially uniform, rectangular cross-section defined by a pair of opposed slab faces interconnected by a pair of opposed slab edges to a rolling apparatus comprising first and second sets of opposing face-working rolls and a set of opposing edge-working rolls disposed intermediate said sets of face-working rolls, means for alternately applying deformation forces by means of said plurality of edge rollers and said plurality of face rollers to effect longitudinal elongation of said slab, and alternately reduce the width thereof and form a bulged-shaped cross-section while deformation force is applied to said edge rollers, and at least restore said slab to a substantially rectangular cross-section while deformation force is applied to said face rollers, and means for maintaining a reducing temperature gradient from the centre-line of said slab outwardly thereof to impart greater deformation resistance to the edge regions than the central portion thereof such that said means for alternately applying deformation forces achieves ma-

terial deformation mainly in the central portion of said slab while force is applied to said edge rollers.

Under certain circumstances it is not sufficient to bring about the temperature drop, which is symmetrical with respect to the centre of the slab, only before the first edging pass, therefore it is appropriate to maintain the temperature drop during the rolling of a slab.

Two possibilities exist for producing the temperature drop, namely either cooling the edge regions of the slab or partial heating of the central region of the slab.

Based on the knowledge that a slab leaving a continuous casting installation automatically has the symmetrical temperature drop starting from the central region of the slab, according to a further proposal of the invention, the use of the method according to the invention with a slab which is still hot, leaving a continuous casting installation, is recommended, i.e. carrying out the method using the continuous casting heat.

One embodiment of a reversing rolling mill according to the invention is illustrated in the drawings, by means of which the rolling method according to the invention is illustrated in detail:

Fig. 1 is a side view of the rolling mill shown diagrammatically for rolling a slab standing on its edge,

Fig. 2 is a plan view of Fig. 1,

Fig. 3 shows a so-called "dog's bone" configuration,

Fig. 5 is a diagram illustrating the temperature drop, and

Fig. 5 shows a slab contour which has been correctly edged.

The reversing rolling mill illustrated comprises a pair of edge-working rolls 1 with horizontal roll axes for rolling down a slab 2 placed on its edge, and pairs of face-working rolls 3 and 4 with vertical roll axes, located on both sides of the pair of edge-working rolls. The slab 2 placed on its edge is supported by the rollers 5 of a roller bed.

It is important to prevent the "dog's bone" configuration illustrated in Fig. 3, with increases in thickness solely in the edge regions of a slab caused by powerful edging passes. When a profile of this type passes through a pair of face-working rolls 3, 4, only the edge regions of the slab are reduced. In order to achieve uniform edging of the rectangular slab profile by the edge-working rolls 1, in order to achieve a profile according to Fig. 5, there are provided on both sides of the pair of edge-working rolls 1 and outside the pair of face-working rolls 3 and 4 on both sides of the slab 2, inductive heating devices 6, 7 and 8, 9, which—as shown in dot-dash line in Fig. 1—serve for the partial heating or retention of heat of the central region of the slab 2 (seen over the height of the latter). Due to these heating devices, a temperature drop which is symmetrical with respect to the central line of the slab 3, possibly along the line 10 in the graph according to Fig. 4, is provided and substantially maintained during the entire rolling operation such that the central region of the slab is at a higher temperature and thus has a lower deformation resistance than at the edge regions of the slab. The edge regions offer greater resistance to the edging pressure of the rolls 1, so that on the whole the edging pressure causes thickening of the slab in the central region, as shown in Fig. 5.

In the embodiment, the slab 2 travels through the rolling mill from left to right. The slab enters the gap between the guide rollers 3 with a rectangular cross section, as shown in dot-dash line at 12 in Fig. 1. In collaboration with the rollers 5 of the roller bed, the rolls 3 serve solely to guide the rolled stock and do not need to be set up for a reduction per pass. On passing between the edge-working rolls 1, a substantial reduction of the slab width takes place by one edging pass, which may naturally also be carried out with edge-working rolls arranged vertically. With a clear reduction of the slab width and with a correct adjustment of the temperature drop according to Fig. 4, a correctly bulged-shaped cross-section is obtained as shown in dot-dash line in Fig. 1 at 13 in front of the face-working rolls 4. The rolls 4 not only smooth the central bulges of the compressed slab profile, but as a result of their adjustability, a reduction per pass preferably takes place over the broad sides of the slab 2, even if this is only a slight reduction, as shown in Fig. 2. Due to this, the material is deformed over the entire width, due to which temperature losses in zones are eliminated. During the reversing pass, the adjusting devices of the face-working rolls 4 are preferably not actuated, whereas the face-working rolls 3 and naturally also the edge-working rolls 1 are adjusted.

The rolling process is continued until the slab 1 has been rolled down to form a billet of rectangular or approximately rectangular cross section, with considerable elongation. Continuous casting installations for billets may become superfluous due to the new rolling method, whereby rolled billets are obtained which from the metallurgical point of view are preferred to continuously cast billets, for further processing in small section rolling mills. However, it is also conceivable to apply the invention to continuous casting by arranging a plurality of edge-working and face-working rolls in an alternating series.

WHAT WE CLAIM IS:—

1. A method of rolling a slab to form a billet, comprising the steps of introducing a slab of substantially uniform rectangular cross-section defined by a pair of opposed slab faces interconnected by a pair of opposed slab edges to a rolling apparatus comprising first and second sets of opposing face-working rolls and a set of opposing edge-working rolls disposed intermediate said sets of face-working rolls, maintaining a reducing temperature gradient from the centre-line of said slab outwardly thereof to impart greater deformation resistance to the edge regions than the central portion of said slab, and alternately applying deformation forces by means of said edge-working rolls and said first and second sets of face-working rolls to effect longitudinal elongation of said slab and alternately effect material deformation of the slab mainly in the central portion thereof to yield a bulged-shape cross-section due to application of a deformation force between said edge-working rolls and to at least restore said slab to a substantially rectangular cross-section by elimination of said bulged shape due to application of a deformation force to the set of face-working rolls next adjacent said edge-working rolls in the direction of travel of said slab.

2. A method as claimed in claim 1, wherein the step of alternately applying deformation forces further comprises applying a thickness reduction-effective force to the said set of face-working rolls next adjacent said edge-working rolls.

3. A method as claimed in claim 1 or 2, wherein said step of maintaining said temperature gradient comprises directing a cooling spray of fluid to said edge regions.

4. A method as claimed in any one of the preceding claims, wherein said step of maintaining said temperature gradient comprises heating the central portion of said slab.

5. Apparatus for rolling a slab to form a billet comprising means for introducing a slab of substantially uniform rectangular cross-section defined by a pair of opposed slab faces interconnected by a pair of opposed slab edges to a rolling apparatus comprising first and second sets of opposing face-working rolls and a set of opposing edge-working rolls disposed intermediate said sets of face-working rolls, means for alternately applying deformation forces by means of said plurality of edge rollers and said plurality of face rollers to effect longitudinal elongation of said slab, and alternately reduce the width thereof and form a bulged-shaped cross-section while deformation force is applied to said edge rollers, and at least restore said slab to a substantially rectangular cross-section while deformation force is applied to said face rollers, and means for maintaining a reducing temperature gradient from the centre-line of said slab outwardly thereof to impart greater deformation resistance to the edge regions than the central portion thereof such that said means for alternately applying deformation forces achieves material deformation mainly in the central portion of said slab while force is applied to said edge rollers.

6. A method of rolling a slab to form a billet, substantially as herein described with reference to the accompanying drawings.

7. Apparatus for rolling a slab to form a billet, substantially as herein described with reference to and as illustrated in the accompanying drawings.

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1561894 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG.1

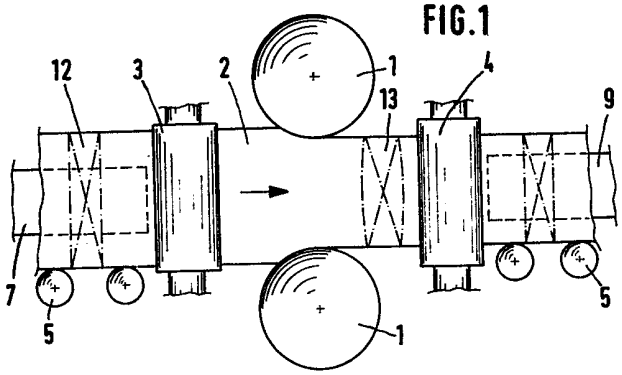
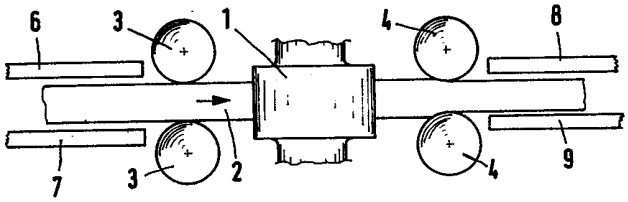


FIG.2



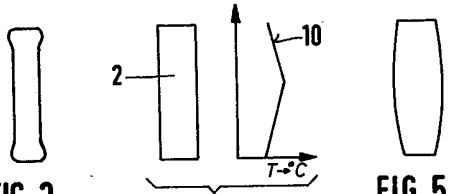


FIG.3

FIG.4

FIG.5