ABSTRACT

The continuous steel stock to be hot-formed has been continuously cast in a rectangular as-cast cross-section which has corner zones and has a shortest side length in excess of 100 millimeters and a side length ratio between 1:1.5 and 1.5:1. The stock is subjected with utilization of its casting heat to a deformation of at least 20 percent by a pair of grooved rolls to form deformed continuous steel stock having side faces which are less curved in cross-section than said corner zones and which include the material of all said corner zones of said as-cast cross-section.

12 Claims, 13 Drawing Figures
PROCESS OF CONTINUOUSLY HOT-FORMING CONTINUOUS CAST STEEL STOCK

This invention relates to a process of continuously hot-forming continuous cast steel stock having a square or rectangular cross-section which has a shortest side length of more than 100 millimeters and a side length ratio between 1:1.5 and 1:5.1, wherein the continuous stock is deformed by grooved rolls and with utilization of the casting heat.

Such processes are particularly adopted to enable the casting of continuous stock which is relatively large in cross-section so that the casting rate can be increased and liquid steel can be cast at a given rate in a continuous casting plant to form relatively few continuous castings. The great reduction in cross-section by the continuous deformation results in continuous stock which is much smaller in cross-section, such as is often required for subsequent shaping operations. In known processes of this kind, one or more pairs of rolls are used. Where only one pair of rolls are used, continuous stock having a cross-section of, e.g., 130 millimeters x 95 millimeters, is upset and deformed into a cross-section of 100 millimeters x 100 millimeters by a pair of horizontal rolls having a box-shaped groove pass. Where two or more pairs of rolls are used to deform the continuous stock, rolling mill stands having horizontal and vertical roll axes will be used in alternation. In that case, a square-section continuous casting is provided in most cases, which has cross-section side lengths generally between 120 millimeters and 200 millimeters. The rolls are either so-called plain rolls or grooved rolls. The first pair of rolls which deform the continuous casting are provided, as a rule, with a box-shaped groove pass. It has also been proposed to deform a continuous casting having a diamond cross-section into a square cross-section. All these deformation processes have the disadvantage that it is very difficult to avoid corner cracks. It has not been possible entirely to eliminate this disadvantage even where temperature-equalizing zones were used along the path of the continuous casting before the first pair of rolls.

It is an object of the invention to avoid said corner cracks. This object is accomplished according to the invention that in continuous stock having substantially the same cross-section is subjected to a deformation of at least 20 percent by a pair of rolls in such a manner that all corner zones of the as-cast cross-section lie in flat or less strongly curved side face zones of the deformed cross-section.

In the process according to the invention, the grooved rolls of the first pair of rolls which deform the continuous stock exert a strong rolling pressure on the corners of the stock so that these corners are forced into the stock. Hence, the delicate corners of the continuous casting are subjected only to compressive stresses so that cracks are avoided.

The invention may be carried out with rolls having groove passes in various shapes.

In one embodiment, the deformation is effected by a pair of rolls having an oval-section groove pass and the long axis of the cross-section of the groove pass and two parallel sides of the continuous stock entering the groove pass are parallel to the roll axes.

In another embodiment, the deformation is effected by a pair of rolls having an octagonal-section groove pass having a cross-section having axes of symmetry in different lengths and the long axis of symmetry and two parallel sides of the continuous stock entering the groove pass are parallel to the roll axes.

In a third embodiment, the deformation is effected by a pair of rolls having a hexagonal-section groove pass and one diagonal of the groove pass cross-section and two parallel sides of the continuous stock entering the groove pass are parallel to the roll axes.

In a further embodiment, the deformation is effected by a pair of rolls defining a diamond-section groove pass and the long diagonal of the cross-section of the groove pass and two parallel sides of the continuous stock entering the groove pass are parallel to the roll axes.

In another embodiment, the deformation is effected by a pair of rolls defining a gothic-section groove pass and the long diagonal of the cross-section of the groove pass and two parallel sides of the continuous stock entering the groove pass are parallel to the roll axes.

In all cases mentioned above, the deformed continuous stock may be deformed further to square-section continuous stock by another pair of rolls which define a square-section groove pass and have axes at right angles to those of the first pair of rolls.

When it is desired to produce circular-section continuous stock, this may be accomplished by the rolls defining groove passes which are oval, octagonal and hexagonal in cross-section.

The groove pass configurations for the several embodiments of the invention are shown on the accompanying drawing, in which

FIG. 1 shows an oval-section groove pass,
FIG. 2 is an octagonal-section groove pass,
FIG. 3 a hexagonal-section groove pass,
FIG. 4 a diamond-section groove pass,
FIG. 5 a gothic-section groove pass,
FIGS. 1a – 5a illustrate the strands of FIGS. 1 – 5, respectively, passing through second groove passes;
FIGS. 1b – 5b illustrate the strands of FIGS. 1 – 3, respectively, passing through third groove passes.

In all figures of the drawing, dotted lines indicate the contour of the cross-section of the continuous stock to be deformed in the respective groove pass. According to FIG. 1, continuous stock having a square as-cast cross-section is deformed by the pair of rolls 1, 1' having horizontal axes. The continuous stock is entered into the groove pass so that the parallel sides a are horizontal. For this purpose, the stock is continuously produced in an upright mold continuous casting and by means of a curved stock guide is deflected into an approximately horizontal direction and in the form shown is entered between the pair of horizontal rolls 1, 1'. These rolls define an oval-section groove pass, which has a long axis which is also horizontal, parallel to the roll axes. The deformed stock has a cross-section conforming to that of the groove pass and the corner zones k of the as-cast cross-section now lie in the strong curved side face zones k' of the deformed cross-section, i.e., those zones which during the deformation are subjected to the strongest tensile stresses, were originally disposed at the flat side faces of the as-cast cross-section, where the same is less liable to crack because they are at a higher temperature. Hence, the deformation according to the invention is controlled in consideration of the different deformability characteristics of different portions of the as-cast cross-section.

FIG. 1a illustrates the subsequent deformation to a square-section stock by a second pair of rolls 2, 2'.

3,837,207
which extend at right angles to the rolls of the first pair. After the deformation, the original corner zones \( k \) of the as-cast cross-section are disposed in the zones \( k'' \)
of the square-section rolled stock.

FIGS. 2, 3, 4, and 5 illustrate the deformation ef-
fect in accordance with the invention in the same
way as in FIG. 1 but with groove passes having different
configurations. For instance, FIGS. 2 and 3 show the
def ormation of continuous stock having a rectangular
as-cast cross-section. The parallel sides \( a \) are somewhat
longer than the sides \( b \) at right angles thereto. In this
case, the original corner zones \( k \) come to lie in flat side
faces of the deformed stock so that the described re-
 sults are produced. In FIGS. 4 and 5, the deformation
is effected in a diamond-section groove pass or a goth-
ic-section groove pass. In these cases too, the original
corner zones of the as-cast cross-section come to lie in
side faces which are flat or only slightly curved. FIGS.
1b, 2b and 3b show the further deformation by a pair of
rolls \( 2'' \) having a circular-section groove pass to
form circular-section stock.

The advantages afforded by the invention reside par-
 ticularly in that the continuous steel casting can be
rolled to effect large reductions whereas corner cracks
or corner brittleness need not be feared. As a result,
continuous stock larger in cross-section can be cast and
can be continuously rolled in fewer passes to that
smaller size which is required for the further process-
ing. In general, two pairs of rolls are required, although
three or four pairs of rolls may be used where a par-
ticularly large reduction is desired. In this case, the groove
pass configurations known for the rolling of steel rod
may be used in the second and following pairs of rolls.

Although the invention is illustrated and described
with reference to a plurality of preferred embodiments
thereof, it is to be expressly understood that it is in no
way limited to the disclosure of such a plurality of
preferred embodiments, but is capable of numerous modi-
fications within the scope of the appended claims.

What is claimed is:

1. A continuous process of hot-forming continuous
steel stock which has been continuously cast in a rec-
tangular as-cast cross-section which has corner zones
and has a shortest side length in excess of 100 millime-
ters and a side length ratio between 1:1.5 and 1.5:1,
which comprises

subjecting said stock with utilization of its casting
heat to a one step deformation of at least 20 per-
cent by a pair of grooved rolls to form deformed
continuous steel stock having side faces which are
less curved in cross-section than said corner zones
and which include the material of all said corner
zones of said as-cast cross-section.

2. A process as set forth in claim 1, in which said as-
cast cross-section is square.

3. A process as set forth in claim 1, in which said side
faces of said deformed stock are flat in cross-section.

4. A process as set forth in claim 1, in which
said deformation is effected by a pair of grooved rolls
defining a groove pass having an oval cross-section,
which has a major axis which is parallel to the axes
of said rolls and
said stock is entered into said groove pass with two
parallel sides of said as-cast cross-section being
parallel to said roll axes.

5. A process as set forth in claim 1, in which
said deformation is effected by a pair of grooved rolls
defining a groove pass having an octagonal cross-
section, which has long and short axes of symme-
try, said long axis of symmetry being parallel to the
axes of said rolls, and
said stock is entered into said groove pass with two
parallel sides of said as-cast cross-section being
parallel to said roll axes.

6. A process as set forth in claim 1, in which
said deformation is effected by a pair of grooved rolls
defining a groove pass having a hexagonal cross-
section, which has a diagonal that is parallel to the
axes of said rolls, and
said stock is entered into said groove pass with two
parallel sides of said as-cast cross-section being
parallel to said roll axes.

7. A process as set forth in claim 1, in which
said deformation is effected by a pair of grooved rolls
defining a groove pass having a diamond cross-
section having long and short diagonals, said long
diagonal being parallel to the axes of said rolls, and
said stock is entered into said groove pass with two
parallel sides of said as-cast cross-section being
parallel to said roll axes.

8. A process as set forth in claim 1, in which
said deformation is effected by a pair of grooved rolls
defining a groove pass having a gothic cross-
section having a long diagonal which is parallel to the
axes of said rolls, and
said stock is entered into said groove pass with two
parallel sides of said as-cast cross-section being
parallel to said roll axes.

9. A process as set forth in claim 1, in which
said deformed stock is subjected to a further deforma-
tion to form square-section stock by a second
pair of rolls having axes which are at right angles
to the axes of said pair of grooved rolls.

10. A process as set forth in claim 4, in which
said deformed stock is subjected to a further deforma-
tion to form circular-section stock by a second
pair of rolls having axes which are at right angles
to the axes of said pair of grooved rolls.

11. A process as set forth in claim 6, in which
said deformed stock is subjected to a further deforma-
tion to form square-section stock by a second
pair of rolls having axes which are at right angles
to the axes of said pair of grooved rolls.

12. A process as set forth in claim 7, in which
said deformed stock is subjected to a further deforma-
tion to form circular-section stock by a second
pair of rolls having axes which are at right angles
to the axes of said pair of grooved rolls.

* * *