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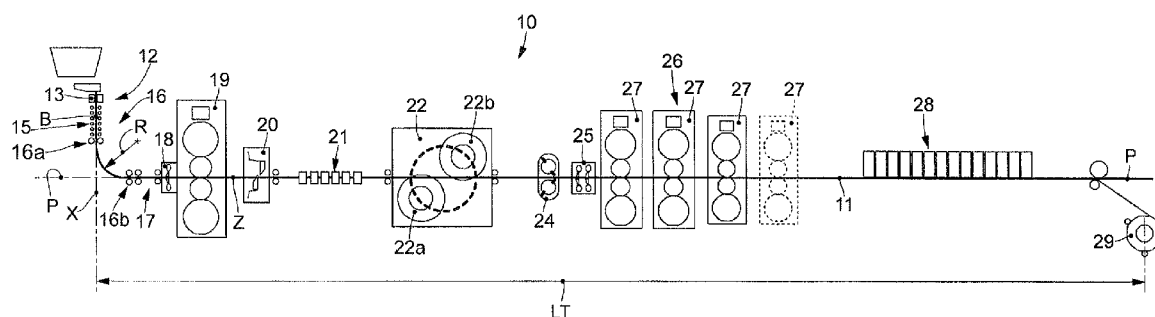


fig. 1

(57) Abstract: Plant (10) and method for the production of a hot-rolled metal strip (11), comprising a vertical continuous casting machine (12) and, disposed in sequence along a horizontal rolling plane (P), a roughing stand (19), a shear (20) for shearing to size, an inductor (21), a winding/unwinding device (22), a shear for head/tail cropping (24), a continuous finishing rolling train (26), a laminar cooling device (28) and a winding reel (29).

“PLANT AND METHOD FOR THE PRODUCTION OF A HOT-ROLLED METAL STRIP”

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FIELD OF THE INVENTION

5 The field of application of the present invention is the steel industry and the production of semifinished metal products, more particularly the production of metal strip, for example made of steel, hot-rolled by means of a rolling line located downstream of a continuous casting machine.

BACKGROUND OF THE INVENTION

10 In the field of production of metal strip, a casting plant and method for the production of hot-rolled steel strip are known for example from document US-B-5.307.864.

Document US-B-5.307.864 describes a steel strip production plant comprising a hot-rolling line located downstream of a continuous casting machine provided,
15 in turn, with a mold equipped with a crystallizer. The casting machine, of the vertical-curved type, also comprises guide devices to divert the metal product from the vertical direction, at exit from the crystallizer, to the horizontal direction following a curved path, with high radii of curvature.

This casting plant comprises, downstream of the guide devices, a roughing
20 stand to roll the cast metal product, a shear to shear the cast slab and a heating device to heat the cast slab before it is wound into a winding/unwinding device from which it is then unwound to be fed to the hot-rolling line provided downstream.

A further heating unit is interposed between the finishing rolling stands of the
25 hot-rolling line, to restore the temperature of the slab being rolled. After which a winding device, or winding reel, is provided.

However, the above plant and the corresponding method have the disadvantage that they are rather rigid and do not allow to easily regulate the hourly productivity. Its size requires considerable investments to make it and
30 keep it operational, and it is uneconomical since it involves performing intermediate heatings of the strip in the finishing train.

Also known from document US-B-7.025.118 is a vertical casting machine and method provided to maintain the position of the kissing point, that is, the point of

complete solidification of the metal product, always in a same position along the containing devices, as the casting speed, the type of steel and the secondary cooling modes vary. This allows, as now consolidated in the state of the art, to maintain the thickness of the cast product constant at exit from the continuous
5 casting machine.

In order to maintain the position of the kissing point unchanged, and therefore to maintain the thickness at exit of the cast product constant, at the different casting speeds, the thickness of the slab is varied so as to maintain the growth of solidification skin constant over time.

10 This casting machine, however, is rigid since it is not able to cast slabs of the ultra-thin type and, above all, it is not able to regulate, with a high degree of variability, the final thickness of the cast slabs and therefore regulate as a consequence the productivity of the plant.

Another known casting and rolling plant for the production of steel strip is
15 described in WO-A-2015/014865.

One purpose of the present invention is to provide a plant and to perfect the corresponding method for the production of a hot-rolled metal strip which, by overcoming the disadvantages of the plants and methods of prior state of the art, are very flexible and particularly suitable for medium-low productions, that is, up
20 to a maximum of 1.1 Mton/year, preferably to obtain an annual production of less than 800,000 ton/year, and easily variable, for example between about 400,000 ton/year and about 800,000 ton/year.

Another purpose of the present invention is to provide a plant for producing a hot-rolled metal strip which has very small overall sizes, for example with a
25 length of less than 130m, consequently reducing the investment and maintenance costs of the buildings connected thereto.

It is also a purpose of the present invention to provide a plant for the production of a hot-rolled metal strip that requires limited investments to make it (Capex) and has low operating transformation costs (Opex) compared to a
30 traditional plant to produce the same strip thicknesses.

Another purpose of the present invention is to provide a plant and to perfect the corresponding method for the production of a hot-rolled metal strip which can easily vary the thickness of the cast slab in relation to the final thickness of the

strip and optimize the productivity of the plant with the lowest possible number of stands, maintaining the maximum casting speed in relation to the steel grade.

The Applicant has devised, tested and embodied the apparatus and perfected the method according to present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

10 In accordance with the above purposes, a plant for the production of a hot-rolled metal strip according to the present invention comprises:

- a continuous casting machine having a substantially vertical casting axis and having a containing length less than or equal to 6m, the continuous casting machine being configured to cast a metal product with a casting speed comprised
15 between about 3.6 m/min and about 6 m/min, and comprising a mold, with a corresponding crystallizer and a roll-type pre-rolling device configured to obtain a liquid core pre-rolling and to supply at exit an ultra-thin slab having first thicknesses selectively settable. Furthermore, the roll-type pre-rolling device has a length, measured in a direction parallel to the casting axis, less than or equal to
20 5m, and is configured to determine the complete solidification of the cast product at a solidification point contained in the roll-type pre-rolling device and selectively located in a zone comprised between the exit end of the latter and a distance from the exit end of at least 80% of the length of the roll-type pre-rolling device, toward the entrance end of the latter. The containing length is defined as
25 the distance between the entrance end of the crystallizer and the exit end of the roller unit.

According to some embodiments of the invention, the plant also comprises downstream of the roll-type pre-rolling device a drawing unit configured to draw the slab and send it downstream.

30 After a curved segment of the continuous casting machine, the plant also comprises, disposed along a substantially horizontal rolling plane:

- at least one roughing stand configured to transform the slab into a roughed slab, also called X-bar, or transfer bar, having a second thickness,

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- first shearing means configured to shear the roughed slab to size,
- induction heating means configured to heat the roughed slab to a determinate rolling temperature, or to keep it at a determinate rolling temperature,
- a winding/unwinding device configured to selectively wind/unwind the
- 5 roughed slab and to keep it at the rolling temperature,
- second shearing means configured to crop the head/tail ends and possibly scrap the roughed slab in the event of an emergency,
- a continuous finishing rolling train to reduce the thickness of the roughed slab until a metal strip is obtained, having a determinate final thickness,
- 10 - cooling means configured to cool the metal strip,
- a winding reel configured to wind the metal strip.

According to another solution of the invention, the roll-type pre-rolling device is configured to be adjustable so that the first thicknesses of the slab are comprised between about 28mm and about 48mm.

- 15 According to a further solution of the present invention, the roughing stand and the continuous finishing rolling train are configured to be adjustable so that the final thickness of the metal strip is comprised between about 0.8mm and about 12mm.

According to a possible embodiment of the present invention, as a function of

20 the casting speed, correlated to one of the first thicknesses of the slab, it is possible to obtain an hourly production of the casting machine comprised between about 80 ton/h and about 160 ton/h, corresponding to about 400,000 ton/year and, respectively, to about 800,000 ton/year.

According to a further embodiment of the invention, the cast product exiting

25 the crystallizer has a determinate thickness comprised between 48mm and 56mm, preferably comprised between 50mm and 54mm and still has a liquid core inside it. According to this solution, it is possible to provide that the crystallizer is defined by at least two plates facing each other and distanced from each other, by a distance, at least in the terminal segment, equal to the thickness of the cast

30 product. According to solutions of the present invention, the size of the crystallizer can be substantially the same for each production condition set, for example linked to the thickness of the strip to be obtained, to the casting speed and to productivity.

According to another embodiment of the present invention, a first descaling device is disposed immediately before the roughing stand that has the function of removing the scale from the surface of the slab.

5 According to another solution of the present invention, a second descaling device is disposed between the second shearing means and the continuous finishing rolling train.

According to one embodiment of the present invention, the continuous finishing rolling train comprises a number of finishing stands comprised between two and five.

10 According to possible solutions, the roughing stand is directly connected to the casting machine, the term “directly connected” meaning that there is no break in continuity between the cast product exiting the crystallizer and the ultra-thin slab that enters the roughing stand. In other words, the slab is not cut between the casting machine and the roughing stand, so these two machines work in endless
15 mode with each other.

According to one embodiment of the present invention, the roughing stand is configured so that the second thickness of the roughed slab is comprised between about 8mm and about 25mm. The size of the thickness of the roughed slab allows to wind the rough slab in the winding/unwinding device.

20 Embodiments of the present invention also concern a method for the production of a hot-rolled metal strip, which comprises:

- a continuous casting step of a metal product with a casting speed comprised between about 3.6 m/min and about 6 m/min and by means of a continuous casting machine having a substantially vertical casting axis, and a containing
25 length less than or equal to 6m, the continuous casting machine comprising a mold, with a corresponding crystallizer, and a roll-type pre-rolling device having a length, measured in a direction parallel to the casting axis, less than or equal to 5m,

- a liquid core pre-rolling step to obtain a reduction in thickness of the cast
30 product along the casting axis and to transform the cast product exiting the crystallizer into a completely solidified ultra-thin slab having a first thicknesses selectively settable, the pre-rolling step providing the complete solidification of the cast product at a solidification point contained in the roll-type pre-rolling

device and selectively located in a zone comprised between the exit end of the latter and a distance from the exit end of roll-type pre-rolling device of at least 80% of the length of the roll-type pre-rolling device.

According to possible embodiments of the invention, the method for the
5 production of a hot-rolled metal strip comprises:

- a step of drawing the slab with a drawing unit that can also comprise a step of reducing the thickness of the solidified slab,

- a step of roughing the slab made along a substantially horizontal rolling plane, to transform the slab into a roughed slab having a second thickness,

10 According to a further aspect of the present invention, in sequence along the rolling plane the following steps are performed:

- a first shearing step to shear the roughed slab to size,

- a heating/temperature maintenance step, to heat the roughed slab to a determinate rolling temperature, or to keep it at a determinate rolling

15 temperature,

- a winding/unwinding step to selectively wind/unwind the roughed slab,

- a second shearing step to crop the head/tail ends and possibly scrap the roughed slab in the event of an emergency,

20 - a finishing rolling step in a continuous train to reduce the thickness of the roughed slab until the metal strip is obtained, having a determinate final thickness,

- a step of cooling the metal strip, and

- a winding step to wind the metal strip.

25 In some embodiments, the drawing unit can consist of a number of pairs of drawing rolls comprised between one and three, in which the rolls of each pair are configured to perform a liquid core reduction of the slab with a decrease in the thickness comprised between 2mm and 7mm.

30 According to one implementation of the invention, the liquid core pre-rolling step reduces the thickness of the cast product exiting the crystallizer so that the first thicknesses are selectively settable and comprised between about 28mm and about 48mm.

According to a further implementation of the invention, the roughing step and the continuous finishing rolling step occur so that the final thickness of the metal

strip is comprised between about 0.8mm and about 12mm.

According to a further implementation of the present invention, the method provides that as a function of the casting speed, correlated to the first selectively set thicknesses of the slab, it is possible to obtain an hourly production of the
5 casting machine comprised between about 80 ton/h and about 160 ton/h, corresponding to about 400,000 ton/year and, respectively, to about 800,000 ton/year.

According to possible solutions of the present invention, the productivity of the casting machine can reach a maximum of 1.1 Mton/year.

10 According to a further implementation of the present invention, the method provides that the cast product exiting the crystallizer has a thickness comprised between 48mm and 56mm, preferably comprised between 50mm and 54mm.

According to a further implementation of the present invention, the method provides that before the roughing step, a step of drawing the slab is performed.
15 This allows to facilitate the introduction and the feed of the slab through the subsequent roughing stand.

According to a further implementation of the present invention, the method provides that immediately before the roughing step, a first descaling step is performed to remove the layer of scale on the slab.

20 According to a further implementation of the present invention, the method provides that between the second shearing step and the continuous finishing rolling step, a second descaling step is performed on the roughed slab.

According to a further implementation of the present invention, the method provides that the roughing step reduces the thickness of the slab so that the
25 second thickness of the roughed slab is comprised between about 8mm and about 25mm.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive
30 example with reference to the attached drawings wherein:

- fig. 1 is a schematic lateral view of a plant for the production of a hot-rolled metal strip according to the present invention;
- fig. 2 is a schematic section of a continuous casting machine of the plant of fig.

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1, on an enlarged scale, in a first example of the functioning thereof;

- fig. 3 is a schematic section of the continuous casting machine of fig. 2 in a second example of the functioning thereof;

- fig. 4 is a schematic section of the continuous casting machine of fig. 2 in a third example of the functioning thereof;

- fig. 5 is a schematic section of the continuous casting machine of fig. 2 in a fourth example of the functioning thereof;

- fig. 6 is a diagram that shows the trend of the operating field of the plant of fig. 1, with the thickness S_b in millimeters of the slab exiting the roller unit on the x-axis, and the casting speed V_c in m/min on the y-axis, with also highlighted iso-productivity curves correlated to different production capacities, respectively $a=80$ ton/h, $b=90$ ton/h, $c=100$ ton/h, $d=110$ ton/h, $e=120$ ton/h, $f=130$ ton/h, $g=140$ ton/h, $h=150$ ton/h, $i=160$ ton/h, for a strip with a width of 1300mm.

We must clarify that in the present description and in the claims the terms “vertical” and “horizontal”, with their declinations, have the sole function of better describing the present invention with reference to the drawings and must not in any way be used to limit the scope of the invention itself, or the field of protection defined by the claims.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

With reference to fig. 1, a plant 10 for the production of a hot-rolled metal strip 11, for example made of steel, according to the present invention, comprises a continuous casting machine 12, which in turn comprises a mold 13 provided with a crystallizer 14 (figs. 2-5), and a roll-type pre-rolling device, also referred to hereafter as containing roller unit or, more simply, roller unit 15 (figs. 1-5), disposed along a substantially vertical casting axis X.

The roll-type pre-rolling device 15 is configured to perform a liquid core reduction in the thickness of the metal product exiting the mold 13, to provide a selectively set first thickness S_b of the slab B.

Downstream of the roller unit 15 a curved segment 16 of the casting machine is provided in which the cast product is diverted, along a curved path, from its substantially vertical condition to its substantially horizontal condition.

Downstream of the curved segment 16 there is a roughing stand 19 to rough the metal product exiting the curved segment 16.

The height of the mold 13 is, for example, comprised between 1000mm and 1200mm.

During use, the liquid metal is cast into the crystallizer 14 to maintain a filling level in the latter, also called meniscus M, which is substantially constant during casting.

According to possible embodiments of the invention, the level of the meniscus M is located lower than the entrance end of the crystallizer 14 at a distance comprised between 50mm and 100 mm, preferably between 80mm and 85mm.

According to possible solutions, the roller unit 15 can have a length LR, measured in a direction parallel to the casting axis X, less than or equal to 5m, preferably less than or equal to 4.2m.

The roller unit 15, according to possible solutions, can comprise a plurality of pairs of segments 30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d as described below, disposed on opposite sides with respect to the casting axis X and each of which is provided with a plurality of rolls 32 to contain and/or compress the metal product being cast. Each pair provides that a segment 30a, 30b, 30c, 30d, faces a corresponding segment 31a, 31b, 31c, 31d.

According to possible solutions, the number of pairs of segments 30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d is comprised between four and eight.

Exiting the crystallizer 14, the cast product has a solidified external shell having the function of containing the liquid metal still present therein.

The roller unit 15 is configured to perform a compression on the cast product (fig. 2) exiting the crystallizer 14, that is, to reduce the thickness of the cast product, while its internal core is still liquid, and to give it the thickness Sb, as will be described in detail below.

According to possible solutions, the roller unit 15 can be associated with cooling devices, not shown, also called secondary cooling, and configured to cool the external surfaces of the slab and to determine its further solidification.

The cooling devices can comprise nozzles to deliver nebulized water or air-mist.

According to one aspect of the invention, it is provided that the closing of the two half-skins which form in the crystallizer occurs inside the roller unit 15 and their point of union, which determines the complete solidification of the cast

product, is referred to as the Kissing Point (KP). The KP can also be seen as the terminal vertex of the liquid cone which originates from the meniscus M in the crystallizer 14.

According to one aspect of the present invention, the roller unit 15 is
5 configured to determine the complete solidification of the cast product in a solidification point contained in the roller unit 15 and selectively located in a zone comprised between the exit end of the latter and a distance from the exit end of at least 80% of the length LR of the roller unit 15, that is, toward and in direct proximity to the entrance end of the roller unit 15. This solidification point
10 defines the kissing point KP as above.

In other words, the invention makes it possible to use at least 80% of the length LR of the roller unit 15 to close the liquid cone and obtain corresponding slab thicknesses at exit from the roller unit.

This aspect can be explained in another way using a quantity that is
15 characteristic of the casting machine which is the solidification length.

The solidification length LS is defined as the distance between the level of the meniscus M of the molten material present in the crystallizer 14 and the position of the kissing point KP, that is, of the solidification point, inside the roller unit 15.

20 In accordance with the above, the casting machine 12 is configured to have a solidification length LS selectively settable to a value chosen between about 1.3m and about 5.9m, preferably between about 1.3m and 5.1m. The setting of the positioning of the kissing point inside the roller unit 15 is performed by intervening on at least one of the following parameters: casting speed, secondary
25 cooling intensity, and intensity of the reduction of the liquid core thickness by adjusting the segments of the roller unit 15, as described below.

According to a further aspect of the present invention, the casting machine 12 has a containing length LC, which is defined as the distance between the entrance end of the crystallizer 14, that is, the end through which the molten material is
30 introduced, and the exit end of the roller unit 15, that is, the end from which the ultra-thin slab B exits. According to one possible embodiment, the containing length LC is less than or equal to about 6m, preferably less than or equal to about 5.2m. The containing length LC is much smaller than known embodiments.

Furthermore, the containing length LC is a fixed value of the casting machine 12, set for example in the design step of the casting machine itself.

A small containing length LC, as defined above, allows to reduce the height, and therefore the bulk, of the casting machine 12, thus also reducing the size of
5 the production plant.

According to a possible solution, the cast product exiting the crystallizer 14 has a determinate initial thickness Sc (fig. 2) which is comprised between 48mm and 56mm, preferably between 50mm and 54mm, in this case, of about 52mm.

According to a possible solution, the crystallizer 14 is defined by at least two
10 plates facing each other and distanced, at least in the terminal segment, by the determinate initial thickness Sc as above.

According to one embodiment of the invention, the same crystallizer 14 can be used for the entire range of strip thicknesses and productivity defined in the introduction thanks to the flexibility of the containing roller unit, thus allowing to
15 simplify the management of the plant. The slab B exiting the roller unit 15, due to a reduction in the thickness obtained by means of the liquid core pre-rolling, can have first thicknesses Sb comprised between about 28mm and about 48mm, so that the slab B is of the ultra-thin type and is completely solidified at exit from the roller unit 15.

20 This allows to have the curved segment 16 (fig. 1) of the casting machine 12 with a very small radius of curvature R compared with known solutions.

According to one possible solution, the radius of curvature R can be comprised between about 1.5m and 2.5m, even more preferably 1.7m and 2.2m.

This allows to obtain the following advantages:

- 25
- bring the casting axis X closer to the roughing stand 19;
 - reduce the spaces, and the overall sizes of the plant 10;
 - arrive at the roughing stand 19 with an ultra-thin slab B at a temperature high enough to allow the rolling, in the roughing stand 19, directly connected to the casting (that is, in endless mode) and allowing lower compression forces with the
- 30
- drastically reduce, if not completely eliminate, the containing and guide rolls of the curved segment, with a reduction in the components and the heat losses due to the heat exchange between the rolls and slab.

According to a possible embodiment of the present invention, a drawing unit 17 is provided downstream of the roller unit 15 configured to draw the slab B downstream, that is, toward the roughing stand 19.

5 The drawing unit 17 comprises a number of pairs of drawing rolls, comprised between one and six.

The rolls of each pair are disposed on opposite sides of the slab to be drawn. The rolls of each pair, or at least one of them, can be associated with movement devices, for example hydraulic cylinders of the known type (not shown), to move the rolls closer to/away from each other and also to determine a predefined
10 compression action on the completely solidified slab B, as described below.

According to possible solutions, the drawing unit 17 can comprise a first drawing device 16a located directly downstream of the roller unit 15, that is, in the vertical segment of the casting machine 12, and a second drawing device 16b located directly downstream of the curved segment 16 of the casting machine 12.
15 The first drawing device 16a and the second drawing device 16b can comprise a number of pairs of rolls comprised between 1 and 3.

As stated above, the rolls of the drawing unit 17 are configured to perform a slight solid core reduction in thickness on the slab and therefore a real rolling. In particular, each single pair of drawing rolls can obtain, when necessary, a
20 compression of an amount comprised between 0.5mm and 1.5mm so as to obtain, overall, a decrease in the thickness comprised between about 2mm and about 7mm.

Performing the rolling already during casting entails a further reduction of the thickness of the slab B thus allowing the roughing stand 19 located downstream
25 to reach thinner second thicknesses Sz of the roughed slab Z.

The drawing unit 17 is an integral part of the casting machine 12 which, thanks to the rolling action performed by its rolls, can be defined as a "Rolling Caster".

By Rolling Caster we mean a casting machine 12 able to perform both the
30 casting of the product and also its rolling, partly with a liquid core and partly with a solid core.

Downstream of the roll-type pre-rolling device 15, in this case downstream of the drawing unit 17, the following are disposed, in sequence, along the same

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rolling plane P:

- a possible first descaling device 18 to remove the scale from the surface of the slab B,
- the roughing stand 19, from which a roughed slab Z exits, also called X-bar or transfer bar,
- first shearing means 20, for example comprising a shear for shearing to size,
- induction heating means, or inductor 21, preferably of the modular type,
- a winding/unwinding device 22, for example of the type described in the international application WO-A-2011/080300 in the name of the Applicant,
- second shearing means 24, for example comprising a shear, to crop the head/tail ends and possibly scrap the roughed slab Z in case of emergency,
- a possible second descaling device 25,
- a continuous finishing rolling train 26 configured to roll the roughed slab Z until the metal strip 11 is obtained,
- cooling means 28 configured to cool the metal strip 11, preferably of the modular type, and
- a winding reel 29 configured to wind the metal strip 11 into a coil.

According to possible solutions, the roughing stand 19 is configured to reduce the thickness of the slab B in relation to the winding and containing capacity of the winding/unwinding device.

According to possible solutions, the roughed slab Z, or transfer bar, at exit from the roughing stand 19 has a thickness comprised between 8mm and 25mm, preferably between 10mm and 25mm.

According to possible solutions of the present invention, the first shearing means 20 are configured to shear the roughed slab Z to size to a length equivalent to the weight of a complete coil of metal strip 11 which is wound around the winding reel 29.

According to possible embodiments of the present invention, the induction heating means 21, positioned upstream of the winding/unwinding device 22, are configured to heat the roughed slab Z to a temperature comprised between about 1000°C and about 1200°C, that is, a temperature suitable for the subsequent rolling of the roughed slab, and therefore they allow to restore the temperature of the roughed slab Z which has been dissipated in the roughing stand 19.

According to possible solutions, the winding/unwinding device 22 comprises a first unit 22a and a second unit 22b which alternate with each other in the winding function of the roughed slab Z received from the roughing stand 19, and in the unwinding function of the roughed slab Z, previously wound, to feed it to the continuous finishing rolling train 26. In particular, while one of the two units 22a, 22b winds a roughed slab Z supplied by the casting machine upstream, the other unit 22b, 22a unwinds another roughed slab supplying it downstream. The winding/unwinding device 22 also allows to define a temporary accumulation buffer to compensate for possible slowdowns and non-synchronization between the continuous casting machine 12 and the continuous finishing rolling train 26. The winding/unwinding device 22 allows to absorb the shutdown times of the rolling mill for small maintenance operations or for the programmed change of the cylinders or for small accidents/stoppages, without the need to interrupt the casting process, and therefore without loss of production and without penalizing the steelworks upstream.

According to possible solutions, the above mentioned winding/unwinding device 22 can comprise one or more heating devices, such as burners, which can be selectively activated to maintain the roughed slab Z at temperature. The winding/unwinding device 22 can also comprise devices for the entrance and exit of the roughed slab Z, for example devices to guide the entrance and the exit of the roughed slab Z.

According to some solutions of the invention, the continuous finishing laminating train 26 can comprise a plurality of rolling stands 27, for example in a number comprised between two and five, for example four, as shown in fig. 1.

According to one possible solutions of the present invention, the cooling means 28 can comprise cooling devices of the laminar type.

The plant 10 is advantageously very compact and has an overall length LT less than or equal to 130m.

According to the embodiments shown in figs. 2-5, the roller unit 15 can comprise intrados segments 30a, 30b, 30c and 30d, in this case four segments which in the drawings are on the right with respect to the casting axis X, and respective and opposite extrados segments 31a, 31b, 31c and 31d, which in the drawings are to the left with respect to the casting axis X. In particular, the

intrados segments 30a, 30b, 30c, 30d, are disposed on the same side of the intrados side of the curved segment 16, while the extrados segments 31a, 31b, 31c, 31d are located on the same side of the extrados side of the curved segment 16.

- 5 According to one possible solution, each segment 30a, 30b, 30c, 30d, 31a, 31b, 31c and 31d can be provided with a plurality of rolls, in this case five rolls 32.

The extrados segments 31a, 31b, 31c and 31d are configured to remain in a fixed position, normally aligned parallel to the casting axis X.

- 10 The intrados segments 30a, 30b, 30c and 30d are instead configured so that they can be individually and selectively inclined by a certain angle α with respect to the casting axis X by means of actuators, such as hydraulic cylinders, not shown in the drawings. The actuators can be controlled by position transducers, also not shown in the drawings.

- 15 The inclination of one or more intrados segments 30a, 30b, 30c and 30d is performed to reduce the thickness of the cast product when the latter is not yet completely solidified and therefore contains a liquid core. The angle α of inclination of the segments 30a, 30b, 30c and 30d can be comprised between about 15 degrees (fig. 2) and zero degrees (fig. 5), and can be different for each
20 segment 30a, 30b, 30c and 30d as a function of its position in the roller unit 15, the casting speed and the final desired thickness of the slab B.

- According to embodiments shown in figs. 2, 3 and 4, the first three segments 30a, 30b, 30c are inclined in order to compress, and therefore reduce the thickness, so that the kissing point is substantially located in the transition zone
25 between one segment and the other, more specifically in the zone comprised between the last roll of one of the segments and the first roll of the following segment. In this way, one can be certain that the segments that are inclined always compress in the presence of a liquid core. In fact, if inside the segment there was even only one segment of slab with a solid core, this would prevent the
30 segment from inclining and therefore compressing, that is, if forced to do so, the rolls and thrust cylinders would be damaged.

 According to further solutions, it can be provided that the KP is positioned not only in the transition zone between the segments 30a, 30b, 30c, 30d, 31a, 31b,

31c, 31d but also in any position whatsoever along the extension of the roller unit 15 comprised between the last roll of the first segment 30a and the last roll of the last segment 30d. In this way, it is possible to obtain, in a desired manner, the closure of the liquid cone in any position whatsoever along the entire length LR of the roller unit 15, with the exception of the first segment 30a.

The intrados segments 30b, 30c and 30d, which come to be below the KP, that is, inside which the KP is positioned, are maintained substantially parallel to the casting axis X since the slab is already completely or partially solidified and therefore they cannot perform any compression since there is no longer a liquid core, or a completely liquid core.

The segments are in any case brought closer to the casting axis X in parallel, to maintain them in contact with the surface of the slab obtained from the reduction in thickness performed by the segments above.

The position of the kissing point KP can also be adjusted as a function of the casting speed and the degree of secondary cooling that is performed along the roller unit 15.

Normally, the fourth intrados segment 30d (fig. 5) is not inclined since, being the last segment, the KP falls inside it. In fact, the KP cannot be positioned below the last segment since there is no longer any containing and cooling, therefore the presence of a liquid core would swell the slab with the risk of the skin breaking and the steel contained inside it leaking, determining the so-called breakout.

The lower limit position of the KP, which determines the maximum solidification length LS that can be reached, is in correspondence with the last roll 32 of the last segment 30d: in this case the fourth segment 30d can also assume a slightly inclined position.

In other words, in the roller unit 15 the extrados segments 31a, 31b, 31c and 31d are fixed and parallel to the casting axis X, while the intrados segments 30a, 30b, 30c, 30d are configured to work in this manner: the segments that “see” liquid steel in all their height are inclined so as to compress and reduce the thickness of the cast product containing the liquid core. Instead, all the segments underneath the KP, or inside which the KP is positioned, are not inclined and are maintained parallel to the casting axis X, so as not to perform any compression on the cast product.

The roller unit 15, thanks to the fact that it is divided, or subdivided, into several segments, although in a reduced space, allows to increase the degree of freedom of the compressions operated by the rolls 32 in the formation of the slab B, being also able to close the liquid cone immediately underneath the crystallizer 14. In this way, the range of variability of the solidification length LS which can be used on the casting machine 12, to which corresponds a range of variability in the thickness of the slab B exiting the roller unit 15, is advantageously increased by increasing the operating capacity of the casting itself.

10 In the embodiment shown in figs. 2 to 5, a roller unit 15 has been considered having four pairs of segments of equal length.

According to other embodiments, the number of pairs of segments, given the same containing length LC, can be increased up to 8.

15 According to other embodiments, the segments of the roller unit 15 can be of different lengths from one another. In particular, it can be provided that the first pair of segments 30a, 31a, located at the entrance end of the roller unit 15, has a shorter length than the length of the segments 30b, 30c, 30d, 31b, 31c, 31d located downstream. In this way, the first pair of segments allows to compress the metal product in a zone even closer to the exit end of the crystallizer 14 and therefore to move the upper limit position of the KP upward. Therefore, the minimum value of the solidification length LS is further reduced, that is, the range of use of the solidification length LS is further extended.

20 By way of example only, each segment 30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d can have a length comprised between 0.4m and 1.5m, preferably between 0.5m and 1m.

The casting machine 12 according to the invention is therefore characterized by a so-called “two-dimensional flexibility” since, with a given crystallizer 14 it is possible to choose a wide range, with respect to the state of the art, both of casting speed and also of thicknesses of the slab B.

30 In the plant 10 the solidification length LS is advantageously very reduced, with respect to the plants of the state of the art, and is preferably comprised between about 1.3m, in the operating condition shown in fig. 2, and about 5.9m, in the operating condition shown for example in fig. 5.

The plant 10 described heretofore allows to obtain a production of a metal strip 11 having a very thin thickness, for example comprised between about 0.8mm and about 12.0mm, preferably between 1.2mm and 12mm and for example an average width of about 1300mm.

5 The diagram of fig. 6 shows the operating capacity of the casting machine 12 in which the casting speed V_c can vary from about 3.6 m/min to about 6.0 m/min and the first thickness of the slab B after the liquid core pre-rolling action can vary from 28mm to 48mm. The curves a, b, c, d, e, f, g, h, i shown in the diagram of fig. 6 are hourly iso-productivity curves expressed in tons/hour (ton/h), from
10 about 80 ton/h to about 160 ton/h, which correspond to an annual productivity comprised between about 400,000 tons/year and about 800,000 tons/year.

The curves refer to an average width of the strip of 1300mm.

The outline, or perimeter, of the diagram of fig. 6 defines the limit conditions of use of the casting machine 12 as a function of the grade of cast steel, also
15 called “steel grade”, and of the geometrical and constructive characteristics of the crystallizer 14 and of the containing roller unit 15.

The diagram has been drawn considering the casting of a low carbon steel.

From the diagram in fig. 6 it is evident how the casting machine 12, with the same crystallizer 14, can advantageously cover a wide range of variation of the
20 hourly productivity, however within the limits of a medium-low productivity.

This flexibility is made possible thanks to the fact that:

- it is possible to vary the solidification length LS with the same crystallizer, substantially exploiting the entire length of the roller unit 15, which translates into the possibility of choosing the first thicknesses S_b in a range comprised
25 between 28mm and 48mm;

- it is possible to vary the casting speed in a wide range, that is, from 3.6 m/min to 6.0 m/min.

In particular, figs. 2 to 5, read together with the diagram of fig. 6, refer to four different working conditions in terms of range of the casting speed V_c and of the
30 first thicknesses S_b of the slab B obtained after the liquid core pre-rolling action by the roller unit 15.

The minimum value of the thickness S_b of 28.0mm (fig. 2) is obtained in a high and narrow range of casting speed V_c , that is, between about 5.2 m/min and

about 6.0 m/min (fig. 6). This is the condition in which there is the minimum solidification length LS, and therefore the highest KP position, as well as the maximum angle of inclination, and therefore the maximum compression of the slab B exerted by the first segment 30a.

5 The maximum value of the first thickness Sb of the slab B of 48.0mm (fig. 5) is obtained, instead, at the casting speed Vc of 5.5 m/min. This is the condition in which there is substantially the maximum length of solidification LS, and therefore the lowest KP position, with the minimum angle of inclination of the intrados segments.

10 Figs. 3 and 4 show two intermediate situations in which, respectively, the first two and the first three segments are inclined. Other intermediate situations, not shown, are possible, in which by inclining one or more segments with different compression angles, the KP is selectively located at any point whatsoever between the limit positions in order to obtain, at the various casting speeds shown
15 in fig. 6, the intermediate range of thicknesses between the extreme values.

The functioning of the plant 10 described heretofore, which also defines the method for the production of the hot-rolled metal strip 11 is as follows.

First of all, the characteristics of steel strip in rolls that is to be produced are established by defining: minimum thickness, width, and steel grade, that is, the
20 type of steel to be cast.

Subsequently, the productivity of the steelworks that feeds the continuous casting machine 10 is established, as a function of how many rolls of strip with the characteristics above have to be produced.

In this way, the iso-productivity curve for the continuous casting machine is
25 determined on the diagram of fig. 6, that is, on the equivalent diagram relating to the selected steel-grade and strip width.

The steel grade also determines the maximum casting speed (VcMAX) that can be used to cast that specific steel grade with the desired quality. In fact, there are “easier” steels to cast, for example low-carbon steels, which allow high
30 casting speeds, and more “difficult” steels to cast, for example peritectic steels, which require low casting speeds.

Setting the VcMAX therefore limits the usable iso-productivity curve to a portion.

As described below, the casting parameters (slab thickness S_b and casting speed V_c) are determined on the defined iso-productivity curve based on the configuration of the finishing train.

With the minimum final thickness of the strip desired, the number of stands 27 required in the finishing train 26 is determined, and therefore the second thickness S_z of the transfer bar Z exiting the roughing stand 19 most suitable to feed the continuous finishing rolling train 26.

The first thickness S_b that the slab B exiting the roller unit 15 has to have, is established as a function of the second thickness S_z that the transfer bar Z has to have.

By way of example, the following Table 1 shows the minimum values of the final thicknesses S_f of the metal strip 11 as a function of assigned values of the first thickness S_b of the slab exiting the roller unit 15, of the second thickness S_z of the roughed slab Z, and of the number of finishing stands 27.

Thickness S_z of the roughed slab Z (X-bar or transfer-bar)	Minimum final thickness S_f of the strip after 2 finishing stands	Minimum final thickness S_f of the strip after 3 finishing stands	Minimum final thickness S_f of the strip after 4 finishing stands	Minimum final thickness S_f of the strip after 5 finishing stands
10mm (starting from a slab B with a thickness S_b of 28mm)	3.4mm	1.8mm	0.9mm	0.7mm
15mm (starting from a slab B with a thickness S_b of 38mm)	5.0mm	2.7mm	1.4mm	1.0mm

20mm (starting from a slab B with a thickness Sb of 48mm)	6.7mm	3.7mm	1.9mm	1.4mm
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Table 1 - Minimum final thickness Sf of the metal strip as a function of the thickness Sz of the roughed slab Z.

With reference to fig. 6 and Table 1, a possible mode to determine the functioning parameters of the plant is described below.

By way of example only, if one wishes to obtain a low carbon content metal strip with a minimum thickness Sf equal to 1.8mm, width equal to 1300mm and a productivity of 110 ton/h, in fig. 6 the iso-productivity curve “d” which corresponds to the desired productivity is taken into consideration. The iso-productivity curve extends over a range of thicknesses of the cast slab comprised between about 32mm to 48mm.

From Table 1, it is possible to identify production ranges that can be adopted for slab thicknesses Sb equal to 38mm and 48mm.

In the first case, that is, slab thickness Sb equal to 38mm, to obtain the minimum desired thickness of 1.8mm 4 rolling stands are necessary. In the second case, that is, slab thickness Sb equal to 48mm, 5 rolling stands are necessary.

It is convenient to identify a configuration with the minimum number of rolling stands of the train, therefore a train with four rolling stands will be chosen.

With the value Sb=38mm, therefore, one follows the diagram of fig. 6 until intercepting the iso-productivity curve “d” previously established and thus obtains the casting speed Vc to be used, which in the specific case is about 4.75 m/min.

If conditions change, the plant can easily adapt to the modified situation. For example, the availability of liquid steel could change for a given casting sequence, due to delays in the steelworks upstream due to setbacks during the steel treatment steps in the secondary metallurgy steps.

In this case, the choice of the iso-productivity curve is modified and the casting parameters are re-determined.

The plant 10 described heretofore is therefore very versatile and easy to control and to set on site.

5 It is clear that modifications and/or additions of parts may be made to the plant 10 to produce a hot-rolled metal strip and to the corresponding method as described heretofore, without departing from the field and scope of the present invention.

10 For example, insulating panels can be disposed along the curved segment 16 in order to avoid and/or reduce the cooling of the slab B between the exit of the roller unit 15 and the drawing unit 17.

15 It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of plants and/or methods to produce a hot-rolled metal strip, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

CLAIMS

1. Plant for the production of a hot-rolled metal strip (11), comprising a continuous casting machine (12) with a substantially vertical casting axis (X) and configured to cast a metal product with a casting speed (V_c) comprised between
5 about 3.6m/min and about 6m/min, said continuous casting machine (12) comprising a mold (13), with a corresponding crystallizer (14), and a roll-type pre-rolling device (15) configured to obtain a liquid core pre-rolling and to supply at exit an ultra-thin slab (B) having first thicknesses (S_b) selectively
10 length (LC), defined as the distance between the entrance end of the crystallizer (14) and the exit end of the roller unit (15), less than or equal to 6m, said roll-type pre-rolling device (15) having a length (LR), measured in a direction parallel to said casting axis (X), less than or equal to 5m, and being configured to determine the complete solidification of the cast product at a solidification point
15 contained in said roll-type pre-rolling device (15) and selectively located in a zone comprised between the exit end of the latter and a distance from said exit end of at least 80% of the length (LR) of said roll-type pre-rolling device (15).
2. Plant as in claim 1, **characterized in that** said casting machine (12) has a solidification length (LS), defined as the distance between the level of the
20 meniscus (M) of the molten material present in the crystallizer (14) and the position of the solidification point, inside the roller unit (15), selectively settable to a value chosen between 1.3m and 5.9m.
3. Plant as in claim 2, **characterized in that**, downstream of said roll-type pre-rolling device (15), said plant also comprises a drawing unit (17) configured to
25 draw said slab (B), **and in that** after a curved segment (16) of said continuous casting machine (12), said plant comprises, disposed along a substantially horizontal rolling plane (P):
- at least one roughing stand (19) configured to transform said slab (B) into a roughed slab (Z) having a second thickness (S_z),
 - 30 - first shearing means (20) configured to shear said roughed slab (Z) to size,
 - induction heating means (21) configured to heat said roughed slab (Z) to a determinate rolling temperature, or to keep it at a determinate rolling temperature,

- a winding/unwinding device (22) configured to selectively wind/unwind said roughed slab (Z) and to keep it at said rolling temperature,
 - second shearing means (24) configured to crop the head/tail ends and possibly scrap said roughed slab (Z) in the event of an emergency,
 - 5 - a continuous finishing rolling train (26) to reduce the thickness of said roughed slab (Z) until said metal strip (11) is obtained, having a determinate final thickness (Sf),
 - cooling means (28) configured to cool said metal strip (11),
 - a winding reel (29) configured to wind said metal strip (11).
- 10 4. Plant as in claim 3, **characterized in that** said drawing unit (17) is an integral part of the casting machine (12) and it consists of a number of pairs of drawing rolls comprised between one and three.
5. Plant as in claim 3 or 4, **characterized in that** said curved segment (16) of said casting machine (12) has a radius of curvature (R) comprised between about
- 15 1.5m and 2.5m, **and in that** said roughing stand (19) is directly connected to said casting machine (12).
6. Plant as in any claim hereinbefore, **characterized in that** said roll-type pre-rolling device (15) comprises a plurality of pairs of segments (30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d), disposed on opposite sides with respect to said casting axis
- 20 (X) and each of which is provided with a plurality of rollers (32) to contain and/or compress the cast metal product, **and in that** the number of pairs of segments (30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d) is comprised between four and six.
7. Plant as in claim 6, **characterized in that** it comprises intrados segments (30a, 30b, 30c, 30d) disposed on the same side of the intrados of said curved segment
- 25 (16) and selectively inclinable with respect to said casting axis (X) by means of actuators, and extrados segments (31a, 31b, 31c, 31d) disposed on the same side of the extrados of said curved segment (16) and configured to remain in a fixed position and aligned parallel with said casting axis (X).
- 30 8. Plant as in claim 6 or 7, **characterized in that** said segments (30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d) have the same length.
9. Plant as in claim 6 or 7, **characterized in that** said segments (30a, 30b, 30c, 30d, 31a, 31b, 31c, 31d) have different lengths from each other, **and in that** the

first pair of segments (30a, 31a), located at the entrance end of said roll-type pre-rolling device (15), have a shorter length than the length of the segments (30b, 30c, 30d, 31b, 31c, 31d) located downstream.

10. Plant as in any claim hereinbefore, **characterized in that** said roll-type pre-rolling device (15) is configured to be adjustable so that said first thicknesses (Sb) are comprised between 28.0mm and 48.0mm.

11. Plant as in any claim from 3 to 5, **characterized in that** said roughing stand (19) and said continuous finishing rolling train (26) are configured to be adjustable so that said final thickness (Sf) of said metal strip (11) is comprised
10 between 0.8mm and 12mm.

12. Plant as in any of the claims from 3 to 5, **characterized in that** said continuous finishing rolling train (26) comprises a number of finishing stands (27) comprised between two and five.

13. Plant as in any of the claims from 3 to 5, **characterized in that** said
15 roughing stand (19) is configured so that said second thickness (Sz) is comprised between 8mm and 25mm.

14. Method to produce hot-rolled metal strip (11), comprising:

- a continuous casting step of a metal product with a casting speed (Vc) comprised between 3.6m/min and 6m/min by means of a continuous casting
20 machine (12) having a substantially vertical casting axis (X), and a containing length (LC) less than or equal to 6m, said continuous casting machine (12) comprising a mold (13), with a corresponding crystallizer (14), and a roll-type pre-rolling device (15) having a length (LR), measured in a direction parallel to said casting axis (X), less than or equal to 5m,
- 25 - a liquid core pre-rolling step to obtain a reduction in thickness of said cast product along said casting axis (X) and to transform the cast product exiting from said crystallizer (14) into a completely solidified ultra-thin slab (B) having a first thickness (Sb) selectively settable, said pre-rolling step providing the complete solidification of the cast product at a solidification point contained in said roll-
30 type pre-rolling device (15) and selectively located in a zone comprised between the exit end of the latter and a distance from said exit end of at least 80% of the length (LR) of said roll-type pre-rolling device (15).

15. Method as in claim 14, **characterized in that** it comprises:

- 26 -

- a step of drawing said slab (B) using a drawing unit (17),
 - a step of roughing said slab (B), made along a substantially horizontal rolling plane (P), to transform said slab (B) into a roughed slab (Z) having a second thickness (Sz),
- 5 and wherein, in sequence along said rolling plane (P) the following steps are performed:
- a first shearing step to shear said roughed slab (Z) to size,
 - a heating/temperature maintenance step, to heat said roughed slab (Z) to a determinate rolling temperature, or to keep it at a determinate rolling
- 10 temperature,
- a winding/unwinding step to selectively wind/unwind said roughed slab (Z),
 - a second shearing step to crop the head/tail ends and possibly scrap said roughed slab (Z) in the event of an emergency,
 - a finishing rolling step in a continuous train to reduce the thickness of said
- 15 roughed slab (Z) until said metal strip (11) is obtained, having a determinate final thickness (Sf),
- a step of cooling said metal strip (11) and
 - a winding step to wind said metal strip (11).
16. Method as in claim 15, **characterized in that** said drawing unit (17)
- 20 consists of a number of pairs of drawing rolls comprised between one and three rolls, in which the rolls of each pair perform a liquid core reduction of said slab (B) with a reduction in the thickness comprised between 2mm and 7mm.
17. Method as in any of the claims from 14 to 16, **characterized in that**, as a function of said casting speed (Vc), correlated to said first thickness (Sb) of said
- 25 slab (B), it is possible to obtain an hourly production of said casting machine (12) comprised between about 80 ton/h and 160 ton/h, corresponding to 400,000 ton/year and, respectively, to 800,000 ton/year.
18. Method as in any of the claims from 15 to 17, **characterized in that** the cast product exiting from said crystallizer (14) has a starting determinate
- 30 thickness (Sc) comprised between 48mm and 56mm, and said pre-rolling step using rolls performs an adjustable reduction in the thickness of said cast product that, at the end of said pre-rolling step with rolls, has a first thickness (Sb) selectively settable to a value chosen in the range between 28.0mm to 48.0mm.

19. Method as in claim 15, **characterized in that** during said drawing step said slab (B) is subjected to a solid core reduction with a reduction in thickness comprised between 2mm and 7mm.
20. Method as in any of the claims from 14 to 19, **characterized in that** during
5 said pre-rolling step using rolls, intrados segments (30a, 30b, 30c, 30d) of a roll-type pre-rolling device (15) are selectively inclined with respect to said casting axis (X), and extrados segments (31a, 31b, 31c, 31d) of said roll-type pre-rolling device (15), opposite said intrados segments (30a, 30b, 30c, 30d), remain in a fixed position and aligned parallel to said casting axis (X).
- 10 21. Method as in claim 15, **characterized in that** said roughing step reduces the thickness (Sb) of said slab (B) so that said second thickness (Sz) of said roughed slab (Z) is comprised between 8mm and 25mm.
22. Method as in any of the claims from 14 to 21, **characterized in that** as a
15 function of said casting speed (Vc), correlated with said first thickness (Sb) of said slab (B), the casting machine (12) allows to obtain an hourly production comprised between 80 ton/h and 160 ton/h, corresponding to 400,000 ton/year and, respectively, to 800,000 ton/year.

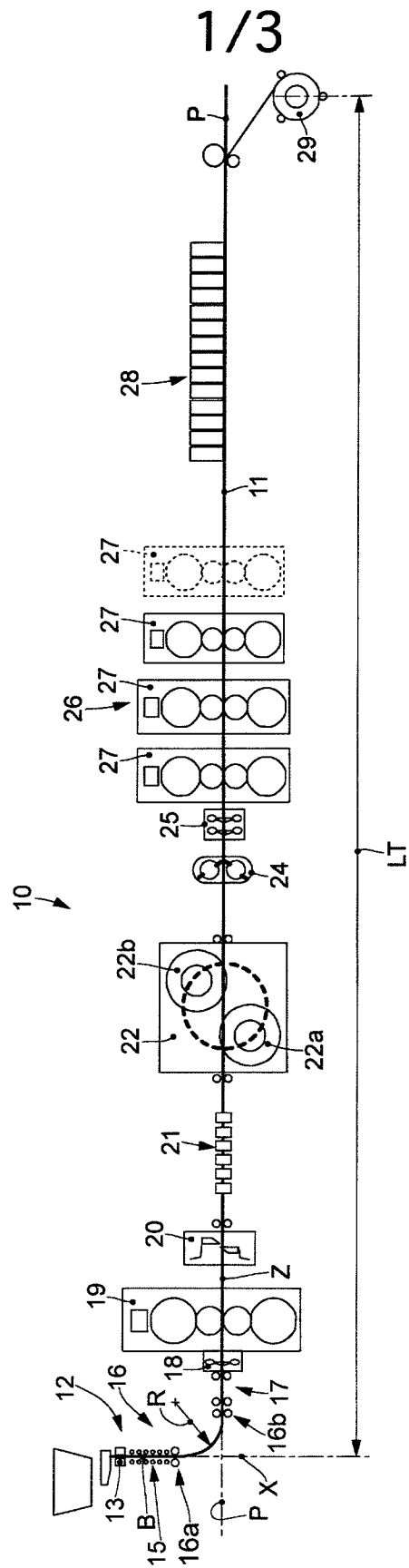
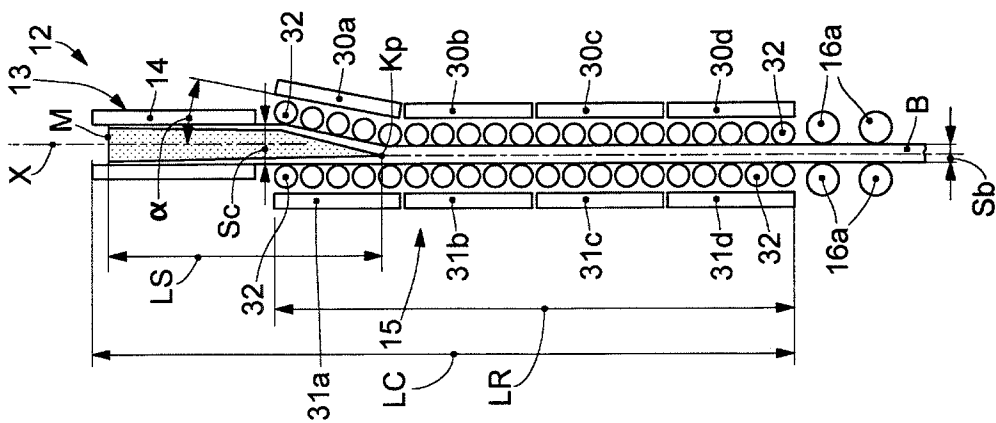
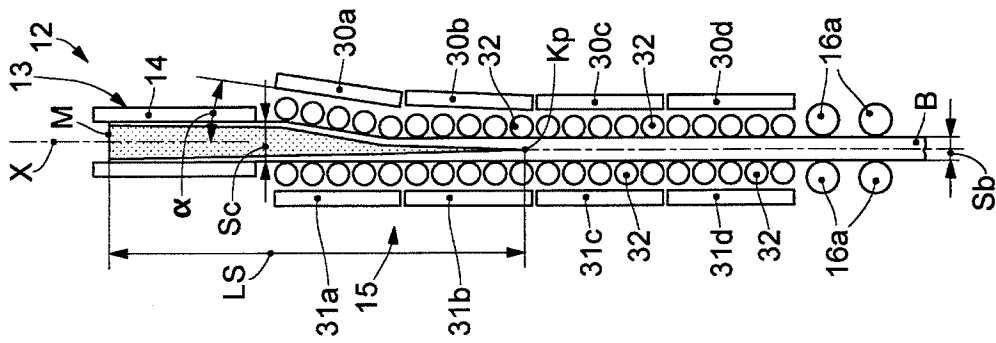
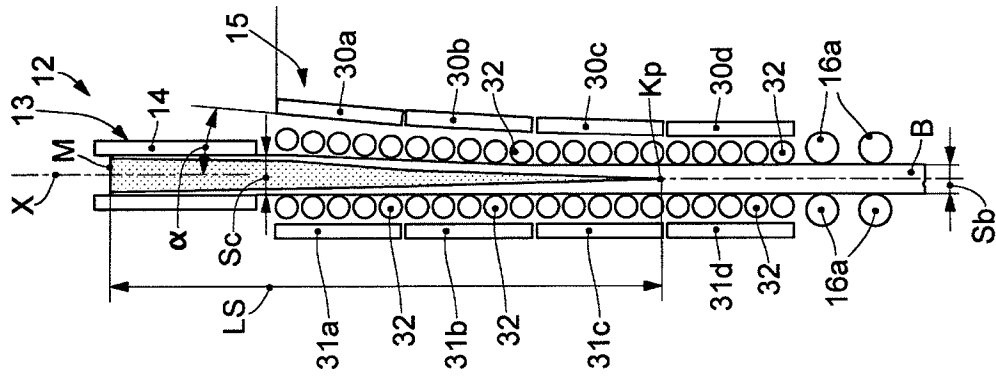
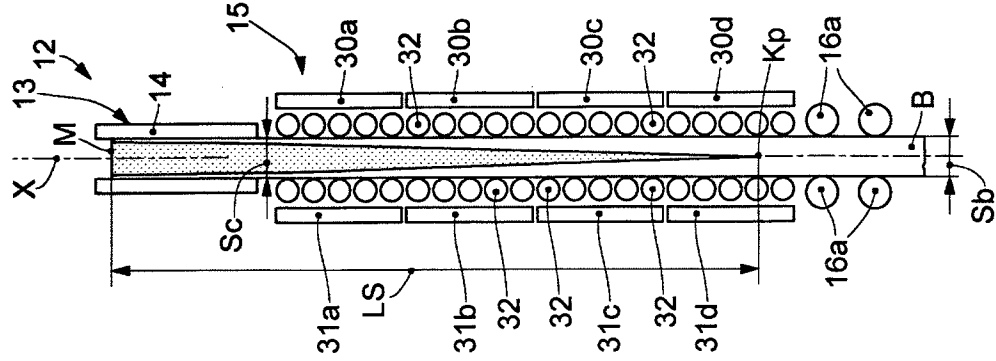


fig. 1



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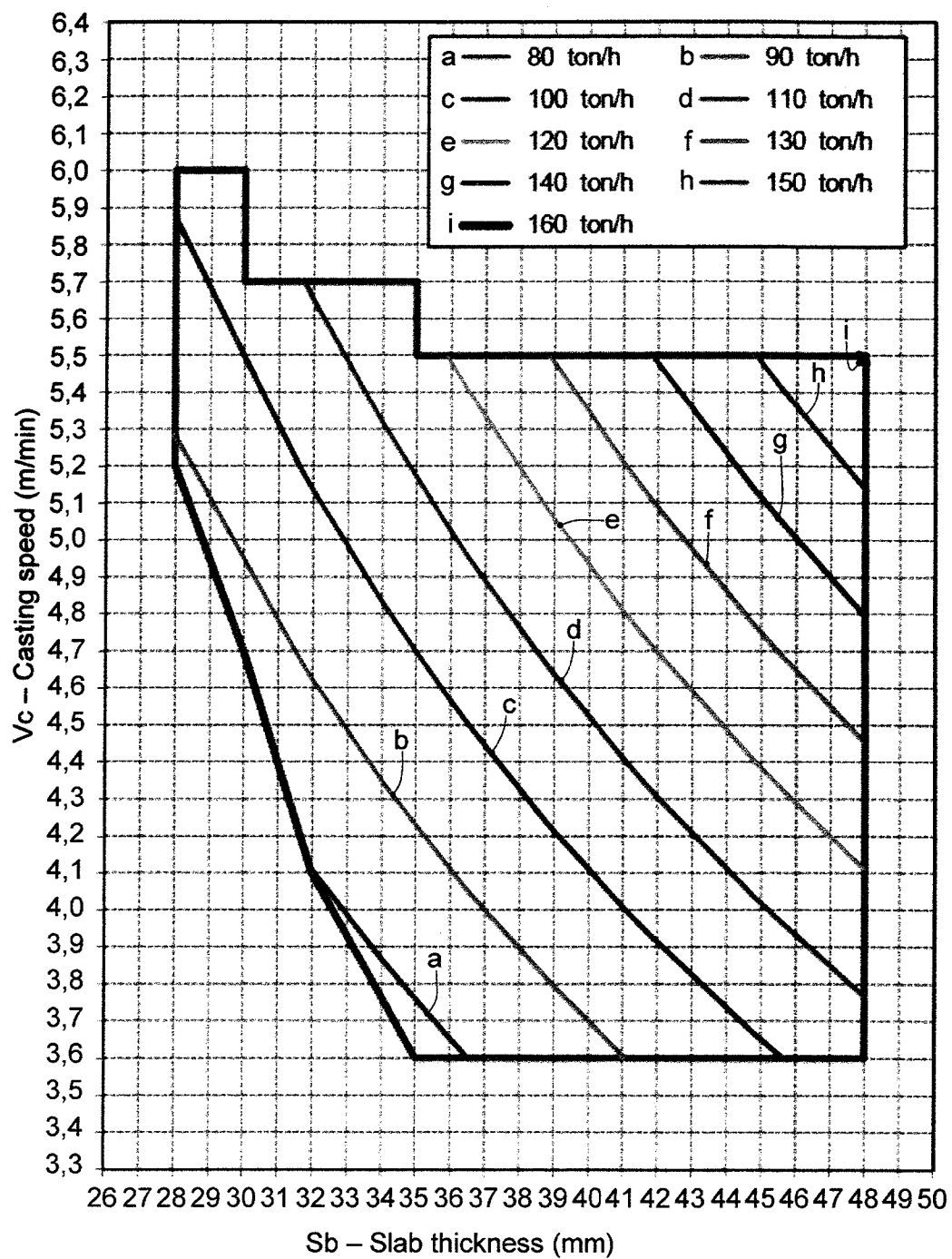


fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2019/050151

A. CLASSIFICATION OF SUBJECT MATTER
INV. B22D11/12 B22D11/14 B21B1/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B22D B21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/014865 A1 (SMS SIEMAG AG [DE]) 5 February 2015 (2015-02-05)	1,2, 6-14, 16-22
Y	the whole document -----	3-5,15
X	WO 99/64189 A1 (SUMITOMO HEAVY INDUSTRIES [JP]; MIZUNO MUNEHITO [JP]; IKEDA MASAHIRO []) 16 December 1999 (1999-12-16) paragraph [0013] figure 1 -----	1,2
X	US 6 129 137 A (PLESCHIUTSCHNIGG FRITZ-PETER [DE]) 10 October 2000 (2000-10-10) the whole document ----- -/-	1,2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2019/050151

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 339 887 A (FLEMMING GUNTER [DE] ET AL) 23 August 1994 (1994-08-23) the whole document -----	1,2
X	US 6 491 088 B1 (SUCKER JUERGEN [DE] ET AL) 10 December 2002 (2002-12-10) figure 1 -----	1
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