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(54) Title: DEVICE FOR PRODUCTION OF A SEAMLESS HOLLOW BODY FROM STEEL

(54) Bezeichnung: VORRICHTUNG ZUM HERSTELLEN EINES NAHTLOSEN HOHLKÖRPERS AUS STAHL

(57) Abstract: The invention relates to a device for the production of a seamless hollow body (10) from a solid round block (7) of steel with a diameter < 95 % of the diameter of the solid round block by means of a twin-roller cross-rolling mill on a mandrel plug (3) held between the cross rollers (1), comprising a piercing piece (5) and at least one finishing piece (4) using pass-closing guides or with a three roller cross rolling mill on a mandrel plug held between the cross rollers, comprising a piercing piece and at least one finishing piece, whereby the separation of the rollers is adjusted in a particular manner at the narrowest cross-section in relation to the diameter (2) of the round block employed and the position of the piercing mandrel in relation to the narrowest cross-section of the rollers.

(57) Zusammenfassung: Die Erfindung betrifft eine Vorrichtung zum Herstellen eines nahtlosen Hohlkörpers (10) aus einem massiven Rundblock (7) aus Stahl mit einem Durchmesser < 95 % des massiven Rundblockdurchmessers durch ein Zwei-Walzen-Schrägwalzwerk über einen zwischen den Schrägwalzen (1) gehaltenen einen Lochungsteil (5) und mindestens einen Glätteteil (4) aufweisenden Lochdorn (3) unter Verwendung von kaliberschließenden Führungen, bzw. durch ein Drei-Walzen-Schrägwalzwerk über einen zwischen den Schrägwalzen gehaltenen einen Lochungsteil und mindestens einen Glätteteil aufweisenden Lochdorn, wobei der Abstand der Walzen im engsten Querschnitt (2) in Relation zum Durchmesser des eingesetzten Rundblockes und die Lage des Lochdornes in Bezug auf den engsten Querschnitt der Walzen in bestimmter Weise eingestellt ist.



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METHOD OF MAKING A SEAMLESS HOLLOW BODY FROM STEEL

Description

The invention relates to a method for making a seamless hollow body from steel.

The manufacture of a seamless hollow body from a solid round block of steel typically involves cross rolling by which a piercing mandrel is held between the inclined rolls to so adjust the round block that the roll distance is smaller in the narrowest cross section by 10-12% than the diameter of the used round block.

The piercing mandrel is positioned with its piercing piece upwardly of the narrowest cross section of the rolls. This plane is also called 'high point'.

The tip of the piercing mandrel is thus positioned before the plane of the smallest roll distance (plane "high point") such that the produced hollow block is free of any internal flaws. The smoothing part and the expansion part of the piercing mandrel (if present) are located behind of the 'high point'. More details are described in "Bänder, Bleche, Rohr 6" [*Strips, Metal Sheets, Tubes 6*], (1965) No. 4, pp. 1840189.

According to this known process, the hollow block diameters range between 5% smaller and significantly greater ($\geq 20\%$) than the diameter of the used solid round block.

The known process is unsuitable to provide a greatly reducing piercing with the hollow block being free of flaws. Internal flaws are encountered in particular when extruded round blocks are involved.

It would thus be advantageous to provide an apparatus for making a seamless hollow body from a solid round block of steel by means of cross rolling, by which extruded round blocks can be pierced also with a diametric reduction of $> 5\%$ in the absence of any internal flaws.

In accordance with the invention, there is provided a method of making a seamless hollow body from a solid round block of steel with a diameter $< 95\%$ of the solid round block diameter, by means of a two-roll cross rolling mill with a piercing mandrel held between the inclined rolls and including a piercer and at least one smoothing part, while using pass-closing guides, wherein the distance of the rolls in the narrowest cross section is adjusted in relation to the diameter of the used round block, and the position of the piercing mandrel is adjusted in relation to the narrowest cross section of the rolls, wherein the incoming solid round block maintains anteriorly of the tip of the piercing mandrel a forming limit X which is dependent on the deformability of the used steel, on the adjusted transport angle as well as on the run-in angle of the rolls, and the tool distances are determined in good approximation ($<3\%$) on the basis of the equations

$$\text{Roll distance} = \text{diameter hollow block} - 0.075 \times \text{diameter round block}$$

$$\text{Guide distance} = \text{diameter hollow block} + 0.075 \times \text{diameter round block}$$

wherein the forming limit X is defined as $(1 - \text{roll distance at the position mandrel tip to diameter of the round block})$ in %.

In accordance with the invention, there is provided a method of making a seamless hollow body from solid round block of steel with a diameter $< 95\%$ of the solid round block diameter, by means of a three-roll cross rolling mill with a piercing mandrel held between the inclined rolls and including a piercer and at least one smoothing part, while using pass-closing guides, wherein the distance of the rolls in the narrowest cross section is adjusted in relation to the diameter of the used round block, and the position of the piercing mandrel is adjusted in relation to the narrowest cross section of the rolls, wherein the incoming solid round block maintains anteriorly of the tip of the piercing mandrel a forming limit X which is dependent on the deformability of the used steel, on the adjusted transport angle as well as on the run-in angle of the rolls, and the tool distances are determined in good approximation ($<3\%$) on the basis of the equation

$$\text{Roll distance} = \frac{3}{2} \times \text{diameter hollow block} - \frac{1}{2} \times \text{diameter round block}$$

wherein the forming limit X is defined as (1 - roll distance at the position mandrel tip to diameter of the round block) in %.

According to the teaching of the invention, the extent of the constriction (ratio roll distance to block diameter cold) is not the crucial factor for realizing a piercing that is free of internal flaws; rather it is maintaining a material-dependent and rolling-mill-dependent deformation anteriorly of the mandrel tip. The variables of block and hollow block diameters provide the basis for calculating the guide and/or roll distance according to the given equations. As a result, the position of the mandrel tip is determined with the aid of the deformation limit to be observed anteriorly of the mandrel tip.

Tests have shown that the forming limit X rises as the transport angle increases and the run-in angle decreases. The material dependency is governed by the deformability of the used steel. When simple carbon steels are involved, the forming limit X is greater in comparison to a 13% chrome steel that is hard to shape.

It has been further shown that the ascertained forming limit must be corrected with a correction factor in dependence of the cone angle, with the cone angle being defined as the angle between rolling stock and rolling axis, when the transport angle is zero degree.

When the cone angle is zero degree (barrel piercer), the correction factor is equal 1 and increases above 1 up to a value <1.3, as the positive cone angle (cone piercer) increases.

When using a three-roll cross rolling mill, the same dependencies hold true, as described above, with the difference residing only in the increase of the forming limit X by at least the factor 1.2 in comparison to a two-roll cross rolling mill.

The configuration of the tools is now a compromise between roll run-in length, roll run-in angle, mandrel length and position of the mandrel tip with consideration of the marginal production parameters.

On one hand, it must be taken into account that the smoothing part of the piercing mandrel has to commence directly at the 'high point' or even in the run-in portion of the inclined roll. On the other hand, a selected roll pass should permit, if possible, the whole range of required shaping because an exchange of inclined rolls is time consuming.

The process according to the invention closes the gap between the currently employed procedure and the process protected in DE 33 269 46 C1 and is applicable for a two-roll cross rolling mill as well as for a three-roll cross rolling mill without guides. DE 332 69 46 C1 discloses for the manufacture of in particular thin-walled hollow bodies without internal flaws and little eccentricity an adjustment of the inclined rolls to a distance in the range of 75 to 60% and an adjustment of the guides to a distance in the range of 85 to 70% of the diameter of the used round block.

The equations for calculating the roll and guide distances are as follows:

Two-roll cross rolling mill:

Roll distance = diameter hollow block - 0.075 x block diameter

Guide distance = diameter hollow block + 0.075 x block diameter

Three-roll cross rolling mill:

Roll distance = $\frac{3}{2}$ x diameter hollow block - $\frac{1}{2}$ x block diameter

As the individual cross rolling mill types and the material to be pierced differ in their flow behavior, the afore-mentioned equations are adequate to be able to check the possibilities to manufacture desired hollow blocks and to configure rolls

and the piercing mandrel with good approximation. Good approximation relates hereby to a deviation of < 3 % of the hollow block diameter.

It is essential that fine tuning permits a change in roll and guide distances as well as piercing mandrel shape, while preventing at the same time that the mandrel tip does not exceed the critical decrease. The forming limit X anteriorly of the mandrel tip is defined as

$$X = \left(1 - \frac{\text{Roll Distance} \tan d(\text{PositionMandrelTip})}{\text{DiameterRoundBlock}}\right)\%$$

As already stated, the permitted variable X depends on the rolling mill and the material to be pierced. It is recommended to select this variable such that all materials are pierced with the same variable.

The advantage of the proposed method for rolling mills that predominantly produce seamless tubes of up to 200 mm diameter resides in that formats that can be extruded can be used as starting material. Normally, the same roll pass allows piercing from greatly reduced to slightly expanding. As a result, the number of the required round block formats can be significantly reduced.

In this manner, a hollow block with a diameter of 186 mm may, for example, be manufactured from a round block of 220 mm diameter. Normally, this would have required a round block with 180 mm diameter and a slight widening thereof. Or, a hollow block could have only been produced from a round block of 220 mm diameter with slight reduction.

An example for the determination of the roll and guide distances while maintaining a particular forming limit X will now be described.

A hollow block having the dimensions 186 x 20 mm should be produced from a round block of a grade of steel ST 52 with a diameter of 220 mm, using a two-roll cross rolling mill. The ratio of hollow block diameter to round block diameter establishes a value of $\frac{186}{220}=0.84$, which, as stated, is far below the currently typical value of a minimum of 0.95. The two-roll cross rolling mill uses in this example a barrel piercer with side guards.

As outlined above, this means that the correction factor is equal 1. The transport angle is 10° and the run-in and run-out angles are at 3.5° . This results in a forming limit value X of 6 %. As the diameter of the round block is 220 mm, a roll distance is realized at the position of the mandrel tip of 206.8 mm.

The roll distance in the 'high point' is $186 \text{ mm} - 0.075 \times 220 = 169.5 \text{ mm}$, and the guide distance is $186 \text{ mm} + 0.075 \times 220 = 202.5$.

The apparatus according to the invention will be described with reference to a schematic length section. The present half-side length section shows only the upper double-conical inclined roll 1 of the cross rolling mill. The pertaining second inclined roll as well as the pass-closing guides, be it side guards or Diescher disks, that are situated in the other plane of the two-roll cross rolling mill have been omitted for the sake of simplicity.

The plane of the narrowest cross section 2 of the inclined rolls, designated as "high point", is characterized by a dashed line.

Clearly shown is the otherwise uncommon disposition of the piercing mandrel 3 in the first example (**Figure 1**). The end of the smoothing part 4 is situated before of the 'high point' 2 and thus also the piercer 5. The mandrel tip 6 assumes hereby a position which ensures that the stated forming limit X is maintained in the run-in zone of the round block, and the round block 7 is pierced free of flaws.

Characteristic is the great diameter reduction from diameter 8 of the round block 7 to the diameter 9 of the hollow block 10.

When the run-in angle of the roll is changed, as illustrated in the second example (Figure 2), it can be shown that a respective hollow block with reduced diameter can be produced, when the smoothing part of the piercing mandrel is positioned behind the 'high point', while maintaining the permitted deformation before the mandrel tip. According to the illustration of Figure 3, the greater run-in angle causes a slightly smaller forming limit X.

Figure 4 shows the dependency of the correction factor from the cone angle.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Method of making a seamless hollow body from a solid round block of steel with a diameter < 95% of the solid round block diameter, by means of a two-roll cross rolling mill with a piercing mandrel held between the inclined rolls and including a piercer and at least one smoothing part, while using pass-closing guides, wherein the distance of the rolls in the narrowest cross section is adjusted in relation to the diameter of the used round block, and the position of the piercing mandrel is adjusted in relation to the narrowest cross section of the rolls, wherein the incoming solid round block maintains anteriorly of the tip of the piercing mandrel a forming limit X which is dependent on the deformability of the used steel, on the adjusted transport angle as well as on the run-in angle of the rolls, and the tool distances are determined in good approximation (<3%) on the basis of the equations

$$\text{Roll distance} = \text{diameter hollow block} - 0.075 \times \text{diameter round block}$$

$$\text{Guide distance} = \text{diameter hollow block} + 0.075 \times \text{diameter round block}$$

wherein the forming limit X is defined as (1 - roll distance at the position mandrel tip to diameter of the round block) in %.

2. Method of making a seamless hollow body from solid round block of steel with a diameter < 95% of the solid round block diameter, by means of a three-roll cross rolling mill with a piercing mandrel held between the inclined rolls and including a piercer and at least one smoothing part, while using pass-closing guides, wherein the distance of the rolls in the narrowest cross section is adjusted in relation to the diameter of the used round block, and the position of the piercing mandrel is adjusted in relation to the narrowest cross section of the rolls, wherein the incoming solid round block maintains anteriorly of the tip of the piercing mandrel a forming limit X which is dependent on the deformability of the used steel, on the adjusted transport angle as well as on the run-in angle of the rolls,

and the tool distances are determined in good approximation (<3%) on the basis of the equation

Roll distance = $\frac{3}{2}$ x diameter hollow block - $\frac{1}{2}$ x diameter round block
wherein the forming limit X is defined as (1 - roll distance at the position mandrel tip to diameter of the round block) in %.

3. Method according to claim 1 or 2, wherein the forming limit X rises as the transport angle increases and the run-in angle decreases.
4. Method according to any one of claims 1-3, wherein the forming limit X lessens as the deformability decreases.
5. Method according to any one of claims 1-4, wherein the determined forming limit X is to be corrected by a correction factor in dependence of the cone angle, with the cone angle being defined as the angle between rolling stock and rolling axis, when the transport angle is zero degree.
6. Method according to claim 5, wherein the correction factor is equal 1, when the cone angle is zero degree, and the correction factor is greater 1 up to a value <1.3, as the positive cone angle increases.
7. Method according to any one of claims 2-6, wherein the forming limit X is greater at least by a factor 1.2 in a three-roll cross rolling mill at otherwise same dependencies, compared to a two-roll cross rolling mill.
8. Method according to any one of claims 1-6, wherein the smoothing part of the piercing mandrel begins at the 'high point', when the wall thicknesses is \leq 10% of the hollow block diameter as viewed in rolling direction.

9. Method according to any one of claims 1-7, wherein the smoothing part of the piercing mandrel is situated in the run-in portion of the inclined rolls.

10. A method of making a seamless hollow body, substantially as herein described with reference to the accompanying figures and as exemplified in the accompanying example.

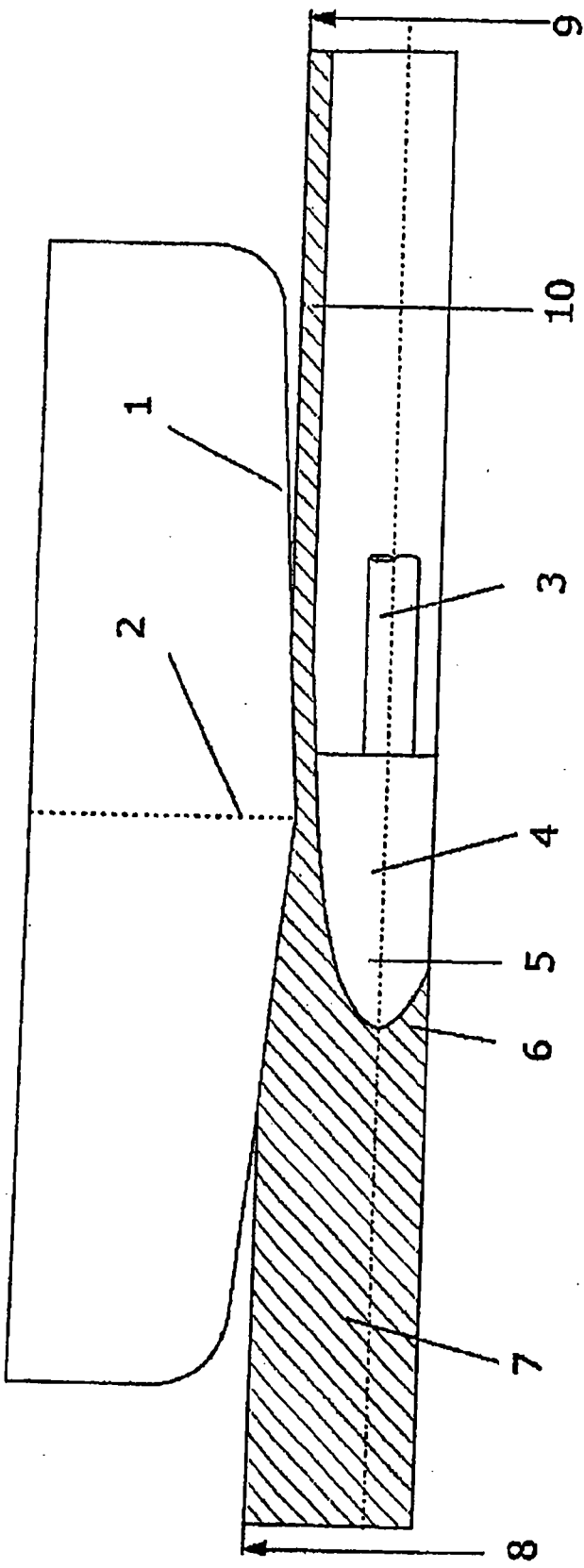


Fig. 1

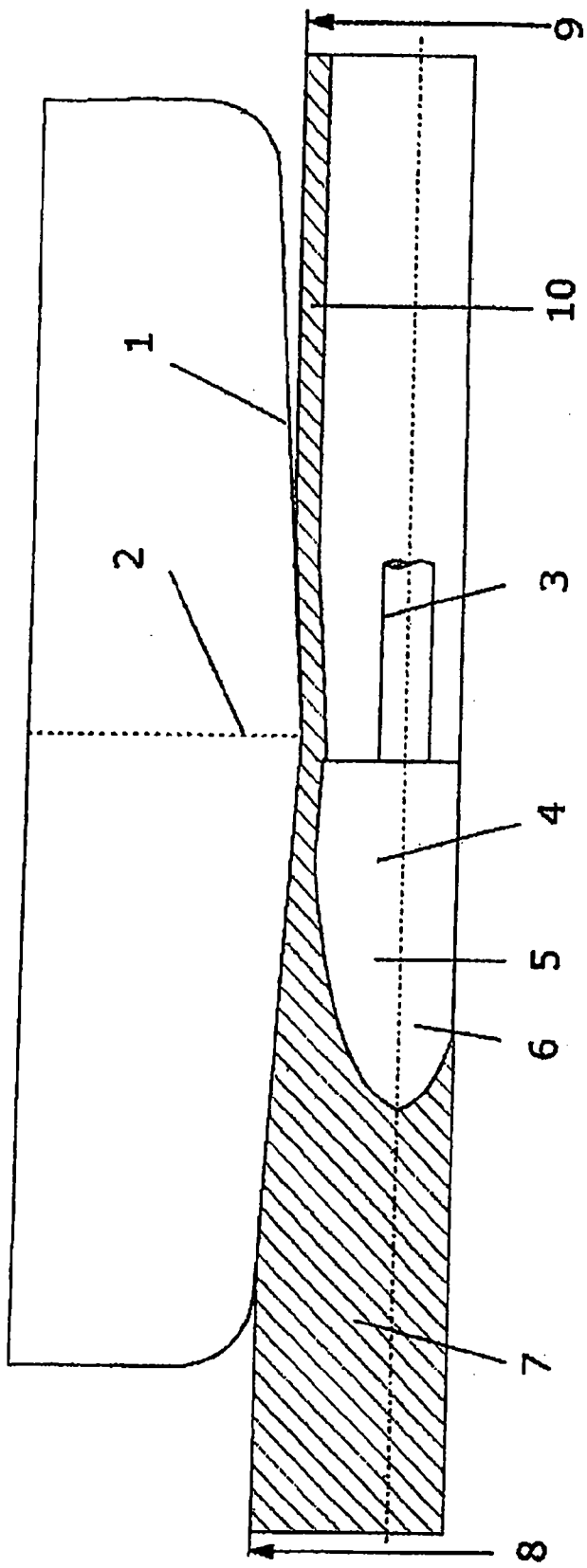


Fig. 2

FIG. 3

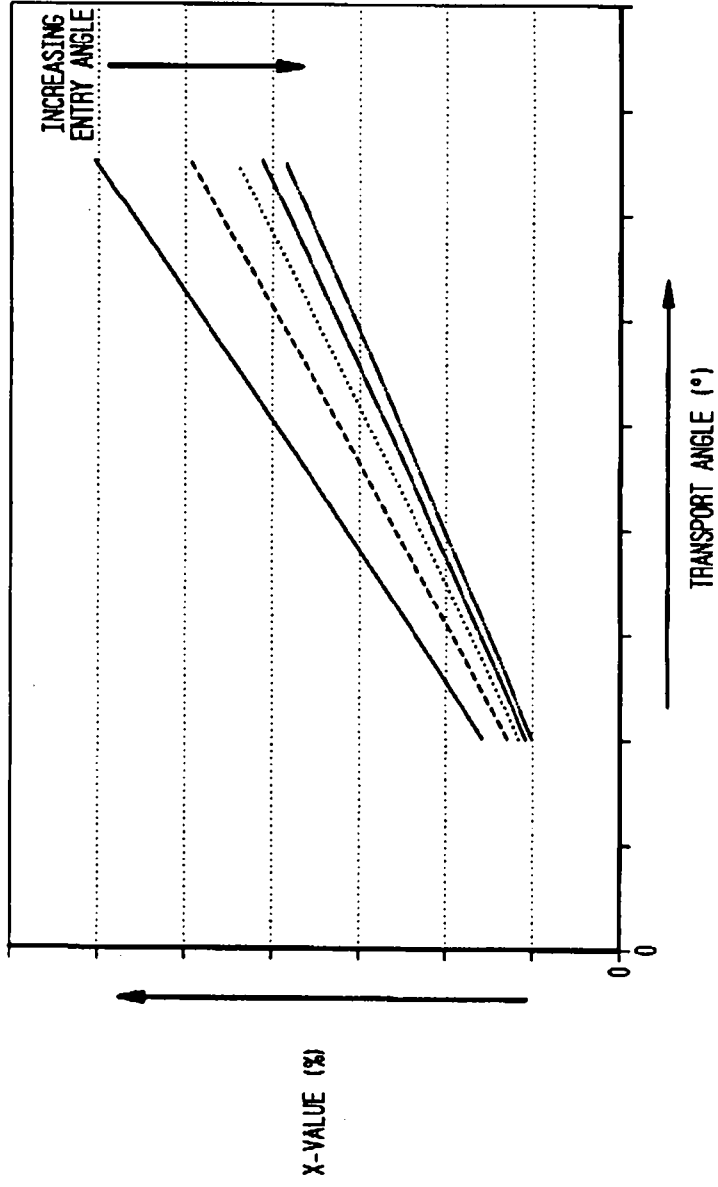


FIG. 4

