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(54) METHOD OF AND ASSEMBLY FOR FORMING SEAMLESS RINGS BY PROCESS OF RING ROLLING

(57) The subject of the invention is a method of forming of seamless rings by process of ring rolling and an assembly for forming of seamless rings by process of hot rolling. The main roll is a shaping tool with a segmented construction, which is composed of a base roll segment (1), placed on the mill's drive shaft (3), where the transmission of the torque from the drive shaft (3) to the base roll segment (1) occurs through the use of rectangular keys (8), and of an exchangeable roll segment (2), the bottom part of which is set coaxially and centred on the surface of the base roll segment (1), whereas the upper part of which is connected with the centre part of the base roll (1) segment by mutually shaped surfaces of both roll segments: the base segment (1) and the exchangeable segment (2), in the form of a regular polygon (12), moreover on the base roll segment (1) and the frontal upper part of the exchangeable roll segment (2) a full ring (9) is placed axially, whereas in the base roll segment a split ring (10) is placed axially with a clamping ring (13) for removing and exchanging the exchangeable roll segment (2).

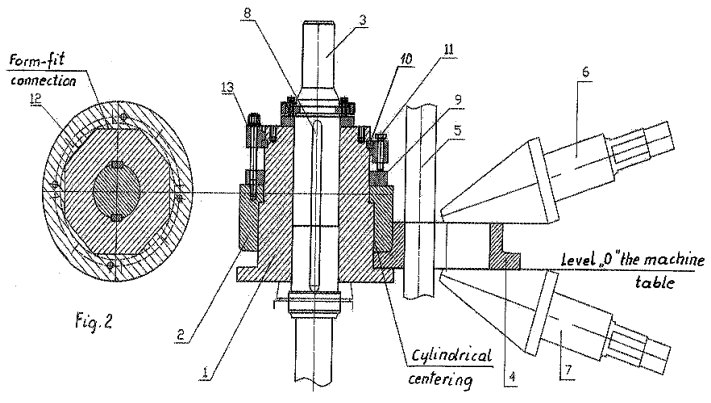

Fig. 2

Fig. 1

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Description

[0001] The subject of the invention is a method of forming of seamless rings by process of ring rolling and an assembly for forming of seamless rings by process of ring rolling, where the rolled rings obtained through a process of hot rolling are used in the manufacturing of large-size elements of slide bearings, rolling bearings, in turbine discs or in semi-finished products for the manufacture of gearboxes in such fields as: automotive, transport, aerospace, machinery and devices, in offshore wind and currently used power engineering technologies.

[0002] A known method for rolling of rings in a system of two rolls with vertical axes consists of circumferential forming of an input ring between two rolls, a main (external) driving roll and a mandrel roll (second internal roll, idle) with forced linear feeding at a defined speed towards the main roll. The height of the shaped ring is controlled by a pair of conical rolls with their own drive, which assist in the rotational movement of the shaped ring and control both its height and the increase of its diameter. Moving the upper conical roll towards the lower conical roll results in the change of height of the rolled ring. An additional pair of rolls placed symmetrically on the circumference of the shaped ring controls the course of the process, taking into account the increase of its diameter in the mill's kinematic system.

A Japanese patent description No. 2010-64134 demonstrates a simple rolling device which contains a single main roll rotating along its axis and two mandrel rolls placed outwards of the main roll in the radial direction and equipped with a rolled item in the form of a ring. The rolling device decreases thickness in the radial direction of the machined item by reducing the spacing between the main roll and the mandrel rolls, which are immobile during the rolling. The rolling device contains a mechanism for actuating the main roll, which allows bringing the main roll to each of the mandrel rolls.

In an American patent application US 2015/0283592 A1 it was demonstrated that in a multi-roll table ring-rolling mill and method, a mandrel roll can be switched from a rolling state into a free-running state, when a predetermined ring diameter is reached, even if the roll gap minimum has not yet been reached, in order to improve the size accuracy of the rolled rings. The mill comprises at least one main roll and two mandrel rolls, wherein the main roll rotates about a main roll axle, and the main roll axle and the mandrel roll table axle are mounted in unchangeable manner and eccentric to one another, at least during the rolling process.

There exist known from descriptions of German patent applications DE 2504996 A1, DE 102011108113 A1 rolling mills for the rolling of rings of various dimensions, whereas in case of very large rings the main roll and the mandrel roll are pressed to each other, and the rolled ring rotates in the rolling gap between the main roll and the mandrel roll. Depending on specific requirements, in case of very large ring mills also axial rolls and/or special rolls are also provided. Therefore the rolling process, and the degree of deformation may be selected relatively freely, since finally the ring may be passed through appropriate gaps between the main roll and the mandrel as often as needed. Such ring mills are of a complex construction, and are therefore expensive.

An American invention known from the patent application US2020/0061686 A1 concerns a method of manufacturing a in hot rolling process of a ring shape body which is formed in the shape of a ring on a die of a main roll, and then the ring shape body is reduced in the radial direction to a desired dimension between the main roll and a mandrel. This invention also concerns a method of cooling of a main roll used for ring rolling.

[0003] Competition on the large rings' market forces a search for solutions which will allow a reduction of costs related to their production. A very advantageous solution is the introduction of low waste shaping technology, which decreases material intensity. Another solution which results in actual decrease of costs is the designing of a system for segment construction of the main roll. Using every time a full height monolithic main roll for an ordered ring has a significant impact on the unit cost of the product. Therefore works have commenced on creating a concept of a segmented type mail roll. This solution must take into account the kinematics of the mill, the universality of the solution and the economic aspect of construction. Due to a wide range of shapes of rolled rings such a design should include a single range of rings, as a part of which the exchangeable systems should enable the rolling of rings with different profile dimensions.

[0004] The essence of an invention, which is a method of forming of seamless rings by process of hot rolling in mills with vertical placement of rolls, where the rolling of a ring consists of increasing, through a forming process, the diameter of a ring-shaped input material while simultaneously shaping the external profile of the input material - a ring, which will be driven by a rotating main roll, is guided by a mandrel roll rotating around its own axis, by forced movement with linear feed at a set speed, moving towards the main roll, whereas conical rolls move in a horizontal movement in accordance with the increase of the ring, and additionally the vertical movement of the upper conical roll enables maintaining a constant height of the ring or reducing the height to a set value, consists of the main roll, used as a forming tool, with a segment construction consisting of a base roll segment and an exchangeable roll segment centred in its lower part on the surface of the base roll segment, where the torque from the base roll segment is transferred to the exchangeable roll segment using a shaped connection of the both segments in the form of a regular polygon, placed coaxially in the centre of the base roll segment, being used to shape, by rolling on a mill, an external shape of a ring, while a mandrel roll creates an internal outline of the ring, where by decreasing the wall thickness and the ring height, the ring diameter increases while maintaining a constant volume, whereby the rolling process ends when

the ring reaches a desired shape and diameter, moreover the roll segments: base and exchangeable connected by a polygon are locked with bolts using a full ring axially placed on the base roll segment and on the front upper part of the exchangeable roll segment and a split ring placed in a base roll segment, whereas the base and exchangeable roll segments are disconnected by using a clamping ring of the split ring, where the clamping ring is placed over the split ring, and using bolts and nuts the exchangeable roll segment is removed and replaced.
It is advantageous if the bottom part of the exchangeable roll segment is set coaxially and centred on the cylindrical surface of the base roll segment, shaping an external outline of the ring.

[0005] It is advantageous if the bottom part of the exchangeable roll segment is set coaxially and centred on the conical surface of the base roll segment, shaping an external outline of the ring.

[0006] This method is implemented by an assembly for the forming of seamless rings on mills for hot rolling of rings with vertical placement of rolls, equipped with a rotationally driven main roll and mated mandrel roll used to place the rolled input material - a ring, with two independently driven conical rolls and with centric rolls, not shown on the figure, moving over the radius of the shaped input material - the ring, maintaining its geometry, characterized in that the main roll is a shaping tool with a segmented construction, which is composed of a base roll segment, placed on the mill's drive shaft, where the transmission of the torque from the drive shaft to the base roll segment occurs through the use of rectangular keys, and of an exchangeable roll segment, the bottom part of which is set coaxially and centred on the surface of the base roll segment, whereas the upper part of which is connected with the centre part of the base roll segment by mutually shaped surfaces of both roll segments: the base segment and the exchangeable segment, in the form of regular polygons, moreover on the base roll segment and the frontal upper part of the exchangeable roll segment a full ring is placed axially, whereas in the base roll segment a split ring is placed axially with a clamping ring for removing and exchanging the exchangeable roll segment.

[0007] It is advantageous if the external surface of the base roll segment, on which the bottom part of the exchangeable roll segment is set coaxially has the shape of a cylinder.

[0008] It is advantageous if the external surface of the base roll segment, on which the bottom part of the exchangeable roll segment is set coaxially has the shape of a cone.

[0009] The use of the assembly for forming of seamless rings, presented in the invention enables, among others, the following technical and utility effects:

- forming of rings with an even surface and low volume of excess process material,
- manufacturing of large-size ring elements with higher rolling speeds using the "ring rolling method", which are not achievable when using the method of free running on a mandrel, and thus increases process efficiency compared to the method of free running on a mandrel,
- manufacturing of rings with profiled side surfaces, e.g. cylindrical, conical etc. while keeping the volume of excess material to a minimum,
- short setup time, due to the use of a segmented design of the main roll, as the tool shaping the external profile of the input material - the ring, constructed by combining a base roll segment with an exchangeable roll segment,
- by obtaining smaller grain and more uniform structure of the rings after a rolling forming process, the ring is more resistant to wear,
- the possibility of rolling rings made of light alloys, e.g. aluminium alloys,
- reducing operational costs related to the construction of tooling and machine setup time, which is results from the use of the segmented design of the main roll as a shaping tool,
- segments acc. to the invention attached to the main shaft of the mill facilitate easy exchange of tooling, which results in simple and fast setup of the machine,
- improving the smoothness, and thus the quality of the finished ring,
- reducing the cost of the finished ring,
- manufacturing a wide range of rings with profiled external side surfaces with a fixed base part,
- the possibility of modifying ring geometry by exchanging only the exchangeable segment,
- lower tooling costs (various exchangeable segments) compared to the fabrication of single monolithic rollers for a given range of rings,

[0010] The subject of the invention, in an example, but not limiting, implementation was presented on the figure, where fig. 1 presents the system of the rolls in cross-section in a plane passing through the axes of the base and exchangeable roll segments and the axes of the conical rolls, fig. 2 presents the shaped connection in cross-section in a plane perpendicular to the axis of the base and exchangeable roll segments.
A method of forming of seamless rings by process of hot rolling of rings in mills with vertical placement of rolls consists of the rolling zone a ring input material is placed, through the hole of which the mandrel roll passes. The main roll is mounted permanently and rotates at a set speed. The mandrel roll is moved linearly towards the main roll, pressing the external surface of the ring input material to the main roll. In this arrangement both the ring input material and the mandrel roll are forced into rotating movement. Further linear movement of the mandrel roll causes the shaping of the ring - increasing its diameter. An important role is played by conical rolls, which have an independent drive and aid in the rotational movement of the ring, move linearly in a horizontal direction along

with the increase of the ring diameter, and additionally the upper conical roll is able to work vertically, reducing the ring height to a set dimension. Centric rolls are placed on the circumference of the shaped ring. During the rolling they are responsible for maintaining correct ring geometry. If a main roll with a profiled side surface is used, it is possible to directly shape the external profile of the ring. The process ends after set dimensions of the ring are reached.

[0011] In a method according to the invention, a main roll, driven by the drive shaft 3 of the mill, as a shaping tool, of a segmented design in the form of a base roll segment 1 and exchangeable roll segment 2 centred in its lower part on a cylindrical surface of the base roll segment 1, with the segments 1 and 2 connected by a shaped connection with a cross-section of a regular polygon 12 (octagon, hexagon etc.), coaxially in the centre part of the base roll segment 1, is used to shape an external outline of a ring 4 by rolling on a mill, whereas the mandrel roll 5 creates an internal outline of the ring 4, where by decreasing the thickness of the wall and the height of the ring 4, the diameter of the ring 4 increases while maintaining a constant volume. Ring 4 driven by a rotating main roll is guided by a mandrel roll 5 rotating along its own axis, moving towards the main roll, whereas conical rolls: upper 6 and lower 7 move horizontally in accordance with the increase of the ring, and additionally the upper conical roll 6 enables with its vertical movement to maintaining a constant height of the ring 4 or reducing it to a set value.

[0012] The ring rolling process ends when the ring 4 reaches a desired shape and diameter. Moreover the connected base roll segment 1 and exchangeable roll segment 2 are locked with bolts 11 using a full ring 9 axially placed on the base roll segment 1 and on the front upper part of the exchangeable roll segment 2 and a split ring 10 placed in a base roll segment 1, whereas the base roll 1 and exchangeable roll 2 segments are disconnected by using a clamping ring 13 of the split ring 10. The clamping ring 13 is placed over the split ring 10, and using bolts and nuts the exchangeable roll segment 2 is removed and replaced.

[0013] In another example implementation, in a technological process of forming of seamless rings a lower part of the exchangeable roll segment 2 is set coaxially and centred on the conical surface of the base roll segment 1, shaping an external outline of the ring 4.

[0014] An assembly for the forming of seamless rings on mills for hot rolling of rings with vertical placement of rolls is equipped with a rotationally driven main roll and mated mandrel roll 5 used to place the rolled input material - the ring 4, with two independently driven conical rolls 6 and 7 and with centric rolls, not shown on the figure, moving over the radius of the shaped input material - the ring 4 and maintaining its geometry. The main roll is a shaping tool with a segmented construction, which is composed of a base roll segment 1, set on the mill's drive shaft 3, where the transmission of the torque from the drive shaft 3 to the base roll segment 1 occurs through the use of rectangular keys 8, and of the exchangeable roll segment 2, the bottom part of which is set coaxially and centred on the surface of the base roll segment 1, whereas the upper part of which is connected with the centre part of the base roll segment 1 by mutually shaped surfaces of both roll segments: the base segment 1 and the exchangeable segment 2 in the form of regular polygons 12. On the base roll segment 1 and the frontal upper part of the exchangeable roll segment 2 a full ring 9 is placed axially, whereas in the base roll segment 1 a split ring 10 is placed axially with a clamping ring 13 for removing and exchanging the exchangeable roll segment 2.

[0015] In another example implementation, an assembly for the forming of seamless rings in a hot ring rolling process, equipped with a main shaft of a segmented design has an external surface of the base roll segment 1, on which the bottom part of the exchangeable roll segment 2 is coaxially set.

Claims

1. A method of forming of seamless rings by process of hot rolling in mills with vertical placement of rolls, where the rolling of a ring consists of increasing, through a forming process, the diameter of a ring-shaped input material while simultaneously shaping the external profile of the input material - a ring, which will be driven by a rotating main roll, is guided by a mandrel roll rotating around its own axis, by forced movement with linear feed at a set speed, moving towards the main roll, whereas conical rolls move in a horizontal movement in accordance with the increase of the ring, and additionally the vertical movement of the upper conical roll enables maintaining a constant height of the ring or reducing the height to a set value, **characterized in that** the main roll, used as a forming tool, with a segment construction consisting of a base roll segment (1) and an exchangeable roll segment (2) centred in its lower part on the surface of the base roll segment (1), where the torque from the base roll segment (1) is transferred to the exchangeable roll segment (2) using a shaped connection of the both segments in the form of a regular polygon (12), placed coaxially in the centre of the base roll segment (1), being used to shape, by rolling on a mill, an external shape of a ring (4), while a mandrel roll (5) creates an internal outline of the ring (4), where by decreasing the wall thickness and the ring (4) height, the ring (4) diameter increases while maintaining a constant volume, whereby the rolling process ends when the ring (4) reaches a desired shape and diameter, moreover the roll segments: base (2) and exchangeable (1) connected by a polygon are locked with bolts (11) using a full ring (9) axially placed on the base roll segment (1) and on

the front upper part of the exchangeable roll segment (2) and a split ring (10) placed in a base roll segment (1), whereas the base roll (1) and exchangeable roll (2) segments are disconnected by using a clamping ring (13) of the split ring (10), where the clamping ring (13) is placed over the split ring (10), and using bolts and nuts the exchangeable roll segment (2) is removed and replaced.

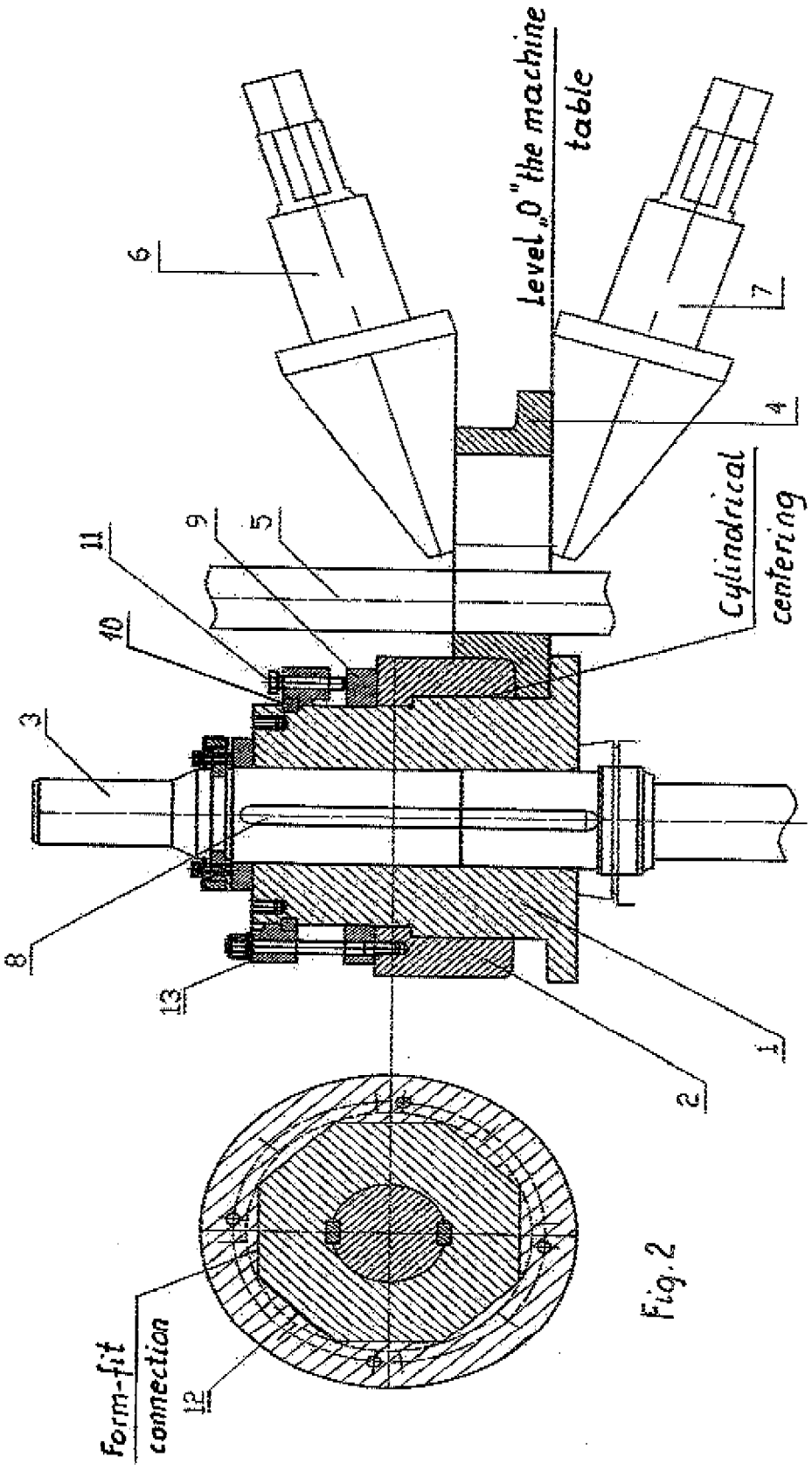
2. A method in accordance with claim 1, **characterized in that** the bottom part of the exchangeable roll segment (2) is set coaxially and centred on a cylindrical surface of the base roll segment (1), shaping an external outline of the ring (4).

3. A method in accordance with claim 1, **characterized in that** the bottom part of the exchangeable roll segment (2) is set coaxially and centred on a conical surface of the base roll segment (1), shaping an external outline of the ring (4).

4. An assembly for the forming of seamless rings on mills for hot rolling of rings with vertical placement of rolls, equipped with a rotationally driven main roll and mated mandrel roll used to place the rolled input material - a ring, with two independently driven conical rolls and with centric rolls, moving over the radius of the shaped input material - the ring and maintaining its geometry, **characterized in that** the main roll is a shaping tool with a segmented construction, which is composed of a base roll segment (1), placed on the mill's drive shaft (3), where the transmission of the torque from the drive shaft (3) to the base roll segment (1) occurs through the use of rectangular keys (8), and of an exchangeable roll segment (2), the bottom part of which is set coaxially and centred on the surface of the base roll segment (1), whereas the upper part of which is connected with the centre part of the base roll (1) segment by mutually shaped surfaces of both roll segments: the base segment (1) and the exchangeable segment (2), in the form of regular polygons (12), moreover on the base roll segment (1) and the frontal upper part of the exchangeable roll segment (2) a full ring (9) is placed axially, whereas in the base roll segment a split ring (10) is placed axially with a clamping ring (13) for removing and exchanging the exchangeable roll segment (2).

5. An assembly in accordance with claim 4, **characterized in that** the external surface of the base roll segment (1), on which the bottom part of the exchangeable roll segment (2) is set coaxially has the shape of a cylinder.

6. An assembly in accordance with claim 4, **characterized in that** the external surface of the base roll segment (1), on which the bottom part of the exchangeable roll segment (2) is set coaxially has the shape of a cone.


Level „0" the machine table
Cylindrical centering
Form-fit connection
1
2
3
4
5
6
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9
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12
13

Fig. 1

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 21 46 0019

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 July 2021	Ritter, Florian

CATEGORY OF CITED DOCUMENTS

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