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(54) Title: METHOD FOR PRODUCING A LARGE STEEL TUBE

(54) Bezeichnung: VERFAHREN ZUM HERSTELLEN EINES GROSSEN STAHLROHRES

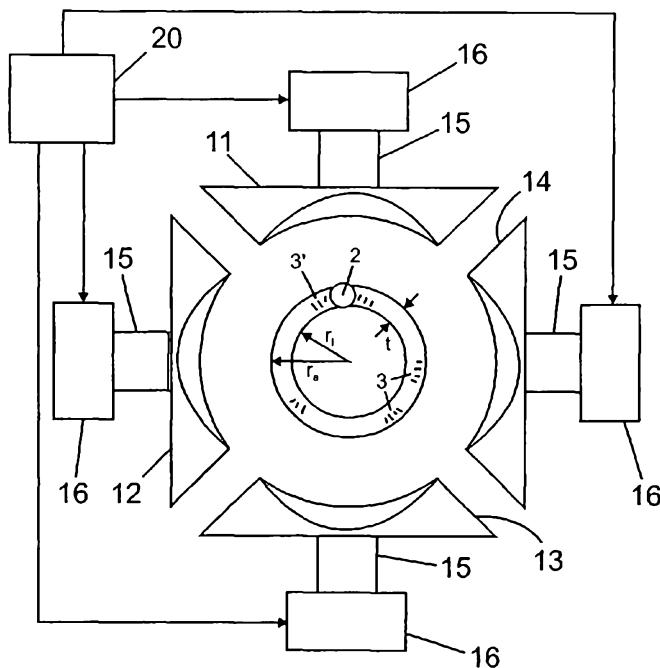


Fig. 1

schen Eigenschaften des Werkstoffs verbessert.

(57) Abstract: The invention relates to a method for pro-
ducing a steel tube, wherein a steel sheet (4) is formed into
tubular body (1.2) having a round cross section in a bending
process (a), welded in a subsequent welding process (b)
along the longitudinal edges facing each other for pro-
ducing a continuous longitudinal seam, and then subjected
to a stress-relieving treatment. The production quality is
improved, with reduced production time, in that the stress-
relieving treatment is performed in a process (c) for con-
centrically truing along the circumference in at least one
segment relative to the longitudinal axis thereof, while
cold forming by compression (Fig. 1). The mechanical
technological properties of the material are also thereby
improved.

(57) Zusammenfassung: Die Erfindung bezieht sich auf
ein Verfahren zum Herstellen eines Stahlrohres, bei dem
eine Blechplatte (4) in einem Biegevorgang (a) zu einem
im Querschnitt runden Rohrkörper (1.2) eingeformt, in ei-
nem nachfolgenden Schweißvorgang (b) entlang den ein-
ander zugewandten Längskanten zum Herstellen einer
durchgehenden Längsnaht geschweißt und anschließend
einer Entspannungsbehandlung unterzogen wird. Die Fer-
tigungsqualität bei verkürzter Herstellungszeit wird da-
durch begünstigt, dass die Entspannungsbehandlung in ei-
nem Vorgang (c) zum Rundrichten entlang dem Umfang
in zumindest einem Abschnitt bezüglich seiner Längsachse
unter Kaltverformung durch Stauchen vollzogen wird
(Fig. 1). Damit werden auch die mechanisch technologi-



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METHOD FOR PRODUCING A LARGE STEEL TUBE

[0001] The invention relates to a method for producing a steel tube, in which a metal sheet or coil is formed in a bending process to a tubular body of round cross section, is welded in an ensuing welding process along the longitudinal edges facing one another to produce one continuous seam, and is then subjected to a stress-relieving treatment.

[0002] One method of this type is described in German Patent Disclosure DE 10 2006 010 040 B3. In this known method, the tube is compressed by means of a straightening machine from the outer circumference, by means of a plurality of welding devices, offset in the circumferential direction and located at an identical location in the axial direction, for concentric straightening, and the welding devices have straightening shells adapted to the shape of the outer cross section of the tube. The straightening shells can be driven, for instance hydraulically, individually or in dependence on one another, and the actuation can be done by open- or closed-loop control. Via the closed-loop control axes, the straightening cylinders, with the straightening shells, can straighten the tube until its contour is circular, and the calibration is done with respect to the diameter and/or the ovality. Upsetting of the material past the elongation limit is also possible by means of what is called here for the first time impansion.

[0003] European Patent Disclosure EP 0 438 205 A2 shows a method and an apparatus for straightening the ends of elongated workpieces. With the workpiece at a standstill, at least one cross section, sought in the end region, is subjected to an alternating increasing and decreasing bending stress, and a predetermined maximum sag extends around the workpiece axis once or multiple times. An alternating increasing and decreasing bending stress is selected such that the cross section sought is deformed into the plastic range. The means for generating a deflection of the workpiece axis into an orbit past the limit of elasticity of the workpiece have at least three tappets, movable in the radial direction and disposed symmetrically about a common axis, which are each connected to a travel- and time-dependently controllable piston-cylinder unit, and the tappets, as a result of a controlled linkage of the piston-cylinder units to one another, execute a sinusoidal reciprocating motion in phase-offset fashion during the straightening process. In this case, straightening is not effected with regard to roundness or ovality; instead, a correction is made of deviations in rectilinearity of the crooked ends; that is, what happens is longitudinal straightening.

[0004] With a straightening machine for tubes shown in French Patent Disclosure FR 737 123 A, these tubes are also straightened in their longitudinal direction, specifically in the warm state. Here, two opposed straightening elements, which between them receive the tube and can be pressed against one another by means of a lever mechanism with a drive, extend over the entire length of the tube. The straightening elements are for instance rounded in accordance with the diameter of the tube, and the inner part of the straightening elements can be replaceable. Before the straightening process, the tubes are heated to the red-hot state and are evacuated. After the thus-performed longitudinal straightening, the tubes are delivered by means of an ejector to a cooling device. Straightening large steel tubes, in particular, by such provisions is complicated, and problems and solutions for concentric straightening are not found in this reference.

[0005] In German Patent Disclosure DE 196 02 920 A1, a method for producing tubes, in particular large tubes, is disclosed in which the tubes are calibrated and straightened by cold widening (expansion) after the seam welding on the inside and outside.

[0006] German Patent Disclosure DE 41 24 689 A1 shows a method and an apparatus for eliminating shape errors and diminishing harmful intrinsic stresses in the longitudinal seam of welded extruded tubes, also by widening the tube, for which purpose a widening mandrel located on the inside is employed. The widening of the extruded tube is done to such an extent that intrinsic stresses present in the circumferential direction are meant to be diminished as much as possible.

[0007] In straightening tubes, nonuniformities in the tube shape, such as local ovality on the tubular body, are corrected by local shaping of material. Stress is not diminished uniformly by way of the tube jacket, in particular the tube circumference. Instead, additional, undefined stresses are generated in the material by means of the known local ovality corrections. Although a target diameter can be established at relatively great effort in this way, with the straightening, nevertheless a uniform upsetting strength of the material over the circumference of the tube, in particular, fails to be achieved.

[0008] In the expansion method, the tools generate a uniform force on the inside of the tube, and in the concentric straightening, this puts the material uniformly into a circular shape. In this operation, however, unfavorable stress states can be created in the tubular body, and as a result the upsetting strength and hence the resistance to collapsing of the pipeline may lessen. In coated

tubes (so-called clad tubes), damage to the material can also occur, so that such tubes can often not be calibrated by this method. Such adverse effects can be further amplified with an increasing degree of expansion.

According to a first aspect a method is disclosed for producing a steel tube, in which a metal sheet or coil is formed in a bending process to a tubular body of round cross section. The tubular body is then welded in an ensuing welding process along the longitudinal edges facing one another to produce one continuous seam. The tube is then subjected to a stress relieving treatment, wherein the stress-relieving treatment is performed in an operation for concentric straightening along the circumference in at least one portion with respect to its longitudinal axis, with cold forming by upsetting.

[0010] In concentric straightening, the stress-relieving treatment is performed with cold forming by upsetting, along the circumference of at least in some portions with respect to the longitudinal axis of the tube.

[0011] Not only may the target diameter be established properly, but in the process of the concentric straightening, a stress-relieving treatment may be done. In this way, not only may the tube tolerance, especially the ovality, be improved in a short time by means of uniform plastic deformation of the material, but the intrinsic stress performance of the tubular body may also be improved as well. Not only are the stresses generated by forming the sheet-metal material mechanically in the fundamental material reduced, but the thermally created stresses caused by the longitudinal seam welding of the sheet-metal material formed to make the tube may be diminished as well. Overall, the mechanical-technological properties of the tube may be improved by the method, namely the upsetting strength and the collapsing resistance, for example. As calculations in the context of research and development work have proven, the intrinsic stress performance after impansion, depending on the degree of impansion, is reduced to a minimum, and diminishing stress practically completely is made possible, without requiring a complicated heat treatment (low-stress annealing, for instance at approximately 600°C), and advantages arising from the heat treatment can be avoided. Because of the uniform upsetting over the outer surface of the tube, the intrinsic stresses generated by the production process may diminish in the longitudinal and circumferential directions in the basic material and in the welded seam. As experiments by the inventors have shown, one reason for the improvements is evidently that the residual stress state is reversed; that is, after the impansion, there is tensile

stress on the inside of the tube and compressive stress on the outside of the tube. With raw materials plated on the inside, the impansion from outside provides additional advantages, since the vulnerable inside surface is not damaged or strained. As a result, there is no lessening of the corrosion properties of the internal material. In coating materials, for instance from alloy 625, the corrosion resistance is even improved from internal residual stresses.

[0012] In one embodiment the concentric straightening, plastic deformation of the tubular body is done over its entire circumference.

[0013] In another embodiment, in the concentric straightening, an adjustment is made to predetermined outside tube diameters or predetermined inside tube diameters.

[0014] In a further embodiment, intrinsic stress performance of the tubular body may be improved through the provision that in the concentric straightening for stress relief, upsetting in the circumferential direction and hydraulic stress relief (for instance with a hydrotester) are combined with one another. The impansion and hydraulic stress relief can also be done in a controlled way multiple times in alteration.

[0015] In another embodiment, the concentric straightening and the stress relief processes are moreover promoted by the fact that the concentric straightening and stress relief may be performed by means of at least two and in particular at least three welding devices, offset in the circumferential direction and pressing from outside in the radial direction toward the tube axis, that have straightening shells which in some portions are adapted to the circumferential contour of the tube.

[0016] According to a second aspect, a tube with desirable properties may be obtained by being produced by one of the aforementioned procedures.

An advantage of the method according to at least one embodiment is that it provides for the production of large steel tubes with which the manufacture of high-quality tubes may be achieved with precise concentric straightening and shorter production times. The method may also furnish correspondingly embodied tubes, in which the mechanical-technological properties of the material are also to be improved.

[0017] The disclosure will be described below in terms of exemplary embodiments in conjunction with the drawings. In the drawings:

[0018] Fig. 1 shows a tube, disposed in a concentric straightening machine, in a schematic cross-sectional view; and

[0019] Fig. 2 is a schematic view of steps in manufacturing a tube.

[0020] Fig. 1 in an axial plan view shows a tube 1 of round cross section, with an inner radial r_i and an outer radius r_a , the difference between which defines a wall thickness t . The tube 1 has a longitudinally extending welded seam 2. In the tube wall, mechanical and thermal stress regions 3, 3' are present, on the one hand as a consequence of the mechanical forming process and on the other as a consequence of the influence of heat in the welding.

[0021] The straightening machine or straightening device 10 has a plurality of welding devices, distributed uniformly in the circumferential direction and disposed at an identical location in the axial direction, each with respective straightening shells 11, 12, 13, 14, which are mounted replaceably each on their own holder 15 and are provided, on their side toward the tube 1, with a surface form adapted to the surface contour of the tube 1, which surface form extends in the circumferential direction along the tube surface, so that when all the straightening shells are in contact, the tube surface is largely surrounded in the circumferential direction. In the axial direction, conversely, the straightening shells 11, 12, 13, 14 extend over only a short portion of the tube 1, and a plurality of such units comprising straightening shells 11, 12, 13, 14 can be disposed in the longitudinal direction of the tube 1, over its outer surface. Because of the replaceability, straightening shells adapted to different tube diameters can easily be inserted or changed. The holders 15 of the straightening shells 11, 12, 13, 14 are adjusted hydraulically along a closed-loop control axis 17 in the radial direction, oriented toward the center of the tube 1, in the support 16, in order to accomplish upsetting of the tubular body and hydraulic stress relief in the opposite direction, with open- or closed-loop control by means of a regulating device 20. Straightening to predetermined inside or outside diameters can be done, and an absolute position can be predetermined via the regulating device.

[0022] Fig. 2 shows essential steps in the production of the tube 1, namely a forming process *a*, in which a sheet-metal plate 4 is gradually shaped, by means of a forming device 30 by forming tools, with advancement of the sheet-metal plate 4, into a bent portion 1.1 and finally into the tubular body 1.2 bent all the way around. Next, the tubular body 1.2, on its edges facing one another, which have been prepared beforehand for the welding, are closed in a welding process *b* by means of a longitudinal welded seam in a welding device 40. As a result of the forming processes and the welding, mechanical and thermal stress regions 3, 3' are created, as mentioned above. Next, possibly after further processing and/or monitoring steps have been performed, a

straightening process *c* with concentric straightening of the tube 1 is done, in which at the same time a stress-relieving treatment also takes place. The stress-relieving treatment can additionally be combined in an ensuing step *d* with hydrostatic stress relief, for instance by means of a hydrotester, in which by means of a pressure medium in the tube interior, an outward-oriented pressure *p* on the inner tube surface is generated.

[0023] In large tubes, that is, those in particular with wall thicknesses $t \geq 9$ mm and diameters $d \geq 300$ mm, for instance up to $t = 80$ mm and $d = 2000$ mm, the concentric straightening with uniform calibration over the circumference is successful with the straightening machine mentioned above, of the kind also shown in DE 10 2006 010 040 B3 mentioned at the outset, with which upsetting of the material in the circumferential direction and concentric straightening with high tolerance requirements are achieved, and upsetting beyond the elongation limit is possible. By plastic deformation in the concentric straightening, stress relief of both mechanical and thermal stress regions 3, 3' can simultaneously be achieved over the entire circumference. As a result, the intrinsic stress performance of the tubular body is improved markedly without an additional heat treatment, and at the same time, negative influences, of the kind that can occur as a result of a heat treatment, for instance in low-stress annealing, are avoided. Thus not only are the stresses caused mechanically by the forming of the sheet-metal material reduced, but the thermally generated stresses caused by the longitudinal seam welding are also diminished, and the plastic deformation of the tubular body 1.2 takes place over the entire tube circumference. The concentric straightening with the stress-relieving treatment is achieved by cold forming.

[0024] By the combination of the impansion and hydraulic stress relief with open- or closed-loop control via the regulating device 20, the stress relief process can be varied in a targeted way. At the same time, outside tube diameters or inside tube diameters can be adjusted in a targeted way to predetermined values. By means of this method, the mechanical-technological properties, such as strength and thermal expansion coefficient of the raw material, can be favorably affected in a targeted way. Moreover, the collapsing performance of the tube and the properties under fatigue strains are improved. Overall, high-quality, practically stress-free tubes with high tube tolerances can be manufactured in a markedly shorter time than in conventional production processes. As has been proven in research and development work by calculations, the intrinsic stress performance after the impansion, depending on the degree of impansion, can be reduced to a minimum, and diminishing stress entirely is even possible.

[0025] The above references to the background art do not constitute an admission that the art forms part of the common general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the method for producing a steel tube and steel tube produced by said method as disclosed herein.

[0026] In the claims which follow, and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word “comprise” and variations such as “comprises” or “comprising” are 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 method for producing a steel tube and steel tube produced by said method as disclosed herein.

Claims

1. A method for producing a steel tube, in which a metal sheet or coil is formed in a bending process to a tubular body of round cross section, is welded in an ensuing welding process along the longitudinal edges facing one another to produce one continuous seam, and is then subjected to a stress relieving treatment,

wherein the stress-relieving treatment is performed in an operation for concentric straightening along the circumference in at least one portion with respect to its longitudinal axis, with cold forming by upsetting.

2. A method for producing a steel tube as claimed in claim 1, wherein in the concentric straightening, a plastic deformation of the tubular body is performed over the entire circumference thereof.

3. A method for producing a steel tube as claimed in claim 1 or 2, wherein in the concentric straightening, an adjustment to predetermined outside tube diameters or predetermined inside tube diameters is effected.

4. A method for producing a steel tube as claimed in any one of the preceding claims, wherein in the concentric straightening, for stress relief, upsetting in the circumferential direction and hydraulic stress relief are combined with one another.

5. A method for producing a steel tube as claimed in any one of the preceding claims, wherein the concentric straightening and stress relief are performed by means of at least two and in particular at least three welding devices, offset in the circumferential direction and pressing from outside in the radial direction toward the tube axis, that have straightening shells adapted in some portions to the circumferential contour of the tube.

6. A tube which is produced by the method as claimed in any one of the preceding claims.

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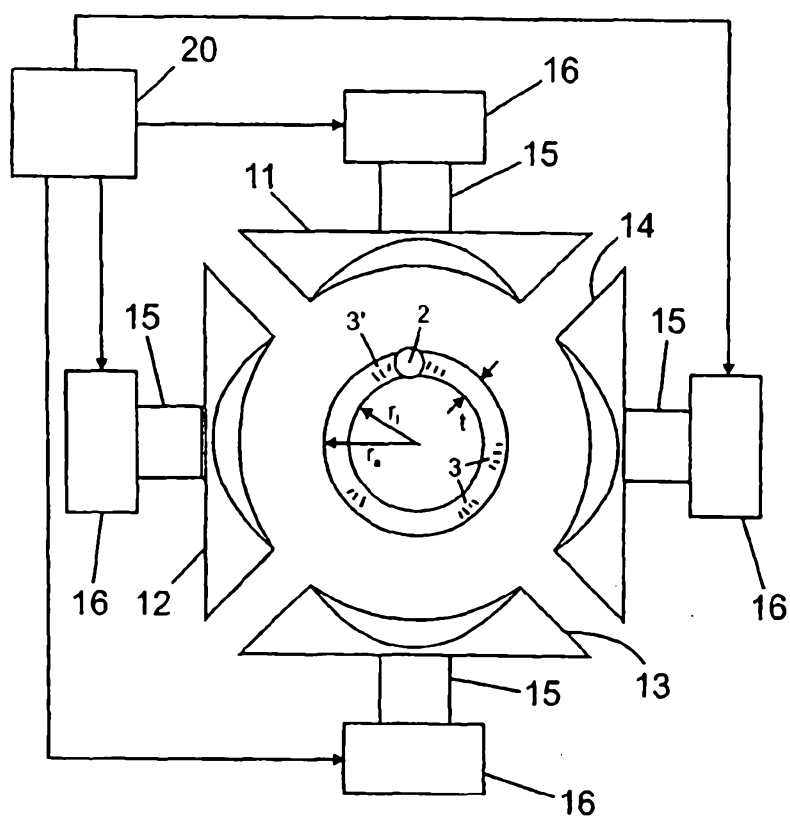


Fig.1

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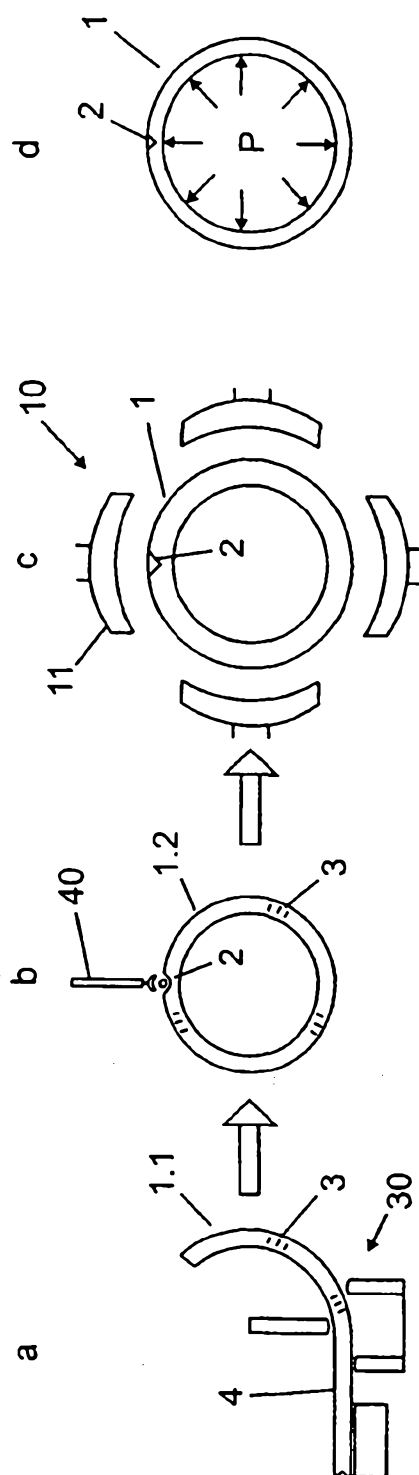


Fig.2