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SEAMLESS TUBES****Publication Classification**(71) Applicant: **SMS INNSE S.P.A.**, San Donato
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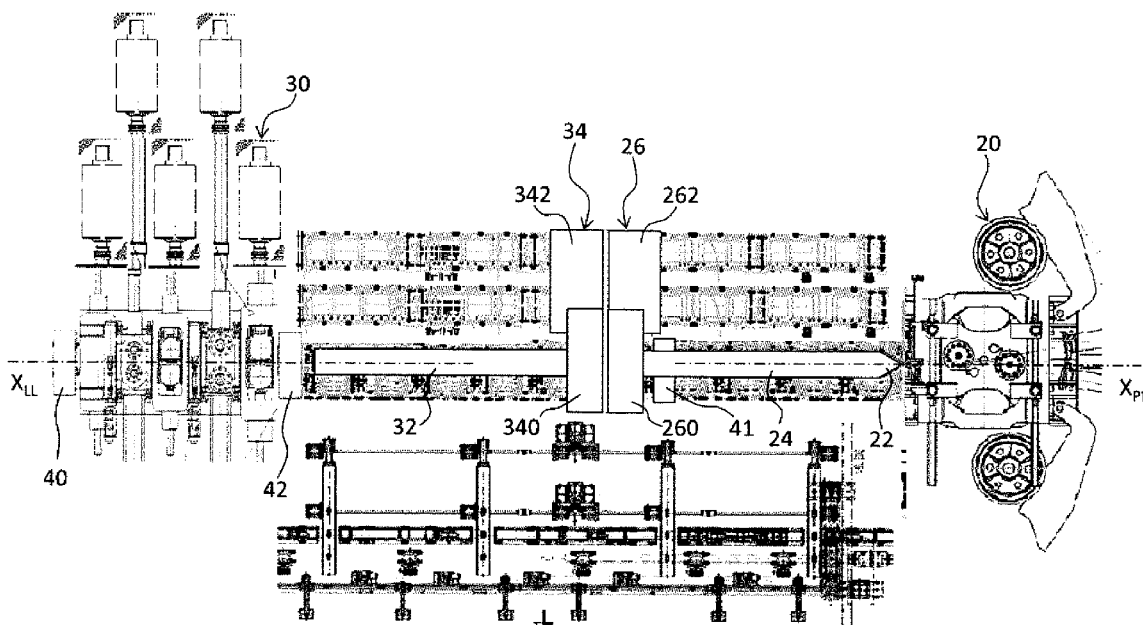
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(57) **ABSTRACT**

The present invention relates to a compact plant **10** for rolling a seamless tube. The plant comprises a rotary piercer **20** which defines a rolling axis X_{PR} and is designed to pierce a billet **11** pressed against a plug **22** mounted on a rod so as to obtain a pierced blank **12**. The rod is connected to a thrust block **26** designed to oppose the axial thrust during piercing. The plant also comprises a longitudinal mill **30** which defines a rolling axis X_{LL} and is designed to roll the pierced blank **12** on a mandrel **32** so as to obtain a semi-finished tube **13**. The mandrel is connected to a retaining block **34** designed to impart to the mandrel a predetermined speed during rolling. In the plant **10** according to the invention the rolling axes X_{PR} and X_{LL} coincide. The invention also relates to a method for rolling a seamless tube.



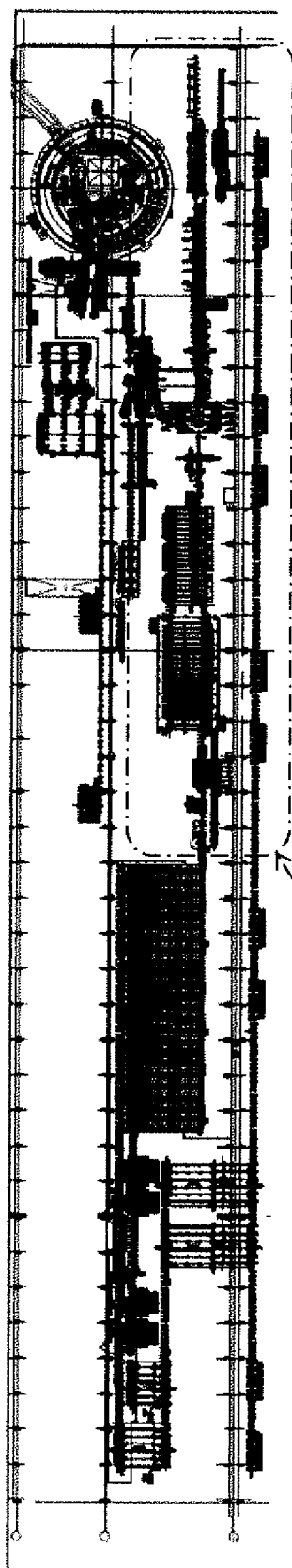


Fig. 1

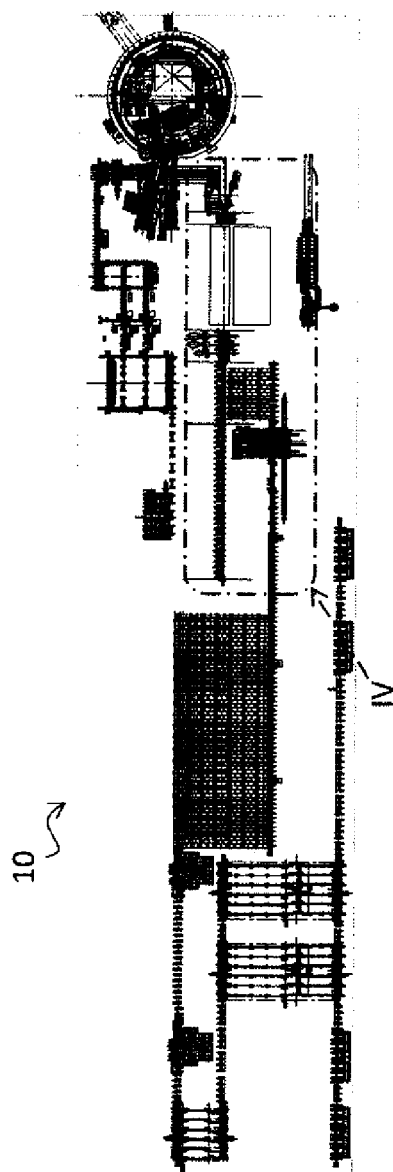


Fig. 2

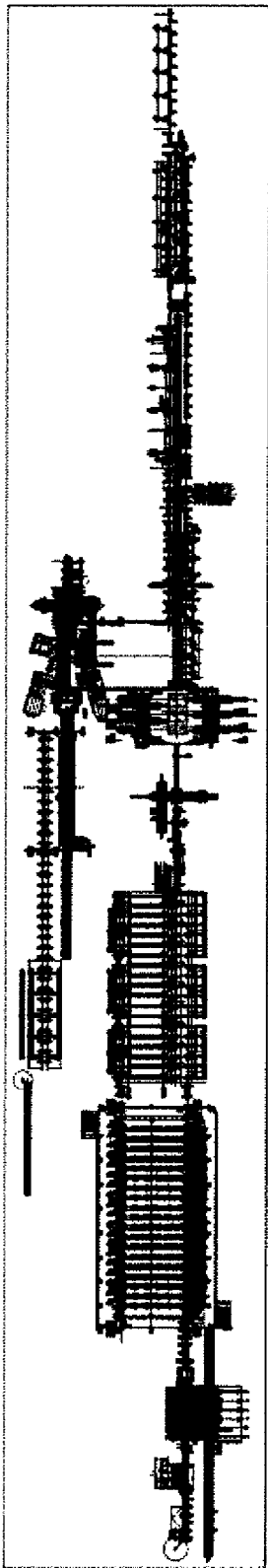


Fig. 3

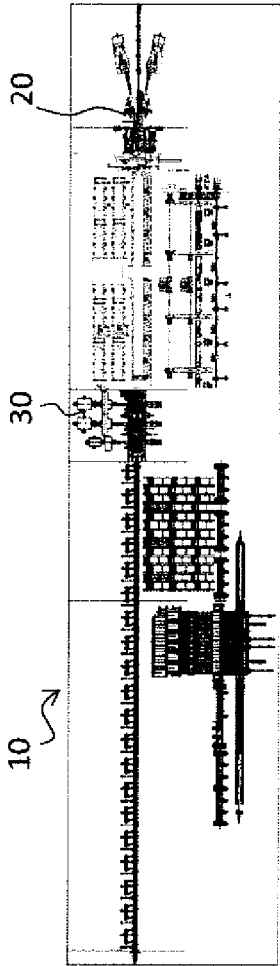
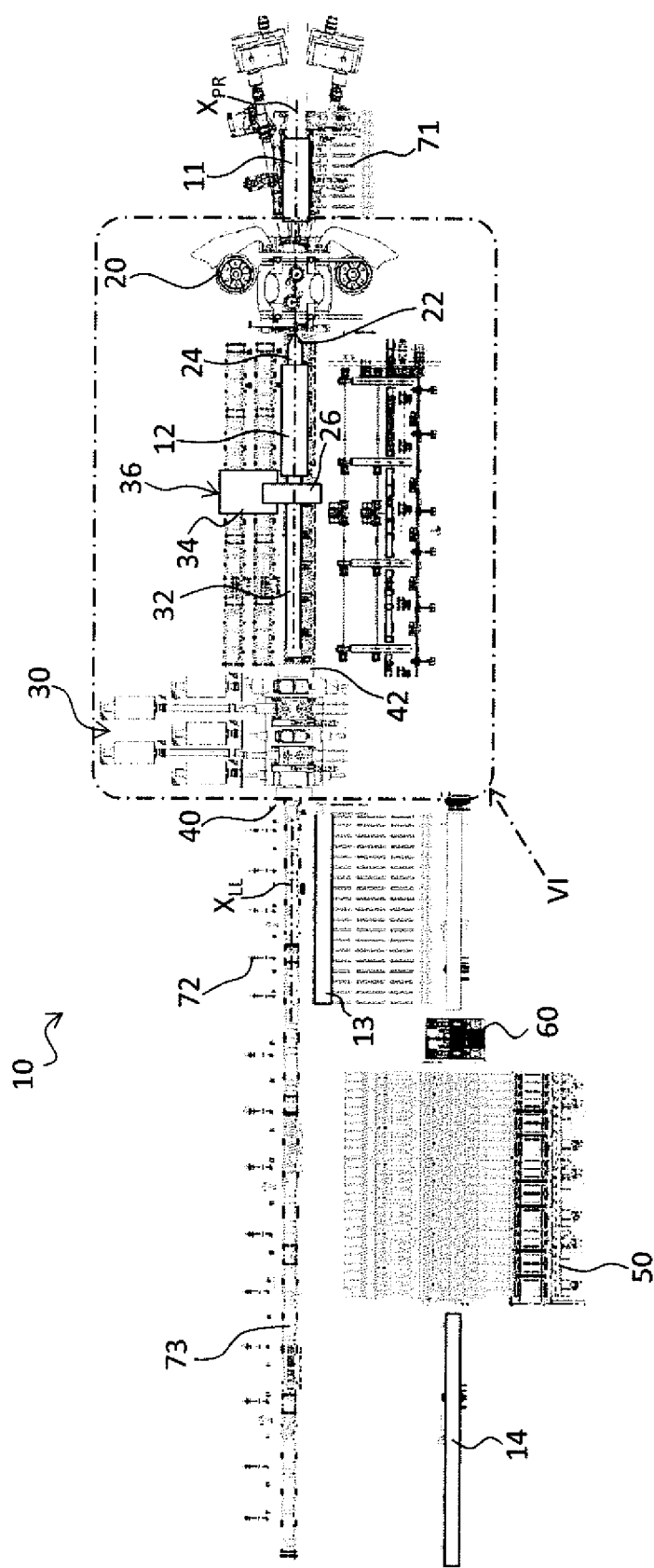
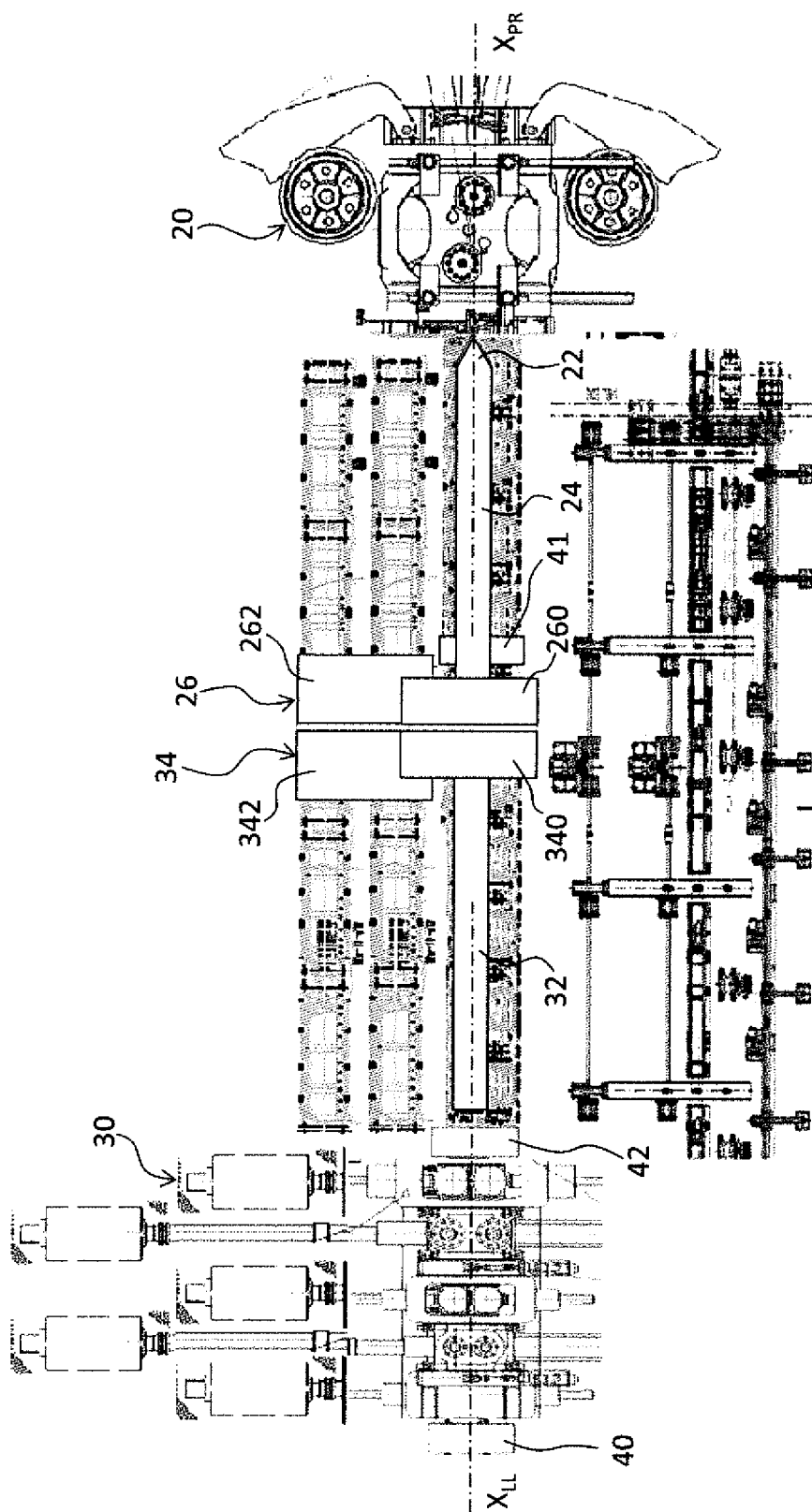


Fig. 4



Fi. 5



File 6

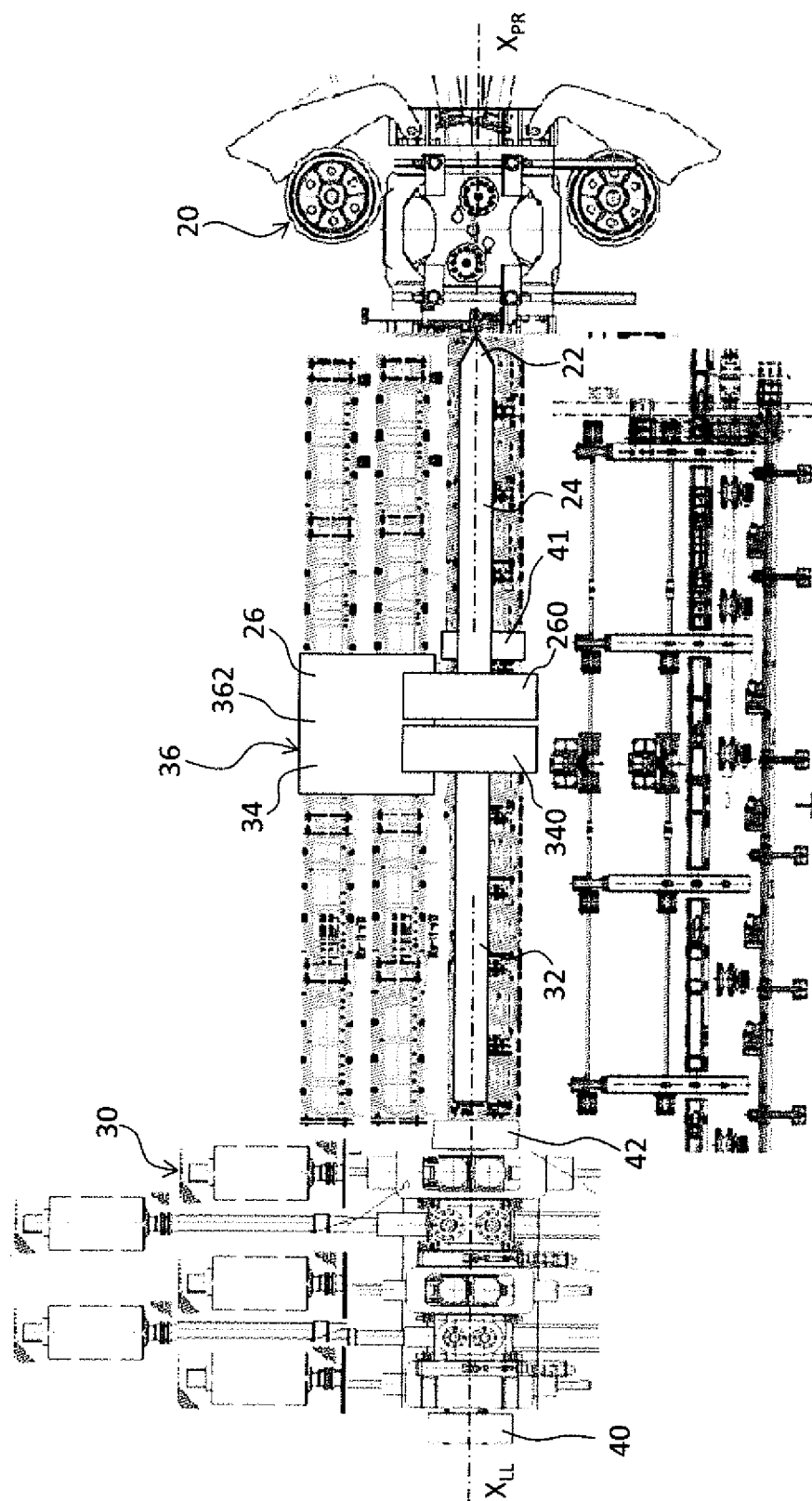


Fig. 7

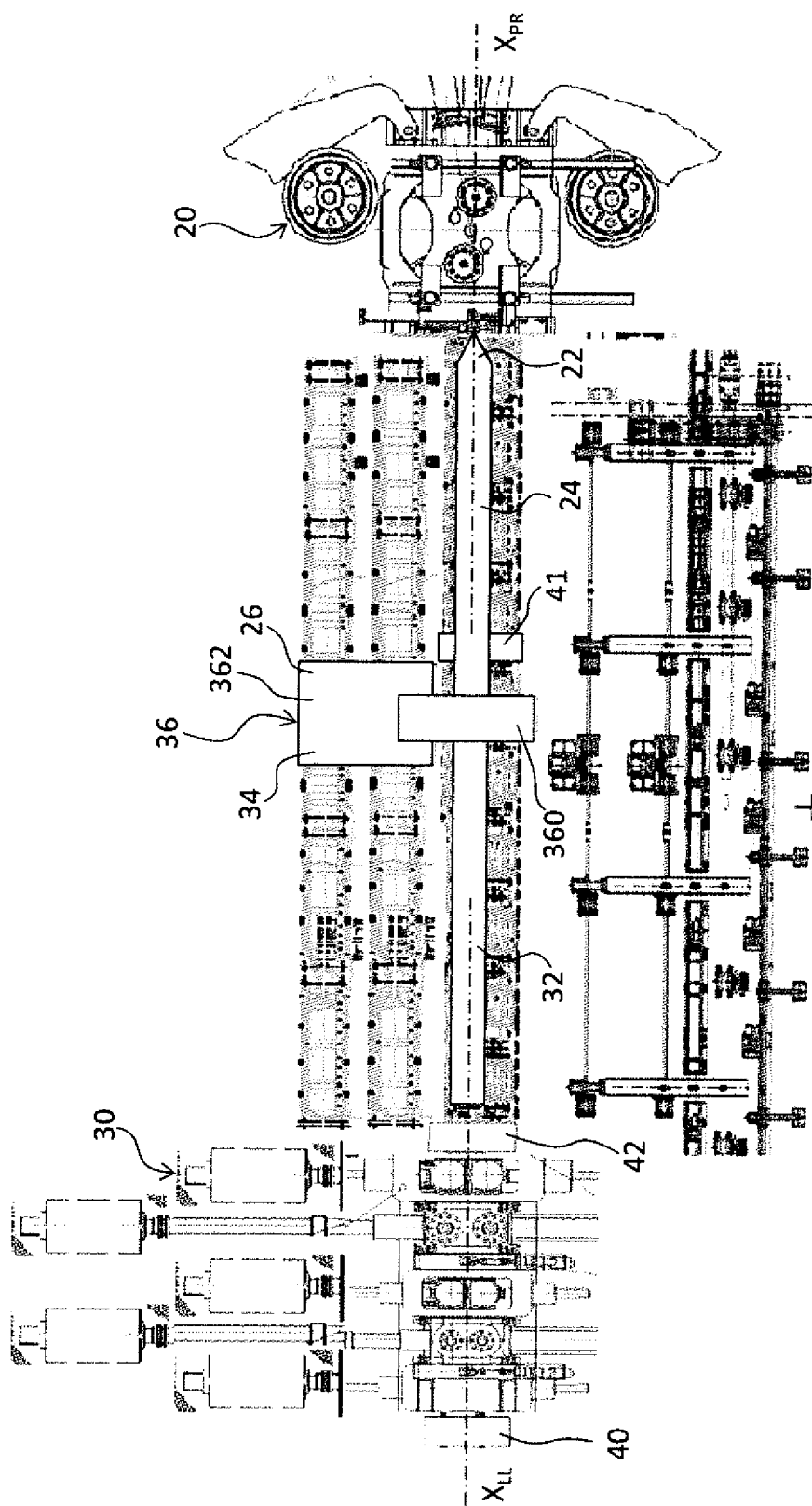


Fig. 8

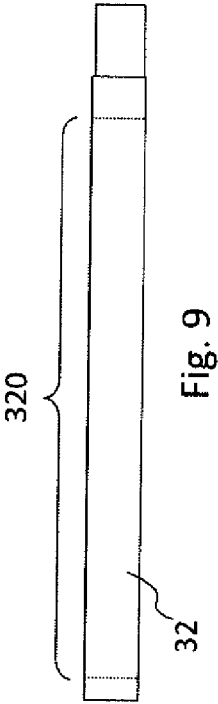


Fig. 10

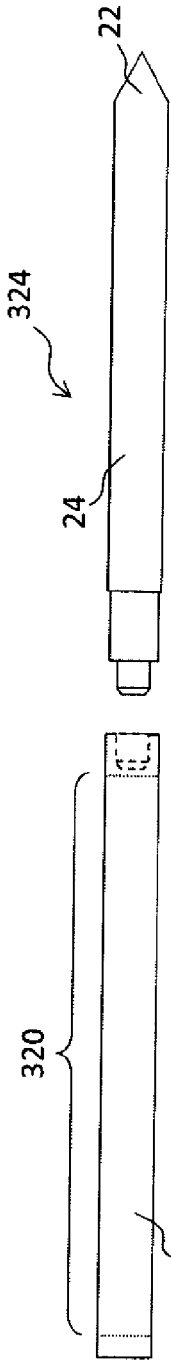


Fig. 11

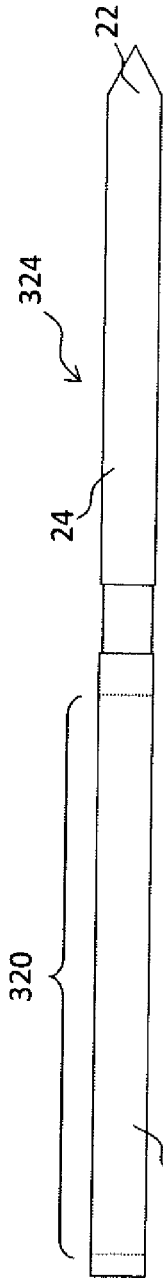


Fig. 12

COMPACT PLANT FOR ROLLING SEAMLESS TUBES

[0001] The present invention relates to a compact plant for rolling tubes, in particular for rolling seamless tubes. The invention also relates to a method for this rolling operation.

[0002] It is known to produce seamless metal tubes by means of successive plastic deformation of a billet. During a first step the billet is heated in a furnace to about 1280° C. Then the billet is fed to a rotary piercer comprising a pair of skew-axis rolls and a plug mounted on a rod. The rolls axially push the billet against the plug, so that the billet is pierced along its longitudinal axis. A semi-finished product (called pierced blank or hollow body), with a thick wall and length 1.5 to 4 times the one of the starting billet, is thus obtained. Then the pierced blank is displaced laterally and the plug and the rod are extracted from it in order to be able to insert a mandrel for the subsequent rolling operation. The mandrel has the function of opposing internally the radial thrusts which will be applied during rolling in order to thin the tube wall.

[0003] In order to complete the operations for lateral displacement of the pierced blank, removal of the plug and insertion of the mandrel, a certain amount of time is required. During this time period the pierced blank is exposed to the action of the air which causes in particular a reduction in the temperature of the pierced blank. Moreover, the action of the atmospheric oxygen results in the rapid oxidation of the surfaces. For this reason a treatment (i.e. deoxidation treatment) using deoxidising materials, such as borax or the like, is usually carried out.

[0004] As already mentioned above, a mandrel for the subsequent rolling operation is then inserted inside the pierced blank. The pierced blank is in fact then passed through a multi-stand rolling mill with longitudinal material flow (which will be referred to below as "longitudinal mill") able to gradually thin the wall through a suitable reduction of the outer diameter, thus increasing the length of the finished product. This rolling mill, as is known, comprises a plurality of rolling units. Each unit comprises a stand on which rolls with profiled grooves are mounted. The set of connected profiles of the grooves of the rolls defines the outer profile of the tube released by the rolling unit. Downstream of the longitudinal mill, the tube must be first extracted from the mandrel. According to the prior art, this operation is performed by means of another rolling mill which generally has three or more stands, called an extracting mill. The extracting mill performs a small reduction in the outer diameter of the tube, with the main aim of allowing the mandrel to perform the stroke necessary for extraction from the semi-finished tube which has just been produced, also called "mother tube".

[0005] Finally, the tube must be sized so as to define more precisely its outer diameter.

[0006] These functions may be performed by a corresponding number of independent machines, called an extracting mill, reducing mill and sizing mill, respectively. More often a single machine may instead perform several functions and thus, for example, the extracting/reducing mill or the reducing/sizing mill is obtained.

[0007] Then the tube must only undergo the inspection and/or finishing operations. The inspection operations may consist of pressure tests and checks which are non-destructive,

for example using ultrasound. The finishing operations may instead consist of cutting to size, cleaning, painting and marking.

[0008] The set of operations described above constitutes the core of the tube production process; in fact at the end of these operations the main characteristics of the tube (i.e. the wall thickness and the outer diameter) are defined. In a corresponding manner the assembly consisting of rotary piercer, longitudinal mill, extracting mill, reducing mill and/or sizing mill defines the main part of the plant, also called technological part. The entire of the layout of the production site, in terms of civil engineering and structural work, must be designed on the basis of the technological part.

[0009] On the other hand, the apparatus necessary for the inspection and/or finishing operations may be usually arranged without significant constraints around the main part of the plant.

[0010] It is known that the combination of transverse flow rolling (performed in the piercer) together with longitudinal flow rolling (performed in the multi-stand rolling mill) ensures qualitative characteristics of the end product which are superior to that obtained with various configurations, for example of the type using transverse double rolling (i.e. with a double piercer).

[0011] It is also known that the rolling in which the mandrel is retained and extracted on-line immediately downstream of the rolling mill ensures quality of the finished product and reliability far greater than those of other known configurations, in which the mandrel is released and/or free and in which extraction thereof is performed afterwards and off-line.

[0012] It is also known that multi-stand longitudinal rolling is suitable for obtaining very high diameter/thickness ratios, where "diameter/thickness ratio" is understood as meaning the ratio between the outer diameter of the tube and the thickness of the tube wall. In particular, the diameter/thickness ratios obtained by means of multi-stand longitudinal rolling reach values of about 48-50, i.e. much higher than the ratios which may be obtained with other configurations of a different kind, such as that using transverse flow double rolling, where the ratios are generally less than 30-35.

[0013] The known plants of the type described above, although widely established, are not entirely satisfactory.

[0014] Typically such plants are designed to achieve optimum tube production on a very large scale, for example in the region of 500,000 tonnes per year. In view of the production on such a vast scale and in order to exploit fully the economies of scale, the plants of the known type produce so-called double-length semi-finished tubes, i.e. with lengths of up to about 32 metres. Obviously all the dimensions of the plant must be defined on the basis of this final tube size. This size and other parameters are such that, for example, the main building of the production site must have dimensions which exceed the standard market dimensions. Such a building may for example have a main span which is nearly 45 metres and a length which measures more than 900 metres. As the person skilled in the art may clearly understand, a span of nearly 45 metres requires the construction of an ad hoc beamwork and overhead crane, since prefabricated parts with such dimensions are not available. For these reasons also, the construction of the entire plant, including civil engineering and structural work, requires a

huge initial outlay, such that an economic return may be guaranteed only if there is production on a vast scale as mentioned above.

[0015] Alongside this type of large-scale production plant there are also plants for production on a smaller scale (50,000 tonnes per year or less). These plants require a much smaller initial outlay and usually employ technologies which are older and less efficient in terms of process yield and process costs per tonne produced. The aforementioned plants designed for production on a large scale are also affected by other problems. For example, the transportation of the pierced blank from the piercer to the longitudinal mill may require from 50 to 70 seconds. During this time the pierced blank tends to disperse heat into the environment, thus reaching the longitudinal mill in a substantially colder condition, typically at a temperature of between about 1050° C. and about 1150° C., depending on the form of the said pierced blank. Obviously, the more the temperature of the pierced blank drops, the more the forces which must be applied by the rolling mill increase in order to obtain the desired plastic deformation of the material. The value of the forces to be applied determines the size of the actuators and the motors of the rolling mill, as well as the power consumption of the latter during rolling.

[0016] As already mentioned, when the plug of the rotary piercer is extracted, the internal cavity of the pierced blank is struck by a flow of ambient air, the oxygen content of which inevitably results in the formation of scale on the inner surface of the pierced blank. This effect must be counteracted because the presence of scale inside the tube during the subsequent processing steps would give rise to the formation of unacceptable defects. For this purpose, the pierced blank is treated internally with anti-oxidising agents, typically borax or substances similar thereto. As the person skilled in the art may easily understand, the industrial use of these substances creates major problems for the safety of the environment and of the workers owing to the toxicity of the substances used.

[0017] Moreover, the need for anti-oxidising treatment negatively affects the transfer time of the pierced blank between rotary piercer and longitudinal mill and the overall costs of the production procedure.

[0018] The object of the present invention is therefore that of overcoming at least partially the drawbacks mentioned above with reference to the prior art.

[0019] In particular, a task of the present invention is to provide a plant for rolling seamless tubes which may be more compact.

[0020] Moreover, a task of the present invention is to provide a plant for the hot rolling of seamless tubes which is sustainable from the environmental point of view, due to the reduction, during the normal production process, of the consumption of electricity and gas, of the emission levels and of the pollutants.

[0021] Moreover, a task of the present invention is to provide a compact plant for rolling seamless tubes which allows the negative effects of exposure to air of the pierced blank to be avoided or at least reduced, thus reducing the formation of scale and increasing the yield of the plant.

[0022] Finally, a task of the present invention is to provide a compact plant for the rolling of seamless tubes which requires a smaller initial outlay and which allows the operating costs to be kept low.

[0023] The object and tasks indicated above are achieved by a plant in accordance with that claimed in claim 1 and by a method according to claim 12.

[0024] The characteristic features and further advantages of the invention will emerge from the description, hereinbelow, of a number of examples of embodiment, provided by way of a non-limiting example, with reference to the accompanying drawings in which:

[0025] FIG. 1 shows a plan view diagram of a complete rolling plant according to the prior art;

[0026] FIG. 2 shows, on the same scale as FIG. 1, a plan view diagram of a complete rolling plant according to the invention;

[0027] FIG. 3 shows the technological part of a plant according to the prior art, indicated by III in FIG. 1;

[0028] FIG. 4 shows, on the same scale as FIG. 3, the technological part of a plant according to the invention, indicated by IV in FIG. 2;

[0029] FIG. 5 shows a plan view of a plant according to the invention similar to that of FIG. 4;

[0030] FIG. 6 shows a detailed view of the plant part according to the invention indicated by VI in FIG. 5;

[0031] FIG. 7 shows a possible variant of the plant shown in FIG. 6;

[0032] FIG. 8 shows another possible variant of the plant according to FIG. 6;

[0033] FIG. 9 shows a mandrel used in some plants according to the invention;

[0034] FIG. 10 shows a rod used in some plants according to the invention; and

[0035] FIG. 11 shows a type of mandrel/rod assembly used in some plants according to the invention; and

[0036] FIG. 12 shows another type of mandrel/rod assembly used in some plants according to the invention.

[0037] The plant for rolling a seamless tube according to the invention is denoted in its entirety by 10. It comprises:

[0038] a rotary piercer 20 comprising two skew-axis rolling rolls and a plug 22 mounted on a rod 24, the rotary piercer 20 defining a rolling axis X_{PR} and being designed to:

[0039] receive at its input a solid billet 11,

[0040] pierce the billet 11 against the plug 22, and

[0041] release the pierced blank 12 engaged on the rod 24 of the plug 22;

[0042] wherein the rod 24 of the plug 22 of the rotary piercer 20 is connected to a thrust block 26 designed to oppose the axial thrust which is generated on the rod 24 during piercing;

[0043] a longitudinal mill 30 comprising a plurality of rolling stations 32 with adjustable rolls, the longitudinal mill 30 defining a rolling axis X_{LL} and being designed to:

[0044] receive at its input the pierced blank 12 released by the rotary piercer 20;

[0045] roll the pierced blank 12 on a mandrel 32, and

[0046] release the semi-finished tube 13,

[0047] wherein the mandrel 32 of the longitudinal mill 30 is connected to a retaining block 34 designed to impart a predetermined speed to the mandrel 32 during rolling.

[0048] Moreover in the compact plant 10 according to the invention the rolling axes X_{PR} and X_{LL} coincide.

[0049] With reference to the rolling plant 10, a rolling axis may therefore be specifically defined. "Axial" or "longitudinal"

dinal" will therefore refer to the direction of a straight line parallel to the axis. Similarly "transverse" will refer to the direction of a straight line not parallel to the axis. Finally "lateral" or "vertical" will refer to the direction of a half line perpendicular to the rolling axis.

[0050] Moreover the processing steps define specifically a rolling direction. Expressions such as "before", "preceding", "upstream" or the like refer to positions which along the rolling axis are relatively close to the start of the plant. On the other hand, expressions such as "after", "following", "downstream" or the like refer to positions which along the rolling axis are relatively close to the end of the plant.

[0051] As mentioned above, in the rotary piercer **20** the axes of rotation of the rolling rolls are skew. "Skew-axis" is used to define machines in which the rolling rolls have axes which are not parallel to each other and which do not lie in the same plane. These machines are also defined as "transverse rolling" machines. On the other hand, the rolling mill **30** is a machine of the so-called "longitudinal rolling" type in that the axes of the rolling rolls of each stand lie in a same plane which is orthogonal to the rolling axis.

[0052] The fact that the rolling axes X_{PR} and X_{LL} coincide means that the pierced blank **12** output from the rotary piercer **20** may be fed directly to the longitudinal mill **30**, without any need to displace it laterally. By means of a simple axial movement the pierced blank **12**, still engaged on the rod **24** of the rotary piercer **20**, is brought into the vicinity of the mandrel **32** of the longitudinal mill **30** in a simple and rapid manner. This axial movement may be performed preferably by means of suitable known devices which, by way of a non-exclusive example, may be motor-driven rolls of the pressure type commonly known as "pinch rolls" or of a similar type.

[0053] In accordance with some embodiments of the plant **10** according to the invention, the rod **24** at the output of the rotary piercer **20**, which is axially aligned with the mandrel **32**, directly comes into contact with the end of the latter. The pierced blank **12** may therefore be slid directly from the rod **24** to the mandrel **32** so that it can be conveyed away for longitudinal rolling.

[0054] In accordance with some embodiments of the plant **10** according to the invention, the rod **24** of the rotary piercer **20** is structurally connected to the mandrel **32** of the longitudinal mill **30**. This solution allows the movement of the tooling, i.e. the two tools, to be simplified since during the operational steps they are structurally connected to each other. In this way it is also possible to achieve perfect alignment of the two tools, this allowing the pierced blank **12** to be displaced easily, without the possibility of unexpected difficulties arising.

[0055] In particular, the embodiments of the plant **10** in which the rod **24** is structurally connected to the mandrel **32** may advantageously use two solutions. In accordance with a first solution, the rod **24** and the mandrel **32** are made as one piece, while in accordance with a second solution the rod **24** and the mandrel **32** are connected together releasably. Both the solutions have specific advantages and positive features and the choice of one as opposed to the other may be made depending on the specific needs.

[0056] With regard to the mandrel **32** and the rod **24** or the single tool referred to below as "mandrel/rod assembly **324**" the following must also be considered: the rolling plant **10** according to the invention is preferably designed to roll single-length tubes, namely semi-finished tubes with a

length of about 15 metres. Based on this measurement all the main measurements of the plant **10** are defined, as the person skilled in the art may easily understand from the attached FIG. 5. Considering this final measurement of the tube and the elongation ratios of the various processing steps, it is possible to define a length of about 8 metres for the rod **24** and about 15 metres for the mandrel **32**.

[0057] In view of this it can be easily understood how also, in the case where it is decided to use the mandrel/rod assembly **324**, the management of such a tool does not pose any difficulties. In fact, the distance between the rotary piercer **20** and the longitudinal mill **30** is greater than the overall length of the aforementioned mandrel/rod assembly **324** and therefore allows easy movement, including lateral movement, of the latter, for example for change-over after rolling or evacuation in the event of an emergency.

[0058] Moreover, this tool may have an overall length of less than 25 metres, therefore consistent with the lengths of the mandrels normally used in conventional plants which produce double-length tubes.

[0059] Moreover, the mandrel/rod assembly **324** represents a more economical solution than the conventional mandrels which are comparable to it in terms of length and weight. The latter in fact must have a treated surface (for example chrome-plated or with a similar finish) called "noble part" **320** extending over practically their entire external surface. The mandrel/rod assembly **324**, on the other hand, must have a treated surface only on the outer surface of the portion which acts as a mandrel **32**, while the portion which acts as a rod **24** does not require any treatment of this kind (see also FIGS. 11 and 12).

[0060] Regarding detailed operation of the plant **10**, the rod **24** of the plug **22** of the rotary piercer **20** is connected to a thrust block **26**, preferably of the electromechanical type. In view of the fact that the piercer **20** is fed with solid parts (typically billets), the thrust block **26** is advantageously positioned downstream of the piercer **20** (see in particular FIG. 6). In this way piercing induces in the rod **24** an axial compressive force. This thrust block **26** comprises advantageously a first gripping unit **260** mounted on a first thrust bearing unit **262**. The first gripping unit **260** is above all designed to grip the rod and transfer the axial thrusts to the first thrust bearing unit **262**. Particularly important is the transfer of the axial thrust which is produced on the rod **24** during piercing. In fact, during piercing, the rolls push the billet **11** against the plug **22** and the thrust is transmitted via the rod **24** to the first gripping unit **260** and then to the first thrust bearing unit **262**. The first thrust bearing unit **262** is in turn designed to transmit this thrust to the ground. Moreover, the thrust/retaining block **26** is also designed to impart to the rod **24** and to the plug **22** the movements which are necessary before and after rolling. The first thrust bearing unit **262** is in fact designed to move the first gripping unit **260**, and along with it the rod **24** and the plug **22**. These movements occur in the axial direction and designed to move the plug **22** from a rest position to a working position and vice versa.

[0061] In accordance with some embodiments, the first gripping unit **260** is also designed to impart to the rod **24** and to the plug **22** a pre-rotation about the rolling axis X_{PR} . The possibility of obtaining the pre-rotation of the plug **22** is particularly advantageous in some cases because it allows, in a known manner, piercing of the billets to be facilitated.

[0062] In turn, the mandrel 32 of the longitudinal mill during rolling is connected to a retaining block 34 which is also preferably of the electromechanical type. The retaining block 34 is advantageously positioned upstream of the rolling mill 30 (see in particular FIG. 6) so that rolling induces in the mandrel 32 an axial tensile stress. This retaining block 36 comprises advantageously a second gripping unit 340 mounted on a second thrust bearing unit 342. The retaining block 34 is above all designed to grip the mandrel 32 and to impart to it a predetermined speed during rolling. In fact, during rolling, the rolls of the longitudinal mill 30 push the pierced blank 12 in an axial direction and this transmits the thrust to the mandrel 32. The mandrel 32 is firmly gripped by the second gripping unit 340 and the axial thrust which is thus generated is transmitted to the second thrust bearing unit 342. The second thrust bearing unit 342 is in turn designed to transmit this thrust to the ground. If the mandrel 32 were not retained it would be displaced along the longitudinal mill 30 together with the pierced blank 12. If, on the other hand, the mandrel were retained in a fixed manner, it would remain stationary inside the piece under processing. On the other hand, in this type of plant, the mandrel 32 is braked by the retaining block 34 which imparts to it a predetermined axial speed. In particular, the axial speed imparted to the mandrel 32 is preferably greater than 0 mm/s and less than 4000 mm/s. The retaining block 34 is also designed to impart to the mandrel 32 the necessary movements before and after rolling. These movements occur in an axial direction and are intended to move the mandrel 32 from a rest position to a working position and to extract the mandrel 32 from the semi-finished tube 13 released by the longitudinal mill 30.

[0063] According to some embodiments of the plant 10 according to the invention, the first gripping unit 260 for the rod 24 and the second gripping unit 340 for the mandrel 32 could be favourably mounted on a single thrust bearing unit 362. According to this solution, a thrust/retaining block 36 which combines and replaces the two blocks of the known type would be obtained. By means of this solution, if present, it is possible to simplify the rolling plant 10 along its portion situated between the rotary piercer 20 and the longitudinal mill 30. In particular the synergy which is obtained arises from the fact that both the thrust block 26 and the retaining block 34 must be designed to generate forces and displacements in the axial direction. In the thrust/retaining block 36, therefore, by means of a single system it is possible to manage both the rod 24 of the rotary piercer 20, i.e. move it and withstand its thrust, and the mandrel 32 of the longitudinal mill 30, i.e. move and retain it. As has already been described separately for the thrust block 26 and the retaining block 34, the thrust/retaining block 36 is advantageously of the electromechanical type. With this solution, in fact, it is possible both to ensure an optimum rigidity of the block and high precision of the movements. By way of example, the system for moving the thrust bearing unit may consist of a carriage, which is able to move by means of a pinion which meshes along a rack, or of a carriage which is able to move along guides by means of cables or chains. Moreover, since in the plant 10 according to the invention the rolling axes X_{PR} and X_{LL} coincide, by replacing the thrust block 26 and the retaining block 34 with a single thrust/retaining block 36 it is possible to obtain a greater compactness of the plant 10 in the longitudinal direction. The thrust/retaining block 26 is advantageously

positioned between the piercer 20 and the rolling mill 30 (see in particular FIGS. 4, 5 and 7, 8). As a result of this particular solution it is possible to limit the overall length of the tooling, whether it be the rod 24 and the mandrel 32 separate from each other, or combined to form a mandrel/rod assembly 324. Relatively simple management of the tools, such as lateral exit at the end of rolling allowing the cooling, inspection and lubrication operations to be carried out on the tools, is thus possible.

[0064] Moreover, a favourable variant of the embodiment of the present invention is one in which the thrust/retaining block 36, in addition to a single thrust bearing unit 362, also comprises a single gripping unit 360. The single gripping unit 360 is designed to grip both the rod 24 and the mandrel 32 and transmit the corresponding axial thrusts to the single thrust bearing unit 362. This variant improves substantially the mechanical synergy between the components to the advantage of costs, space and cycle times. Moreover, In accordance with some embodiments, the single gripping unit 360 is also designed to impart to the rod 24 and to the plug 22 a pre-rotation about the rolling axis X_{PR} .

[0065] Particularly advantageous is the embodiment in which the mandrel/rod assembly 324 is used together with the single gripping unit 360 of the thrust/retaining block 36. This solution in fact is particularly compact and efficient.

[0066] Moreover, it is thus possible, using suitable systems known per se, called "terns" (not shown in the figures), to constrain the part of the mandrel/rod assembly 324 which during piercing is acted on by compressive loads, so as to prevent buckling, i.e. instability due to axial loading. At the same time, the terns do not intervene on the noble part 320 of the mandrel/rod assembly 324 which is intended for longitudinal rolling, the surface of this part having been previously treated with lubricant (generally graphite-based) for subsequent longitudinal rolling. Since the terns do not come into contact with this noble part 320 of the mandrel/rod assembly 324, the lubricant distributed over it remains in good condition until the moment of the rolling operation. This allows on the one hand a good quality of the finished tube to be obtained and on the other hand the noble part 320 of the mandrel to be preserved, increasing consequently its working life.

[0067] As already mentioned with regard to operation of the plant 10, during the piercing performed by the rotary piercer 20, the rod 24 rests axially on the thrust/retaining block 36 intended to transfer the axial thrust exerted by the rolls on the billet 11 and then transmitted from the latter to the plug 22 of the rotary piercer 20. At the end of piercing, the first gripping unit 260 and the second gripping unit 340 (or in certain cases the single gripping unit 360) are removed to allow the axial displacement of the pierced blank 12 engaged on the rod 24 (if the rod 24 is separate from the mandrel 32) or of the pierced blank 12 alone (if the rod 24 and mandrel 32 are connected to each other). Once the pierced blank 12 is engaged on the mandrel 32, the latter is connected to the second gripping unit 340 or to the single gripping unit 360. The retaining block 34 or, if present, the thrust/retaining block 36 is intended to apply a tractional force on the mandrel 32 so as to impart to the latter a predetermined axial speed during rolling in the longitudinal mill 30.

[0068] In the light of the above comments, the person skilled in the art may certainly understand how the simple axial displacement of the pierced blank 12 reduces to a

minimum its movement and, along with it, its transfer time. More particularly, the transfer time of the pierced blank **12** from the outlet of the rotary piercer **20** to the inlet of the longitudinal mill **30** is thus limited to only about 15 seconds, compared to the about 50-70 seconds which are needed in the known plants. During this short time period the pierced blank **12** disperses much less heat into the environment, thus reaching the longitudinal mill **30** in a substantially hotter condition, typically at a temperature of between about 1210° C. and about 1240° C., depending on the form of the said pierced blank **12**.

[0069] Moreover, the fact that the pierced blank **12** is displaced directly from the rod **24** to the mandrel **32** (or even more simply is displaced along the mandrel/rod assembly **324**) prevents its internal cavity from being filled with ambient air and from being subject to oxidation. In this way it is avoided having to perform known anti-oxidising treatments, which are typically borax-based.

[0070] As regards the rotary piercer **20**, it may be a piercer with barrel rolls or a piercer with conical rolls. Both the solutions, which are not described here because they are well-known to the person skilled in the art, have specific advantages and positive features and the choice of one as opposed to the other may be made depending on the specific needs.

[0071] The longitudinal mill **30** may also be designed with forms which differ slightly. In general this rolling mill has advantageously the rolls movable radially in order to adjust the position thereof and therefore the force applied during rolling, resulting in the formation of the semi-finished tube **13** from the pierced blank **12**.

[0072] In accordance with some embodiments of the plant **10**, the longitudinal mill **30** is of the type comprising two rolls for each rolling station. This type of longitudinal mill is particularly compact, reliable and low-cost. According to this type of rolling mill, for example, since the two rolls of each station are operated by the same motor, it is sufficient to use a number of motors equal to the number of rolling stations contained therein. This obviously results in advantages in terms of initial cost, operating consumption, complexity (which is lower) and overall reliability.

[0073] According to other embodiments of the plant **10**, the longitudinal mill **30** is of the type comprising three rolls for each rolling station. This type of longitudinal mill is particularly precise and suitable for the production of high-quality tubes. According to this type of rolling mill, for example, the three rolls of each station manage to transmit the deformation force in a particularly regular manner onto the outer profile of the tube. This clearly results in advantages in terms of quality of the end product.

[0074] Also as regards the longitudinal mill **30**, both the solutions, which are not described here because they are well-known to the person skilled in the art, have specific advantages and positive features and the choice of one as opposed to the other may be performed depending on the specific needs.

[0075] According to some embodiments, the plant **10** according to the invention also comprises an operating fork **40** for extracting the mandrel **32** from the semi-finished tube **13**. This operating fork is positioned immediately downstream of the longitudinal mill **30** and is designed to replace the extractor mill present in conventional plants. At the end of the rolling of the semi-finished tube **13**, the latter exits the longitudinal mill **30** and remains engaged for a short portion

on the mandrel **32**. In fact, the longitudinal mill imparts to the tube a significant axial speed, while the mandrel **32** contained inside it is retained by the retaining block **34** upstream. This results in relative sliding of tube **13** and mandrel **32**, so that they are almost entirely extracted. Once the tube has left the longitudinal mill **30**, the operating fork **40** retains it in position and the mandrel **32** may be extracted backwards by applying a sufficient axial tractional force via the retaining block **34** or the thrust/retaining block **36**.

[0076] As the person skilled in the art may easily understand, the replacement of a complex and bulky machine such as the extractor mill with a simple and compact device such as the operating fork **40** results in significant advantages in terms of compactness, simplicity and overall reliability.

[0077] After extraction from the semi-finished tube **13**, the mandrel **32** must undergo a series of treatments so that it may be available for use again. The treatments consist mainly of a suitable cooling and surface treatment with lubricant, which is typically graphite-based. Special stations intended for these treatments are positioned alongside the rolling plant **10**.

[0078] Downstream of the operating fork **40**, the plant **10** according to the invention may also comprise a stretch-reducing mill **50**, whereby said mill may be advantageously preceded by a small induction furnace **60**. The stretch-reducing mill **50** is designed to receive at its inlet the semi-finished tube **13** and to release the finished tube **14**, at least depending on its main characteristics (i.e. thickness of the wall and the outer diameter). Downstream of the stretch-reducing mill **50**, the finished tube **14** may if necessary undergo other secondary operations, such as inspection and/or finishing operations.

[0079] The presence of the induction furnace **60** immediately upstream of the stretch-reducing mill **50** may be advantageous if in that position of the plant **10** there is a reduction in the temperature of the semi-finished tube **13**. With regard to the above comment, this reduction in temperature should be avoided or kept at a negligible level, but in some particular cases the use of the induction furnace **60** could however be advantageous. For example, in the case of high-alloy steel tubes, the temperature required for rolling in the stretch-reducing mill **50** could be advantageously raised in order to reduce the rolling stresses. Furthermore, raising of the temperature during this step could be advantageous in the case of tubes with a particularly thin wall which are more exposed to cooling during the—albeit—small movements. It should be noted here how the induction furnace **60** constitutes a particularly compact and simple solution for dealing with the need to raise the temperature of semi-finished tube **13**. This furnace in fact has particularly small dimensions since it is formed simply by a short tunnel inside which the semi-finished tube **13** is axially displaced. Special circuits create induction currents in the metal mass of the tube and these currents determine heating thereof.

[0080] In accordance with other embodiments of the plant **10**, the stretch-reducing mill **50** may be replaced by a sizing mill. The choice of one as opposed to the other solution may be made on the basis of the specific needs such as the size of the final tube, without adversely affecting the advantages of the invention.

[0081] The rolling plant **10** according to the invention also comprises a series of escape ways which prove to be particularly advantageous in emergency conditions, namely when there is a malfunction in the rolling process.

[0082] A first escape way 71 is situated alongside the path for feeding the billet 11 to the rotary piercer 20. This escape way 71 may be used to discard a billet 11 which is ready for rolling, in the event of a problem of any kind occurring along the rolling line. In this case, in fact, it is not possible to feed the billet to the piercer 20 because the downstream plant may not receive other parts before the current problem is resolved.

[0083] In the event of a problem occurring during piercing, it may happen that the billet 11 may still be extracted from the plug 22 through forwards displacement of the latter. In this condition, therefore, the only partially pierced billet 11 may be extracted from the rod 24 and the plug 22 downstream of the rotary piercer 20. In order to extract the plug 22 from the partially pierced billet 11 a first emergency fork may be advantageously used, said fork being designed to keep the billet 11 in position, while the rod 24 and the plug 22 are extracted forwards. The forwards extraction of the plug 22 and the rod 24 is performed by means of the thrust block 26 or, if present, the thrust/retaining block 36.

[0084] The only partially pierced billet 11 may then be removed laterally or vertically, for example by means of a crane, while the rod 24 and the plug 22 may be removed by means of the normal lateral exit system, used after rolling.

[0085] Similarly, should the plug 22 remain blocked inside the billet 11, also the two parts together may be fed forwards, downstream of the piercer 20, and discharged laterally. One possible lateral exit is the normal exit path of the mandrel 32, in particular if the rod 24 and the mandrel 32 are structurally connected together. Another possible escape way is vertical and is made possible by a crane which may raise the assembly consisting of the billet 11 and the rod 24 inserted inside it, thus removing them from the rolling line. The further operations needed to remove the plug 22 from the billet 11 may at this point be duly performed off-line, in the manner known per se.

[0086] A second escape way 72 and a third escape way 73 are arranged in the vicinity of the outlet for the semi-finished tube 13 from the longitudinal mill 30. In the case of a problem occurring during longitudinal rolling, it may happen that the pierced blank 12 may still be extracted from the mandrel 32 by displacing the latter backwards. In this condition, therefore, the only partially rolled pierced blank 12 may be moved forwards downstream of the longitudinal mill 30 and from here discharged laterally into the second escape way 72.

[0087] In order to extract the mandrel 32 from the partially rolled pierced blank 12, advantageously it is possible to use, depending on the circumstances, the operating fork 40 or a second emergency fork 42 situated immediately upstream of the longitudinal mill 30 and designed to keep the pierced blank 12 in position, while the mandrel 32 is extracted backwards. The backwards extraction of the mandrel 32 is performed by means of the thrust/retaining block 36.

[0088] Should, on the other hand, the mandrel 32 remain blocked inside the pierced blank 12, the two parts must be fed further forwards downstream of the longitudinal mill 30, along the third escape way 73 which forms essentially an extension of the outlet of the longitudinal mill 30. In this case, the rolling rolls of the stands of the longitudinal mill 30 are positioned outside of the overall volume by means of the adjustment devices which are normally used during rolling, so as to allow the pierced blank 12 and the mandrel 32 inserted inside it to pass through.

[0089] The further operations needed to remove the mandrel 32 from the pierced blank 12 may at this point be duly performed off-line, in the manner known per se.

[0090] In accordance with a further aspect thereof, the invention also relates to a method for rolling a seamless tube. The method according to the invention comprises the steps of:

[0091] providing a solid billet 11;

[0092] providing a rotary piercer 20 comprising two skew-axis rolling rolls and a plug 22 mounted on a rod 24, the rotary piercer 20 defining a rolling axis X_{PR} ;

[0093] providing a longitudinal mill 30 comprising a plurality of rolling stations with adjustable rolls, the longitudinal mill 30 defining a rolling axis X_{LL} and being designed to roll a pierced blank 12 on a mandrel 32;

[0094] feeding the solid billet 11 to the rotary piercer 20;

[0095] piercing the billet 11 against the plug 22 so as to obtain a pierced blank 12;

[0096] opposing the axial thrust which is produced on the rod 24 during the step of piercing the billet (11);

[0097] releasing a pierced blank 12 engaged on the rod 24 of the plug 22;

[0098] displacing the pierced blank 12 from the rod 24 of the plug 22 to the mandrel 32 of the longitudinal mill 30;

[0099] feeding the pierced blank 12 engaged on the mandrel 32 to the longitudinal mill 30;

[0100] rolling the pierced blank 12 on the mandrel 32 so as to obtain a semi-finished tube 13;

[0101] imparting to the mandrel 32 a predetermined speed during the step of rolling the pierced blank (12); and

[0102] releasing the semi-finished tube 13.

[0103] Moreover, in the method according to the invention, the rolling axes X_{PR} and X_{LL} coincide.

[0104] As will be clear to the person skilled in the art, the rolling plant and method according to the invention overcome at least partially the drawbacks identified with reference to the prior art.

[0105] In particular, the person skilled in the art will clearly recognize the advantages arising from the substantial reduction in the movement of the pierced blank 12 between the outlet of the rotary piercer 20 and the inlet of the longitudinal mill 30. The substantial difference in temperature which arises, as a result, at the inlet of the longitudinal mill 30 has already been mentioned, this temperature having values in the region of 1210-1240° C. instead of 1050-1150° C. The effect of such a temperature may be fully appreciated when one considers that, following the tests carried out, the Applicant has established that the plant 10 according to the invention, all other conditions being equal, may use a nominal rolling power per stand which is even 35% lower than that of a plant of the known type.

[0106] Similarly, as a result of the plant 10 according to the invention, the power consumption during normal operation may be reduced. As an alternative to a reduced power consumption, rolling of steels with a higher binder content which otherwise could not be processed is possible with the plant according to the invention.

[0107] Further effects of the reduction in the transfer time of the pierced blank 12 are associated with the management of the mandrels 32. Firstly, the higher temperature of the

pierced blank 12 results in smaller stresses on the external surface of the mandrel 32 and therefore less wear. Moreover, the smaller transfer time of the pierced blank 12 gives rise to a shorter overall cycle time and this leads to the possibility of reducing the number of mandrels 32 which must be simultaneously present in the plant 10 in order to ensure operation thereof. This number of mandrels, which in the case of conventional plants is equal to about 6 or 7, in the plant according to the invention is reduced to 3. Obviously it is necessary to consider that the noble part 320 of the single mandrel 32 used in the plant 10 according to the invention is about half that of a conventional mandrel 32.

[0108] All these aspects mentioned above result in significant savings associated with the overall management of the mandrels 32. Also in connection with the mandrels, a smaller environmental impact due to the smaller overall area of the surfaces to be treated superficially—for example a smaller area of the noble part 320 of the mandrel to be treated by means of chrome-plating, multiplied by a smaller overall number of mandrels 32—is obtained.

[0109] As mentioned above, the characteristic features of the invention enable a particularly compact rolling plant 10 to be obtained. In this connection, for example, the main building of the production site may have much smaller dimensions. As regards the technological areas (shown in FIGS. 3 and 4) the width of the plant according to the invention is 30% smaller than that of a conventional plant, while the length is 60% smaller. As the person skilled in the art may fully understand, such a reduction in space results in major savings in terms of initial investment and management costs. For example a prefabricated beamwork and overhead crane may be used for the span of about 30 metres present in a plant according to the invention, thus allowing considerable savings compared to the special reinforced overhead cranes needed for spans for example of 45 metres or more.

[0110] Considering the overall dimensions of the lines (shown in FIGS. 1 and 2), the area occupied by the plant according to the invention is reduced by 50% compared to a conventional plant.

[0111] Another particularly advantageous aspect is the possibility of eliminating completely the borax-based deoxidation treatments. In this way, not only the costs associated with the provision and use of the treatment station are avoided, but also the use of toxic substances is eliminated, with a consequent reduced environmental impact. A more rapid transfer of the pierced blank 12 is also obtained, this being particularly advantageous for heat-related reasons in the case of a pierced blank 12 which is particularly thin and therefore subject to more rapid cooling.

[0112] The person skilled in the art, in order to satisfy specific requirements, may make modifications to the embodiments of the plant and the method for rolling seamless tubes according to the invention and/or replace the parts described with equivalent parts, without thereby departing from the scope of the accompanying claims.

1. Compact plant (10) for rolling a seamless tube, comprising:

- a rotary piercer (20) comprising two skew-axis rolling rolls and a plug (22) mounted on a rod (24), the rotary piercer defining a rolling axis X_{PR} and being designed to:
 - receive at its input a solid billet (11),
 - pierce the billet (11) against the plug (22), and

- release a pierced blank (12) engaged on the rod (24) of the plug (22);

- wherein the rod (24) of the plug (22) of the rotary piercer (20) is connected to a thrust block (26) designed to oppose the axial thrust which is generated on the rod (24) during piercing;

- a longitudinal mill (30) comprising a plurality of rolling stations with adjustable rolls, the longitudinal mill defining a rolling axis X_{LL} and being designed to:
 - receive at its input the pierced blank (12) released by the rotary piercer;

- roll the pierced blank (12) on a mandrel (32), and
- release a semi-finished tube (13);

- wherein the mandrel (32) of the longitudinal mill (30) is connected to a retaining block (34) designed to impart to the mandrel (32) a predetermined speed during rolling; and

wherein

the rolling axes X_{PR} and X_{LL} coincide.

2. The plant (10) according to claim 1, wherein:

- the thrust block (26) is designed to impart to the rod (24) and to the plug (22) the necessary movements before and after piercing; and

- the retaining block (34) is designed to impart to the mandrel (32) the necessary movements before and after rolling.

3. The plant (10) according to claim 1, wherein the thrust block (26) is positioned downstream of the piercer (20) and the retaining block (34) is positioned upstream of the longitudinal mill (30).

4. The plant (10) according to claim 1, wherein the thrust block (26) comprises a first gripping unit (260) mounted on a first thrust bearing unit (262); and the retaining block (34) comprising a second gripping unit (340) mounted on a second thrust bearing unit (342).

5. The plant (10) according to claim 4, wherein the first gripping unit (260) of the thrust block (26) and the second gripping unit (340) of the retaining block (36) are mounted on a single thrust bearing unit (362).

6. The plant (10) according to claim 5, wherein the first gripping unit (260) and the second gripping unit (340) of the thrust/retaining block (36) form a single gripping unit (360).

7. The plant (10) according to claim 1, wherein the rod (24) of the plug (22) of the rotary piercer (20) is structurally connected to the mandrel (32) of the longitudinal mill (30).

8. The plant (10) according to claim 7, wherein the rod (24) of the plug (22) of the rotary piercer (20) and the mandrel (32) of the longitudinal mill (30) are formed as one piece.

9. The plant (10) according to claim 7, wherein the rod (24) of the plug (22) of the rotary piercer (20) and the mandrel (32) of the longitudinal mill (30) are releasably connected together.

10. The plant (10) according to claim 1, wherein the rotary piercer (20) is chosen from the group comprising piercers with barrel rolls and piercers with conical rolls.

11. The plant (10) according to claim 1, wherein the longitudinal mill (30) is chosen from the group comprising rolling mills with two-roll rolling stations and rolling mills with three-roll rolling stations.

12. The plant (10) according to claim 1, further comprising an operating fork (40) for extracting the mandrel (32) from the semi-finished tube (13).

13. The plant (10) according to claim 1, wherein the predetermined speed imparted to the mandrel (32) by the retaining block (34) during rolling is between 0 mm/s and 4000 mm/s.

14. Method A method for rolling a seamless tube, comprising the steps of:

- providing a solid billet (11);
- providing a rotary piercer (20) comprising two skew-axis rolling rolls and a plug (22) mounted on a rod (24), the rotary piercer (20) defining a rolling axis X_{PR} ;
- providing a longitudinal mill (30) comprising a plurality of rolling stations with adjustable rolls, the longitudinal mill (30) defining a rolling axis X_{LL} and being designed to roll a pierced blank (12) on a mandrel (32);
- feeding the solid billet (11) to the rotary piercer (20);
- piercing the billet (11) against the plug (22) so as to obtain a pierced blank (12), and

opposing the axial thrust which is produced on the rod (24) during the step of piercing the billet (11);

releasing the pierced blank (12) engaged on the rod (24) of the plug (22);

displacing the pierced blank (12) from the rod (24) of the plug (22) to the mandrel (32) of the longitudinal mill (30);

feeding the pierced blank (12) engaged on the mandrel (32) to the longitudinal mill (30);

rolling the pierced blank (12) on the mandrel (32) so as to obtain a semi-finished tube (13);

imparting to the mandrel (32) a predetermined speed during the step of rolling the pierced blank (12); and releasing the semi-finished tube (13).

wherein the rolling axes X_{PR} and X_{LL} coincide.

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