EUROPEAN PATENT SPECIFICATION

Method of manufacturing metallic bent pipe.

Priority: 03.09.82 JP 152655/82

Date of publication of application: 14.03.84 Bulletin 84/11

Publication of the grant of the patent: 11.05.88 Bulletin 88/19

Designated Contracting States: BE DE FR GB IT NL

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DE-B-2 546 695
DE-B-2 559 694
GB-A-1 466 500

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Description

This invention relates to a method of manufacturing a metallic bent pipe having tangent portion at both ends of a bent portion, in which a pipe to be bent is guided through an annular heating device with an attached cooling device to heat the pipe at a narrow circular zone, and is then bent by a clamp of a bending arm which grasps the pipe firmly, whereby the ratio between the relative speed between the heating device and the heat energy supplied per unit time is kept substantially constant. They are advantageous in many fields, especially pipe lines under severe conditions, such as nuclear power service, northern-most cold service or slurry transportation service. Such a method is known from EP—A—0 025 929.

From GB—A—1 466 050 a method is known in which a straight pipe to be bent is heat treated throughout in advance of a bending operation, and the pipe is additionally heated and quenched during normal bending procedure. By this known process the bent portion and tangent portions are also heat treated, but certain border portions between the bent portion and tangent portions are annealed at the start and the end of heating. These narrow weakened zones are sometimes harmful for strength and durability of the products. Another conventional method, such as heat treating after bending, requires a two-step process, and it is difficult to equalize the effects of heat treatment. Therefore, there have been few bent pipes heat-treated uniformly throughout said bent and tangent portions. However according to this invention, the above object is achieved by a method according to the pre-characterizing part of claim 1 wherein heat treating the forward straight portion, heat treating and bending of the intermediate portion by applying a bending moment, and heat treating the rear straight portion after removing the bending moment are all processed successively and without interruption so that the said portions of the pipe are heat treated uniformly.

Moreover, from DE—B—2 559 694, it is known that abrupt changes of pipe wall thickness such as bulging, rippling, wrinkling or buckling are prevented by advancing the pipe clamp of the bending arm or retracting the heater slightly. However according to DE—B—2 559 694, it is inevitable that the bending radius is increased in the former case and heating temperature is reduced additionally in the latter. Because the bending radius is formulated as follows:

\[ R = \frac{\Delta s}{\Delta \theta} \]  

(1)

If \( \Delta s \) becomes larger owing to the moving of the heating device or the pipe, and \( \Delta \theta \) is not changed, \( R \) becomes larger, and if the relative speed between the heater and the pipe becomes larger and heating energy supplied is not changed, the heating temperature becomes lower.

In an embodiment of the invention, a pipe to be heat treated and bent is heated at a narrow circular zone, by a circular heating device with a cooling device, such as an induction heater or the like, where the heated zone is moved relative to the pipe by means of moving the heating device and or the pipe in a longitudinal direction and the pipe is bent by a clamp on a bending arm which grasps the pipe firmly, the ratio between the relative speed between the pipe and the heater and amount of heat energy supplied per unit time being kept substantially constant throughout the following three portions, namely the forward straight portion to be heat treated, the intermediate portion to be heat treated and bent, and the rear straight portion to be heat treated.

Fig. 1 is a skeleton diagram showing the state where a metallic bent pipe is bent by a hot pipe bending apparatus convenient for description of the principle of a method of manufacturing a metallic bent pipe in accordance with the invention;

Figs. (1) through 2(8) show the states of heat treatment and bending processing respectively, in the operating order, in accordance with an embodiment of the invention employing the apparatus shown in Fig. 1; and

Fig. 3 illustrates the state where the travelling speed of a pipe and that of a heating means are linearly varied with respect to time while the relative speed therebetween is maintained constant at all times.

Referring now to Fig. 1 which is a skeleton diagram showing the state where a metallic bent pipe is bent by a hot pipe bending apparatus convenient for description of the principle of the invention, reference numeral 1 denotes a pipe to be bent, while reference numeral 2 designates a bent pipe portion formed by bending the pipe 1. A heating device H comprises a high frequency induction heater or the like integrally provided with a cooling device. Reference numeral 3 represents the centre of the heating zone, while reference numeral 4 denotes a bending arm which clamps the front end of the pipe 1 and is rotatable around a pivot 0. Moreover, reference numerals 5, 6 designate guide rollers for supporting and guiding the pipe 1.

Fig. 2 shows the states of heat treatment and bending processing in the operating order in accordance with the embodiment of the invention employing the apparatus shown in Fig. 1, while Fig. 3 illustrates the state where the travelling speed \( w \) of the pipe 1 and the travelling speed \( v \) of the heating device H are linearly varied with respect to time while the relative speed \( v \) therebetween is maintained constant at all times.

In carrying out a preferred embodiment of the invention, in order to apply heat treatment to the straight pipe portion at the front end portion of the pipe 1, the heating device H is previously moved towards the front end of the pipe 1 so as to
be at a required distance from the intersection between the pipe 1 and a perpendiclar to the pipe passing through the pivot 0 and is made to stand by at this position.

The operation is started at this state.

Steps will be described hereunder in due order.

1) A step of moving the pipe 1, with the travel of the heating device H suspended, to effect heat treatment (see Fig. 2(1) and a section a of Fig. 3).

At the above-mentioned standby state, the front end portion of the pipe 1 is inserted in the heating device H as shown in Fig. 2(1). At this state, the heating device H is actuated, and only the pipe 1 is advanced at the relative speed v as shown in the section a of Fig. 3 thereby to heat treat the pipe 1.

2) A step of advancing the pipe 1 while retracting the heating device H in the longitudinal direction of the pipe thereby to heat treat the pipe 1 (see Fig. 2(2) and a section b of Fig. 3).

After the pipe 1 is advanced by a proper distance in the previous step, the travelling speed of the pipe 1 is reduced as shown in the section b of Fig. 3 and at the same time, the heating device H is retracted in the longitudinal direction of the pipe so that the relative travelling speed to the pipe 1 will be v at all times, thereby to heat treat the pipe 1.

3) A step of suspending the travel of the pipe 1 while retracting the heating device H in the longitudinal direction of the pipe thereby to heat treat the pipe 1, and clamping the pipe 1 by a bending arm 4 (see Fig. 2(3) and a section c of Fig. 3).

When the retracting speed of the heating device H reaches the relative speed v as shown in the section c of Fig. 3, the travel of the pipe 1 is suspended, and only the heating device H is retracted in the longitudinal direction of the pipe at the relative speed v to continue the heat treatment. The front portion of the stationary pipe 1 is clamped by the bending arm 4 as indicated by a symbol x in Fig. 2(3).

4) A step of suspending the travel of the heating device H and advancing the pipe 1 as well as applying a bending moment thereto thereby to bend the pipe 1 (see Fig. 2(4) and sections G1 and d of Fig. 3).

When the heating device H being retracted in the previous step further travels at the relative speed v thereby to heat treat a desired straight pipe portion 7 and reaches a position near the intersection between the pipe 1 and the perpendicular for pipe passing through the turning point 0, the travel of the heating device H is suspended as shown in the section G2 of Fig. 3, and at the same time, the pipe 1 is advanced again at the relative speed v by a thrusting force P in order to apply a bending moment to the pipe 1 to bend the same as shown in Fig. 2(4) and the section d of Fig. 3 thereby to form a desired heat treated bent pipe portion 2.

5) A step of suspending the travel of the pipe 1 and heat treating the same while retracting the heating device H in the longitudinal direction of the pipe and releasing the pipe 1 from the clamp of the bending arm 4 (see Fig. 2(5) and sections G2 and e of Fig. 3).

After the bent pipe portion 2 is formed by the previous step, the advance of the pipe 1 is suspended as shown in the section G2 of Fig. 3 and at the same time, the heating device H is retracted at the relative speed v to continue the heat treatment. The front end portion of the pipe 1, clamped by the bending arm 4 in step 3), is released as shown in Fig. 2(5).

6) A step of retracting the heating device H and advancing the pipe 1 to heat treat the same (see Fig. 2(6) and section f of Fig. 3).

When a predetermined time has passed after the retraction of the heating device H at the relative speed v in the previous step, the travelling speed of the heating device H is reduced as shown in the section f of Fig. 3, and at the same time, the pipe 1 is heat treated while being advanced so that the relative travelling speed to the heating device H will be v at all times, as shown in Fig. 2(6).

7) A step of suspending the travel of the heating device H and advancing the pipe 1 to heat treat the same (see Fig. 2(7) and a section g of Fig. 3).

When the retraction of the heating device H in the previous step is suspended, the pipe 1 is advanced at the relative speed v as shown in Fig. 2(7) and the section g of Fig. 3. When a desired heat treated straight pipe portion 8 is obtained, the travel of the pipe 1 is suspended and also the operation of the heating device H is suspended, as shown in Fig. 2(8).

Thus, it is possible to manufacture a winged metallic bent pipe having straight pipe portions 7, 8 at both ends of a bent pipe portion 3, which have been subjected to the same heat treatment as that for the bent pipe portion 3.

It is to be noted that the period of each of the sections G1, G2 of Fig. 3 is only required to be set so as not to affect the heat treatment in the ordinary bending processing, since the period thereof has an effect on the shifting state of the bending radius at each of the boundaries between the straight pipe portions 7, 8 and the bent pipe portion 3. Also in such a case, it is, as a matter of course, necessary to maintain the relative speed between the metallic pipe and the heating device constant.

Moreover, since the straight pipe portions require a smaller force in processing than the bent pipe portion, the processing speed can be increased. In this case, however, the ratio between the relative speed between the pipe and the heating device and the quantity of heat supplied per unit time is made constant. In the case where the pipe has a large thermal capacity, such as a pipe having a large wall thickness, and hence has large effects of heat conduction, heat dissipation and heating depth it is difficult to maintain the heating temperature. Therefore, the change in heating temperature of an essential part is detected, and control is affected so that the
change in heating temperature will be within a range that has no hindrance to processing.

Although the operation in each of the above-described steps is seemingly complicated, the steps can simply be embodied by effecting a proper control such as program control.

As will be fully understood from the foregoing description, the invention permits manufacture of what is called a winged metallic bent pipe having the whole thereof subjected to a uniform heat treatment. Accordingly, the invention is exceedingly useful from the industrial viewpoint.

Claims

1. A method of manufacturing a metallic bent pipe (1) having tangent portions at both ends of a bent portion, in which a pipe to be bent (1) is guided through an annular heating device (H) with an attached cooling device to heat the pipe (1) at a narrow circular zone, and is then bent by a clamp of a bending arm (4) which grasps the pipe (1) firmly, whereby the ratio between the relative speed between the heating device (H) and the heat energy supplied per unit time is kept substantially constant, characterised in that heat treatment of the forward straight portion (7) of the pipe (1), heat treating and bending of the intermediate portion (2) of the pipe by applying a bending moment, and heat treatment of the rear straight portion (8) of the pipe (1) after removing the bending moment are all effected successively and without interruption, so that all the said portions of the pipe (1) are heat treated uniformly.

2. A method according to claim 1, characterised in that the relative speed between the pipe (1) and the heating device (H) and the amount of heat energy supplied per unit time are both kept substantially constant.

3. Method according to claim 1 or 2, characterised in that at the end of the heat treatment stage of the said forward portion (7) and also at the beginning of the heat treatment stage of the said rear portion (8), the heating device (H) is retracted in the longitudinal direction of the pipe (1) while at the same time the pipe (1) is held stationary, said bending arm (4) being clamped to the end of said pipe at the end of treatment of said forward portion (7) and released from clamping at the beginning of treatment of said rear portion (8) of said pipe (1).

4. Method according to claims 1—3, characterised in that the change in heating temperature of a part of the pipe (1) is detected and control is effected so that the heating temperature is maintained within a range suitable for processing.

Patentansprüche

1. Verfahren zur Herstellung gebogener Metallrohre (1) mit Tangentialabschnitten an den beiden Enden eines gebogenen Abschnitts, bei welchem ein zu biegendes Rohr (1) durch eine ringförmige Heizvorrichtung (H) mit angeschlossener Kühlvorrichtung geführt wird, um das Rohr (1) an einem kurzen Kreisbogenvuster zu erhitzten, und anschließend gebogen wird durch eine Klammer eines Biegeomats (4), die das Rohr (1) sicher festhält, wobei das Verhältnis der Relativgeschwindigkeit zwischen dem Rohr (1) und der Heizvorrichtung (H) zu der je Zeiteinheit zugeführten Wärmeenergie im wesentlichen konstant gehalten wird, dadurch gekennzeichnet, daß die Wärmebehandlung des vorderen geradlinigen Abschnitts (7) des Rohres (1), die Wärmebehandlung und das Biegen des Zwischenabschnitts (2) des Rohres durch Anbringen eines Biegemomenten und die Wärmebehandlung des rückwärtigen geradlinigen Abschnitts (8) des Rohres (1) nach dem Wegnahme des Biegemomenten sämtlich nacheinander und ohne Unterbrechung vorgenommen werden, so daß alle Abschnitte des Rohres (1) gleichmäßig wärmebehandelt werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß sowohl die Relativgeschwindigkeit zwischen dem Rohr (1) und der Heizvorrichtung (H) als auch der Betrag der je Zeiteinheit zugeführten Wärmeenergie im wesentlichen konstant gehalten werden.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß am Ende des Wärmebehandlungsabschnitts des vorderen Abschnitts (7) und auch zu Beginn der Wärmebehandlungsabschnitts des rückwärtigen Abschnitts (8) die Heizvorrichtung (H) in Längsrichtung des Rohres (1) zurückgezogen wird, während gleichzeitig das Rohr (1) an Ort und Stelle gehalten wird, und daß der Biegeomat (4) am Schluß der Behandlung des vorderen Abschnitts (7) an das Ende des Rohres geklemmt wird und zu Beginn der Behandlung des rückwärtigen Abschnitts (8) des Rohres (1) abgenommen wird.

4. Verfahren nach den Ansprüchen 1 bis 3, dadurch gekennzeichnet, daß die Änderung der Erhitzungstemperatur eines Abschnitts des Rohres (1) ermittelt und eine Steuerung derart vorgenommen wird, daß die Erhitzungstemperatur innerhalb eines für die Verfahrensführung günstigen Bereichs gehalten wird.

Revendications

1. Méthode de fabrication d’un tube métallique cintré (1) comportant des parties tangentiels aux deux extrémités d’une partie cintrée, dans lesquelles le tube qui doit être cintré (1) est guidé à travers un dispositif de chauffage annulaire (H) avec un dispositif de refroidissement attaché pour chauffer le tube (1) dans une zone circulaire étroite, le tube étant ensuite cintré par la pince d’un bras de cintrage (4) qui saisit fermente le tube (1), le rapport entre la vitesse relative entre le dispositif de chauffage (H) et l’énergie de chauffage fournie par unité de temps étant maintenu substantiellement constant, caractérisée en ce que le traitement thermique de la partie droite avant (7) du tube (1), le traitement thermique et le cintrage de la partie intermédiaire (2) du tube par l’application du couple de cintrage et le traitement thermique de la partie arrière droite (8) du tube (1)
après l'élimination du couple de cintrage sont 
tous effectués successivement sans interruption 
de manière à ce que lesdites parties de tube (1) 
soient traitées uniformément.

2. Méthode selon la revendication 1, caracté-
risée en ce que la vitesse relative entre le tube (1) 
et le dispositif de chauffage (H) et la quantité 
d'énergie de chauffage fournie par unité de temps 
sont toutes deux maintenues substantially 
constantes.

3. Méthode selon les revendications 1 ou 2, 
caractérisée en ce qu'à la fin de l'étape de traite-
ment thermique de ladite partie avant (7) et aussi 
aux début de l'étape de traitement thermique de 
ladite partie arrière (8), le dispositif de chauffage 
(H) est retraité en direction longitudinale du tube 
(1) alors qu'au même moment le tube (1) est 
maintenu en place, ledit bras de cintrage (4) étant 
fixé à l'extrémité distale du tube à la fin du traitement 
de ladite partie arrière (7) et est relâché au début 
du traitement de ladite partie arrière (8) dudit tube 
(1).

4. Méthode selon les revendications 1—3, 
caractérisée en ce que le changement de la 
température de chauffage d'une partie du tube (1) 
est détecté et un contrôle est effectué de manière 
à ce que la température de chauffage soit maintene-
nue dans une plage adaptée au procédé.
FIG. 2(1)

FIG. 2(2)

FIG. 2(3)