The invention relates to a method of producing cast strands (2) in shapes of billets or ingots wherein the strand (2) is guided between pairs of rollers (4 to n). In their straightening region (A), the strands (2) are formed, with the use of profiled rollers (4 to) with one-sided or multiple-sided projections (h, b) or recesses (-A, b). In the casting direction (10), downstream of the straightening region, the strands are subjected to a soft-reduction with at least one roller pair (7 to 9) with smooth rollers. The invention also relates to a casting machine provided with correspondingly formed rollers.
METHOD AND CASTING MACHINE FOR PRODUCTION OF CASTING BARS IN THE SHAPE OF BILLET OR BLOCKS

[0001] The invention relates to a method of producing cast bars or strands in shape of billets or ingots, with the strands being guided between pairs of rollers.

[0002] It is known to reduce or to completely prevent segregation and the core porosity by soft reduction in casting installations. To this end, the strand thickness is reduced in a precisely directed manner in the region of the residual solidification with one or, preferably, several pairs of rollers. The reduction of thickness in the region of soft reduction can be effected uniformly or non-uniformly.

[0003] In ingot installations, the strand cross-sections for soft reduction are formed with one or several projections or recesses in order to obtain a noticeable improvement of the strand quality with a comparably low power requirement. The soft-reduction starts in the straightening region of a cast strand by appropriately adjusting the rollers. To this end, the speed and strand cooling can be so adjusted that the residual solidification takes place in the straightening region.

[0004] At high speeds and/or large cast cross-sections, the cast radius should be noticeably increased. This results in increased costs of a corresponding installation. Furthermore, an adjustment of rollers with the use of spacers or the use, preferably, of position-controlled hydraulic cylinders is necessary in order to prevent a strand reduction with smooth rollers at a wrong location.

[0005] U.S. Pat. No. 3,628,594 discloses a device for reduction of a cross-section of a strand and which includes a pair of rollers driven in a horizontal plane and pairs of rollers driven in a vertical plane on opposite sides of the strand. The roller pairs, between which a strand is displaced, are adjusted relative to each other with hydraulic piston/cylinder units and serve for reducing vertical and horizontal cross-sectional dimensions of the cast strand.

[0006] A not yet laid-open German application 1014234.3 discloses a method of and a device for optimization of quality of cast strands with round or substantially round cross-sections in the region of soft-reduction.

[0007] To this end, the cast strand, beneath the mold, is deformed, in the region of residual solidification, at least in one reduction plane with adjustable rollers in order to improve the inner quality. In a further step, the round or approximately round cast cross-section is deformed in the region of the residual solidification with two-sided adjustable rollers, which are offset by 90° relative to the reduction plane, by an amount between 5% and 60% of the main reduction in order to increase the inner quality and the core densification. With round or approximately round, in particular, comparatively large strand cross-sections or strand cross-section regions, there are provided additional two-sided adjustable rollers, which are offset by 90° relative to the reduction plane, in order to prevent structural cracks or an uncontrolled deformation of the strand.

[0008] Japanese Publication JP 12 37 062 disclose prevention of inner cracks in a cast strand during straight bending, even at high cast speeds, by providing the strand with a reverse trapezoidal shape. To this end, the strand is formed in a mold the inner wall surfaces of which have trapezoidal shape, with the width on the inner side of the bend being greater than the width on the outer side of the bend in order to obtain a reverse trapezoidal shape.

[0009] This method permits to reduce the tension stress in the first region of the upper side of the cast strand and, thereby, the cast speed can be increased.


[0011] The strand casting machine is followed by groups of rollers for a stepwise rolled reduction and which effect the predetermined reduction alternatively vertically and horizontally. Because the continuously cast material, which has a round or polygonal shape, is reduced by rollers before solidification in the central region, segregation and cavitation are prevented.

[0012] Thereafter, the strand is cut to predetermined lengths to obtain separate cast workpieces. When the cast workpieces have a rectangular shape, the treatment becomes easy, the formation of voids and of a central segregation is prevented, and the structural quality is noticeably improved.

[0013] Japanese Publication JP 12 02 342 proposes in order to reduce tension stresses in the solidified region of a cast strand and to improve the formation of strand of melting steel, to form notches in a portion of the upper side of the strand and to form the notch region during the continuous casting process. Upon vertical extraction of the strand out of the mold, it is, firstly, bent in an arcuate shape and then is guided to a horizontal break-down region.

[0014] The strand is guided in the horizontal break-down region with upper and lower squeegee rollers in order to stretch it into a horizontal shape. After a complete solidification in the region of the lowest point of the liquid pool, the strand is cut with a cutting burner on the outer side of the horizontally stretched region. This method permits to reduce tension stresses in the solidified region of the boundary region on the outer side of the stretched region, which enables to conduct a continuous casting process at increased casting speeds. In addition, structural cracks are prevented, and the productivity is increased.

[0015] Japanese Publication JP 21 42 654 discloses production of round cast strands without formation of cracks by breaking down the cast strand with break-down rollers and pulling the strand with rotatable pinch rollers after solidification. With this method, the bending stresses appear only in a non-solidified region of the strand, which reduces formation of inner cracks.

[0016] Proceeding from the foregoing state of the art, the object of the invention is to provide a method of and a casting machine for formation of billets and ingots, with which the casting radius is not determined by the soft-reduction but is selected in particular based on casting technological and qualitative grounds and economical considerations.

[0017] The object is achieved by a method of producing cast strands in shape of billets or ingots wherein the strand is guided between pairs of rollers, and in which according to the invention in a straightening region, the strands are formed with one or several projections or recesses by using
profiling rollers, and downstream of the straightening region, in a casting direction, the strands are subjected to a soft-reduction with at least one roller pair with smooth rollers.

[0018] Further particularities of the method according to the invention follow from corresponding subclaims.

[0019] It is suggested that in the region of the soft reduction, the roller pair is advanced toward and away according to a position of the lowest point of the liquid pool.

[0020] At that, the soft reduction is effected preferably with a single roller pair.

[0021] It is further advantageous when the position of the liquid pool lowest point is determined with an aid of calculation models and/or by measurement technique, e.g., by measuring a position or force, with the roller pair being correspondingly adjusted.

[0022] It is further advantageous when with two-sided projections or recesses, they are, preferably, provided on opposite sides of the strand.

[0023] In particular, with steel stocks with segregation tendencies and/or core porosity, advantageously, the projections or recesses of the strand cross-sections are provided on all four sides.

[0024] At a one-sided shaping, the projection height constitutes maximum 8% of thickness of a reducable strand, at a two sides shaping, the projection height on each side constitutes maximum 6%, and at all-sided shaping, the projection height on each side constitutes maximum 4%.

[0025] A width of a profile constitutes from 30 to 80% of a width of a corresponding side.

[0026] A casting machine for producing cast strands in shape of billets or ingots with formation of one-sided or multiple sides projections is characterized according to the invention in that profilled roller pairs are associated with a straightening region, and at least one roller pair with smooth rollers is associated with a region of the soft reduction.

[0027] Further embodiments of the casting machine are developed according to corresponding subclaims.

[0028] Below, the invention will be explained in detail with reference to the drawings which show:

[0029] FIG. 1 a casting machine with a mold and an adjoining strand guide;

[0030] FIGS. 2a, 2b, 2c strand cross-sections C, D, E with one or several projections according to the invention;

[0031] FIGS. 3a, 3b, 3c strand cross-sections F, G, H with one or several recesses according to the invention;

[0032] FIG. 4a a profile roller for forming the projections;

[0033] FIG. 4b a profile roller for forming the recesses.

[0034] FIG. 1 shows a casting machine with a mold 1 to which a steel melt 10 is fed, and formation of a cast strand 2 beneath the mold. The strand 2 passes through a deflection section with a cast radius R from a vertical cast direction to a horizontal direction 13 with a tangent point 3. The tangent point 3 is located approximately in the center of a straightening region A with straightening rollers 4, 5, 6 and which is adjourned by a soft-reduction region B. In the soft reduction region B, soft reduction takes place which is effected with pairs 7, 8, 9 of smooth rollers. During the soft reduction, the position of the lowest point of the liquid pool in the soft-reduction region B is determined with the aid of a computation model or measurement technique, e.g., by measuring the position or forces, with the roller pairs 7, 9 being correspondingly adjusted.

[0035] All in all, the soft reduction is so effected by controlling the strand cooling or the cast speed that it starts at the straightening region with the liquid pool lowest point and ends at the end of the soft-reduction region B.

[0036] FIGS. 2a through 2c show formation of the strand cross-sections according to the invention with one or several projections (h, b) which results in formation of the cross-sectional shapes C, D, E.

[0037] FIGS. 3a through 3b show strand sections according to the invention which are formed with recesses (−h, b) and which have cross-sectional shapes F, G, H. On the opposite side, respective recesses are designated with −h (or −h')

[0038] Respective profiles are produced with correspondingly profilled straightening rollers 4-6 having a shape 11 according to FIG. 4a for forming projections, and having a shape 12 for forming recesses.

[0039] By displacing a roller pair or pairs and/or by advancing the rollers toward and away, an optimal position (region of the residual solidification) for the soft-reduction can be obtained, which permits to reliably achieve the desired improvement of the inner quality. Further, the measures according to the invention permit to obtain a smaller cast radius which, in turn, permits to noticeably reduce the height of the machines, the shop height, and casts of the base.

1-15. (Cancelled).

16. A method of producing cast strands (2) in shape of billets or ingots which are formed into a cast strand (2) in a continuous casting mold (1) and beneath it are deflected by a cast radius R from a vertical into a horizontal casting direction (13) and finally pass through a straightening region where the strand (2) is guided between pairs (4 to n) of rollers which are adjourned by a soft-reduction region B at least one roller pair, characterized in that in a straightening region (A), the strands are formed with one or several projections (h, b) or recesses (−h, −b) by using profilled rollers (4-6), and in that downstream of the straightening region (A), in the casting direction (13), the strands are subjected to a soft-reduction (B) with the at least one roller pair (7 to 9) with smooth rollers.

17. A method according to claim 16, characterized in that in a region of soft reduction (B), the roller pair (7-9) is advanced toward and away according to a position of a lowest point of a liquid pool.

18. A method according to claim 16, characterized in that the soft reduction (B) is preferably effected with one roller pair (7 to 9).

19. A method according to claims 16, characterized in that the position of the liquid pool lowest point is determined with calculation models and/or measurement tech-
nique, e.g., by measuring a position or force, with the roller pair (7 to 9) being correspondingly adjusted.

20. A method according to claim 16, characterized in that with two-sided projections (h, h', b', b') or recesses (−h, −h', −b', −b') are, preferably, provided on opposite sides of the strand (2).

21. A method according to claim 16, characterized in that with steel stocks with segregation tendencies and/or core porosity, the projections (h, b) or recesses (−h, −b) of the strand cross-sections are provided on all four sides.

22. A method according to claim 16 characterized in that at a one-sides shaping, the projection height (h) constitutes maximum 8% of thickness of a reducible strand (2).

23. A method according to claim 16, characterized in that at a two-sided shaping, the projection height (h) on each side constitutes maximum 6%.

24. A method according to one or more of claims 16, characterized in that at an all-sided shaping, the projection height on each side constitutes maximum 4%.

25. A method according to claim 16, characterized in that a width (b) of a profile constitutes from 30 to 80% of a corresponding side.

26. A casting machine for producing cast strand (2) in shape of billets or ingots, comprising a continuous casting mold (1) for forming a cast strand (2) that is deflected by a cast radius (R) from a vertical in horizontal casting direction (13) and is provided with a straightening region (A) with straightening roller pairs (4, 5, 6) which are adjoined by a soft-reduction region (B) with at least one roller pair (7, 8, 9), characterized in that

profiled roller pairs (4 to 6) are associated with the straightening region (A), and the at least one roller pair (7 to 9) has smooth rollers.

27. A casting machine according to claim 26, characterized in that

for the straightening region (A), in particular on both sides of a tangent point (3) at least one pair of profiled rollers (4 to 6) is provided.

28. A casting machine according to claim 26, characterized in that

for an optimal adaptation of the roller pair (7-9) to a position of a liquid pool lowest point, the rollers are displaceable substantially horizontally in a casting direction (13) or in a direction opposite the casting direction.

29. A casting machine according to claim 26, characterized in that

the roller pair(s) are arranged horizontally and/or vertically in the region of soft-reduction (B).

30. A casting machine according to claim 26 characterized in that

the profiled rollers (4 to 6) are formed with negative diametrical regions (−h, −b) or with positive diametrical regions (h, b).

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