(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 431 775 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90312467.5**

(51) Int. Cl.5: **B21D 3/04**

(22) Date of filing: **15.11.90**

(30) Priority: **22.11.89 JP 301922/89**
22.11.89 JP 301923/89

(43) Date of publication of application:
12.06.91 Bulletin 91/24

(84) Designated Contracting States:
DE FR GB IT

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(54) Method of continuous finishing of pipe.

(57) The invention provides a method of finishing long pipes composed of straightening rolled pipes after they have been cooled at a cooling bed (10), inspecting the pipes by nondestructive inspection and cutting the pipes to a predetermined length. A high speed straightener having five roll pair stands is utilized in the straightening, wherein the plural pairs of the rolls adjacent to each other co-operate to achieve the maximum offset.

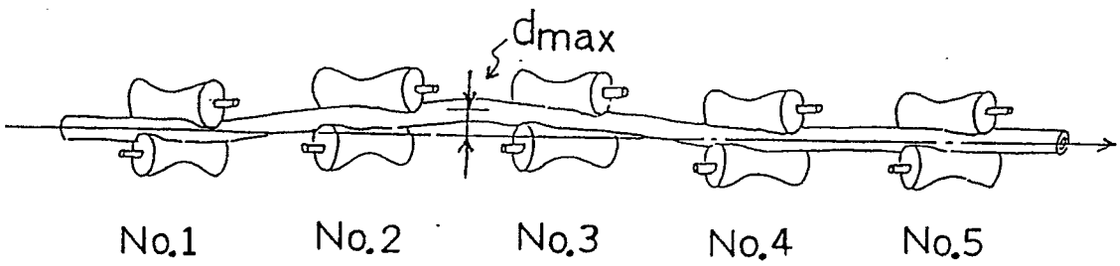

Fig.4

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METHOD OF CONTINUOUS FINISHING OF PIPE

This invention relates to the continuous finishing of pipe.

In the production of steel pipe, pipes are rolled or formed and finally processed in finishing facilities which are usually composed of a straightener, nondestructive inspection equipment and an end cutter.

Conventionally, pipes are cooled on a cooling bed, and the ends of the pipes are cut by an end cutter to a predetermined length. The cut pipes are straightened and inspected for quality by nondestructive inspection facilities.

The conventional finishing method has the following problems:

1) the pipes have to be straightened after having been cut to the required length. However, the end parts of the pipes are difficult to straighten using a rotary straightener. Therefore, after cutting, another straightening step is required, as an off-line operation;

2) when the ends of the pipes are seized by the rolls of the rotary straightener, they are prone to deformation or crushing. Any crushed ends have to be cut off by an end cutter, which is another off-line operation, and which lowers the yield;

3) the length of the pipes can change with straightening. Where there is a severe dimensional requirement, the pipe may have to be re-cut, which is another off-line operation.

4) the pipes have to be inspected after cutting. However the end parts of the pipes are difficult to inspect by nondestructive inspection facilities. This lowers the inspection accuracy which thus threatens the guarantee of quality of the products. Therefore the cut pipe ends have to be re-inspected, which is another off-line operation. Sometimes, the end parts have to be re-cut after re-inspection, which lowers the yield of the products.

Generally a conventional rotary straightener is composed of three or four pairs of skewed concave rolls accommodated in stands.

Japanese laid-open Patent Publication No.123419/1986 discloses a method of straightening wherein the offset, or the deviation of the path line of bent pipes, and the crush, or the difference between the pipe diameter and the roll clearance of the straightener, are predetermined by a set of equations. However the ends of the pipe cannot be straightened by the method according to this publication.

Japanese laid-open Patent Publication No.18244/1985 discloses a method wherein the pressure of the rolls is dynamically adjusted to avoid crushing of pipe ends. However, it is very difficult to avoid crushing when the pipes are straightened at high speed.

It is an object of the invention to provide a method of continuous finishing of pipe. It is an object of the invention to provide a method which continuously finishes the pipe without re-straightening and re-inspecting.

The invention provides a method of continuous finishing of pipe comprising the steps of:

straightening rolled pipes which have been cooled on a cooling bed;

inspecting said straightened pipes by nondestructive inspection; and

cutting the inspected pipes, to a predetermined length.

In this method, a high speed straightener having at least five roll pair stands can be utilized for the straightening step. The number of the stands is preferably five but may be six or seven. The plural pairs of the rolls of the stands adjacent to each other can co-operate to achieve the maximum offset. As a rule the distance between adjacent ones of the stands is 750 to 850mm. The skew angle of said pair of rolls is normally set in a range of from 35° to 50°. The outer diameter of the pipe should be from 25.4mm to 153.7mm. As a rule, the speed of advance of the pipes is less than 4.0 m/sec. A cutter is utilized for the cutting, which cuts plural pipes in one cycle.

For a better understanding of the invention, and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

FIGURE 1 is a flow chart of an embodiment of the invention;

FIGURE 2 is an explanatory illustration of an embodiment of the invention;

FIGURE 3 is an explanatory illustration wherein is shown a previous proposal not in accordance with the present invention; and

FIGURE 4 is an explanatory illustration wherein an embodiment of the invention is shown.

A problem encountered in the conventional finishing of rolled pipes is that straightening and inspection in on-line operation is not sufficient to achieve the required quality. Therefore off-line operation is required, wherein additional operations have to be carried out. Moreover, pipes with a length of from 6 to 45m and with comparatively small diameter are straightened at a maximum speed of only 120 m/min, which is not sufficient for on-line operation. Hence the rolled pipes are cut, straightened and inspected by off-line operation.

To solve these problems, it is proposed to straighten and inspect the rolled pipes before they

are cut to the required length.

The main obstacle in this on-line operation is the capacity, that is, the line speed of the straightener.

As shown in Figure 1, a rotary straightener 20 is arranged downstream of a rolled pipe cooling bed 10 and a nondestructive inspection device 30 is arranged downstream of the rotary straightener 20. A pipe cutter 40 is arranged downstream of the nondestructive inspection device 30.

The nondestructive inspection device 30 is composed of a leakage flux detector; a thickness meter which may be an electromagnetic supersonic thickness meter or a supersonic thickness meter; and a meter which measures the outside diameter of the pipe. The detecting capacity of the device is 192 m/min. The cutter having a cutting grinder can cut the plural pipes in one cutting cycle which promotes cutting efficiency and cutting accuracy, and minimises burring.

This is an on-line operation. By this operation the bent parts and collapsed ends of pipes are cut off as crop ends, or removed in the cutting operation.

Also the uninspected ends of the pipes are included in the crop ends.

Therefore in this on-line operation, there is no off-line operation and no lowering of the yield by re-cutting of the pipes.

As an example of this improvement the number of persons in an operating crew was cut by 30. The yield increases were almost 1%. A guarantee of quality was established.

All these improvements depend upon the capacity of the high speed straightener.

In the illustrated embodiment of Figure 2 a high speed straightener having five stands and five pairs of rolls is utilized in the straightening. As shown in Figure 2, the rotary straightener is composed of five stands each of which incorporates two concave rolls skewed as for the pass line. The top and bottom rolls are skewed at the same absolute value of angle as for the pass line but in the positive and negative direction. As the rolls are rotated at the same speed, the pipe is spirally moved towards the delivery side.

The clearances between the top and the bottom rolls are set smaller than the outside diameter of the pipe to apply a plastic deformation. The middle points of the clearances of the rolls at No.1, No.4 and No.5 are on the pass line. The middle points of the clearances of the rolls at No.2 and No.3 are off the pass line which is called the offset of the rotary straightener.

To increase the speed of the rotary straightener the rate of rotation of the motor which drives the roll may be increased. However as the result of the increase of the rotational speed of the rolls, the rotational speed of the pipe increases, which gives rise to vibration of the pipe and may break the pipe. To increase the translational speed of the pipe without increasing the rotational speed of the rolls, it is desirable to set the skew angle in a range of from 35 to 50° instead of the conventional range of from 25 to 35°. However, with such a high skew angle, the area of contact of the pipe with the rolls is decreased, which reduces the plastic deformation of the pipe, which is needed to straighten the pipe. This problem, met in high speed straightening, is solved by adopting a five-stand rotary straightener.

As shown in Figure 3, in an earlier method, the rolls of No.1, No.3 and No.4 stands are on the line, or the middle point of the clearance between the top and the bottom roll of a stand on the pass line. The rolls of No.2 stand are in an offset position. the straightening deformation is carried out be a single bending with the maximum offset of d_{max}.

As shown in Figure 4 in the present method, the rolls of No.1, No.4 and No.5 are on the line and the rolls of No.2 and No.3 are in offset positions. As shown in this embodiment, when the plural sets of the rolls adjacent to each other co-operate to achieve the maximum offset of d_{max}, the quantity of the maximum offset can be increased without applying an excessive offset on a single stand which may cause a spirally shaped defect on the surface of the pipes.

The number of the stands of the rotary straightener is not limited to five but may be more than five. However when the number is increased, the chance of defect generation and the investment and the maintenance cost are increased. Therefore the number is limited to seven.

The distance between adjacent stands is preferably from 750 to 850 mm. When the distance is more than 850 mm, the leading end of the pipe is seized only with difficulty by the rolls. When the distance is less than 750 mm, a severe enough bending is difficult to impose on the pipes. Therefore the distance is determined to be from 750 to 850 mm.

As a rule, range of outer diameters of the pipe wherein the invention is practicable, is from 25.4 to 153.7 mm.

It is desirable to set the angle of the rolls in a range of from 35° to 50°. are on the skew angle is less than 35°, the rotational speed of the roll is excessive and the pipe wall may be cut through during its straightening. When the skew angle is more than 50°, the area of contact of the pipe with the rolls is so low that a reasonable plastic deformation cannot be achieved.

The translational speed of advance of the pipes is preferably no more than 4.0 m/sec., since when the rotational speed of the pipe at the rotary

straightener is over 3000 rpm, it may cause the breakage of the pipe even when the skew angle of the rolls is set as 50°.

As for the length of the pipes, there is no limitation. In this example, the upper limit of the length of the pipes is 45 m. However it may be 100 m or more. It depends on the overall capacity of the rolling mills.

Claims

1. A method of continuous finishing of pipe, characterized by the steps of:
straightening rolled pipes already cooled on a cooling bed;
inspecting the straightened pipes by nondestructive inspection; and
cutting the inspected pipes to a predetermined length.

2. A method according to claim 1, characterized in that a cutter is utilized for the cutting, which cuts a plurality of pipes in one cycle.

3. A method according to claim 1 or 2, characterized in that the translational speed of advance of the pipes is below 4.0 m/sec.

4. A method according to claim 1, 2 or 3, characterized in that a high speed straightener comprising five stands, each having a pair of rolls therein, is selected for performing said straightening step.

5. A method according to claim 4 characterized in that the skew angle of each said pair of rolls is set in a range of from 35° to 50°.

6. A method according to claim 4 or 5, characterized in that the number of the stands is six.

7. A method according to claim 4 or 5, characterized in that the number of the stands is seven.

8. A method according to any one of the claims 4, 5, 6 or 7 characterized by the step of causing two adjacent plural pairs of the rolls to co-operate with each other to achieve the maximum offset.

9. A method according to any one of claims 4 to 8, characterized in that the distance between adjacent ones of said stands is from 750 to 850 mm.

10. The use of a high speed straightener comprising five stands of roll pairs, in an on-line method of continuous finishing of pipe.

FIG. 1

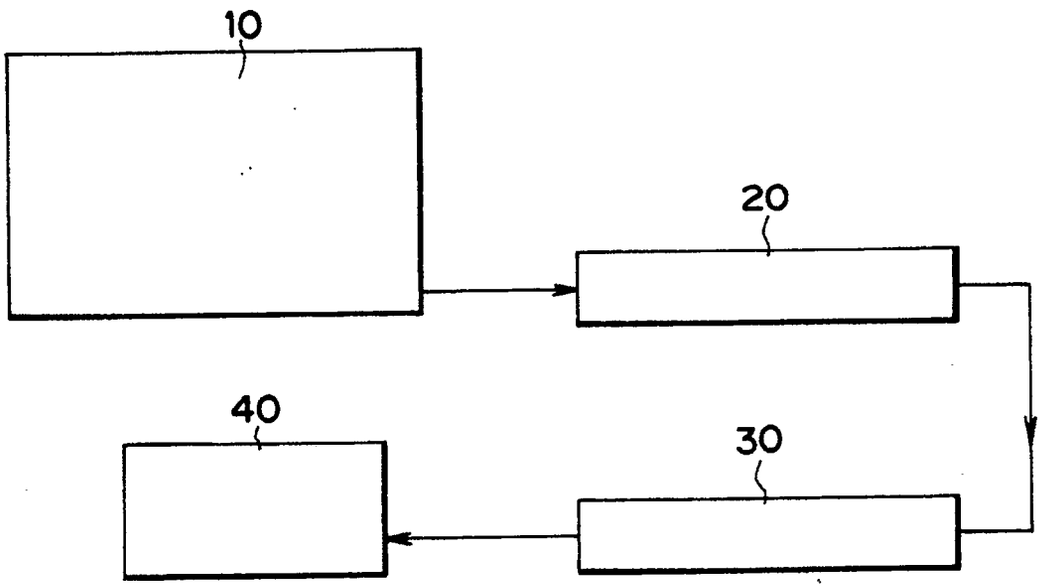
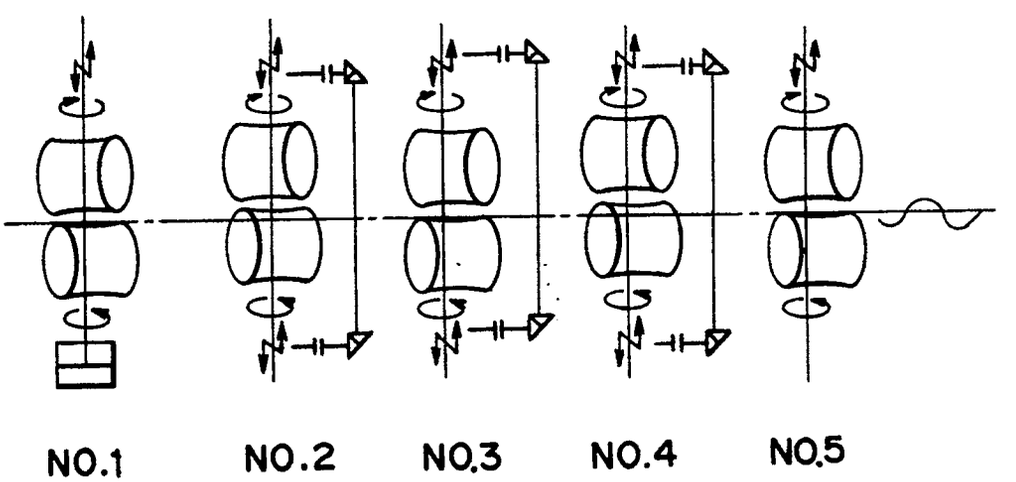


FIG. 2



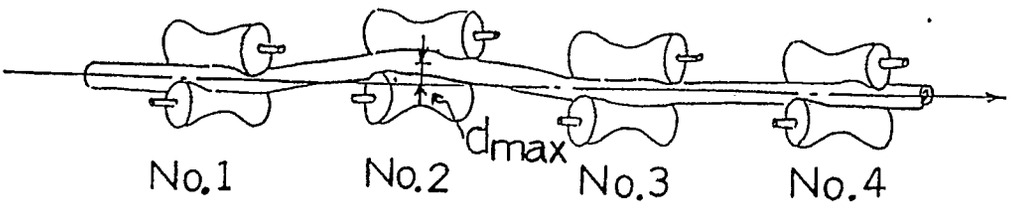


Fig. 3

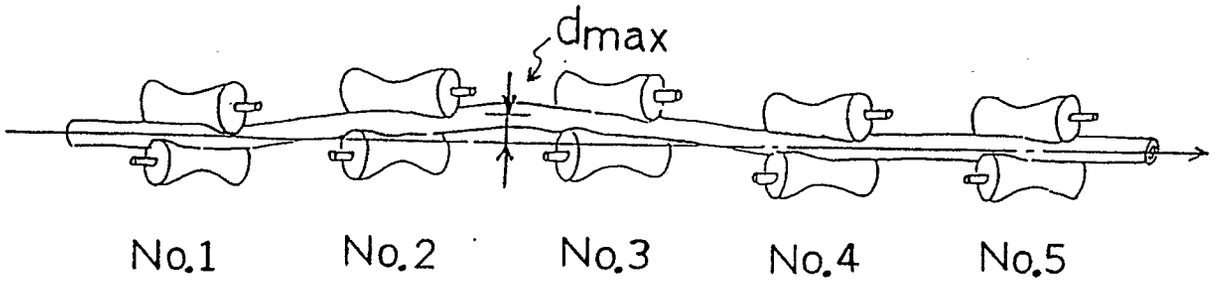


Fig. 4