

May 19, 1970

KENZO KATO

3,512,403

METHOD OF DETERMINING THE PIERCEABILITY OF SEAMLESS METAL TUBES

Filed March 29, 1968

3 Sheets-Sheet 1

Fig. 1

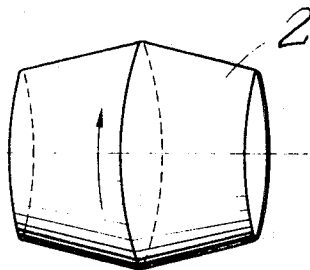
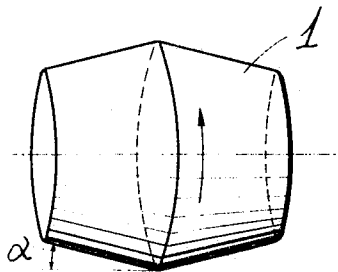
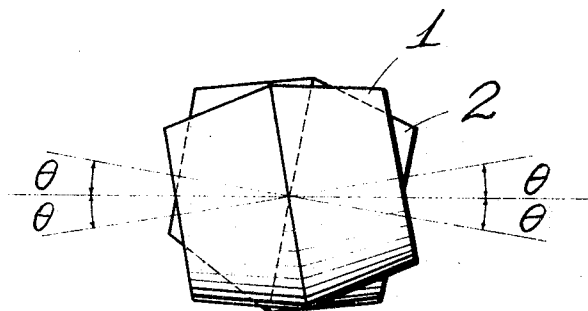


Fig. 2



Kenzo Kato
INVENTOR.

BY Robert D. Flynn

May 19, 1970

KENZO KATO

3,512,403

METHOD OF DETERMINING THE PIERCEABILITY OF SEAMLESS METAL TUBES

Filed March 29, 1968

3 Sheets-Sheet 2

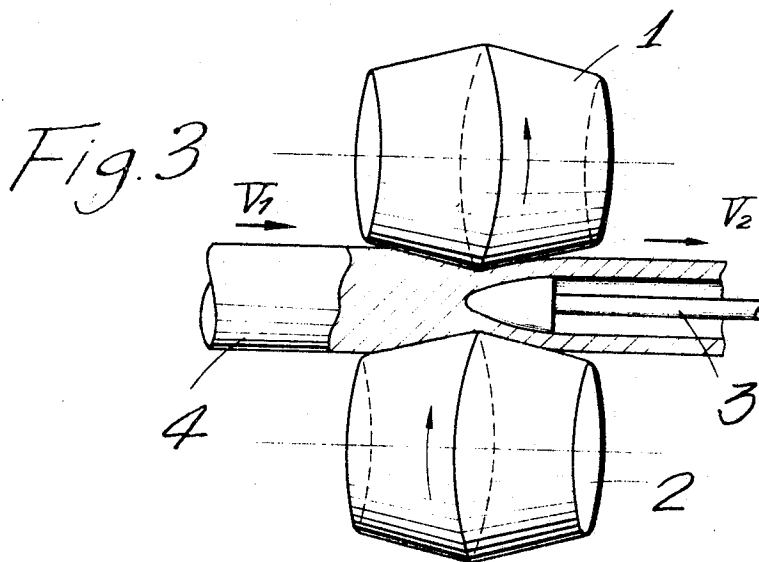
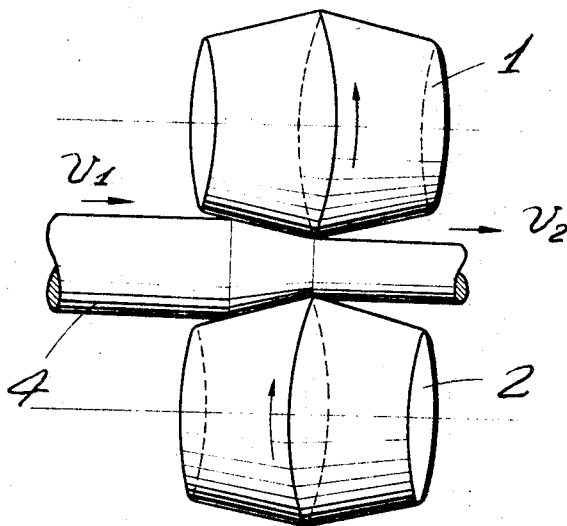


Fig. 4



Kenzo Kato
INVENTOR

BY Robert D. Flynn

May 19, 1970

KENZO KATO

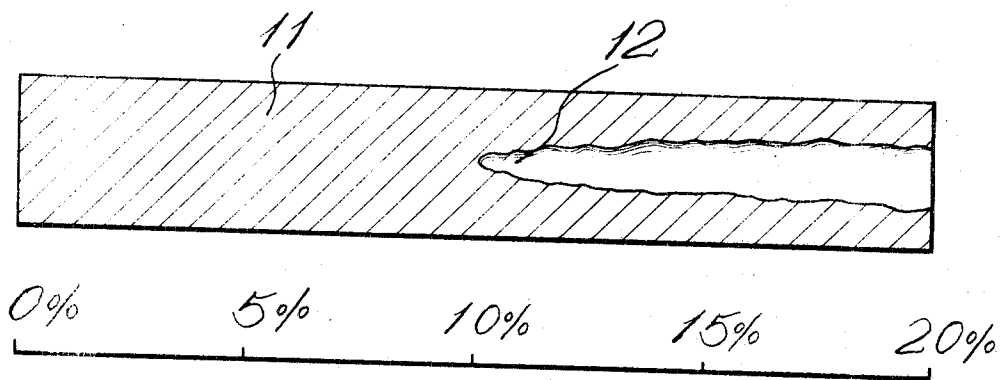
3,512,403

METHOD OF DETERMINING THE PIERCEABILITY OF SEAMLESS METAL TUBES

Filed March 29, 1968

3 Sheets-Sheet 3

Fig. 5



Kenzo Kato
INVENTOR

BY Robert D. Flynn

1

3,512,403

METHOD OF DETERMINING THE PIERCEABILITY OF SEAMLESS METAL TUBES

Kenzo Kato, Takatsuki-shi, Japan, assignor to Nippon Kokan Kabushiki Kaisha, a corporation of Japan
Filed Mar. 29, 1968, Ser. No. 717,474
Claims priority, application Japan, Mar. 30, 1967, 42/19,500

Int. Cl. G01n 19/08

U.S. Cl. 73-87

2 Claims

ABSTRACT OF THE DISCLOSURE

To determine the optimum piercing conditions for producing a seamless metal tube, a billet is pierced by a Mannesmann type piercer without utilizing a piercing plug, and the angle of delivery of the work rolls is varied such that the delivery speed of the billet in the absence of the piercing plug becomes equal to that of the billet in the presence of the piercing plug. The operating conditions are then varied until the produced tube has the desired characteristics.

BACKGROUND OF THE INVENTION

This invention relates to a method of determining the optimum working conditions required for producing high grade seamless metal tubes having excellent internal surfaces.

It has been tried in the past to determine the optimum piercing conditions by piercing a specimen without utilizing any piercing plug while the piercer is set to perform commercial operation. More particularly, the method utilizing the hot twist testing machines contemplates to stimulate the twisting action of the Mannesmann piercer by varying the working speed, working temperature, rate of reduction, and so forth, to determine the correct conditions for the piercing operation. According to this method, although it is possible to perform twist working for the surface layer of the peripheral zone of the test piece, the actual piercing operation is performed by the piercing plug at the center of the test piece. For this reason it is impossible to dynamically analyze the problem of forming an opening at the bore half on the entry side of the piercing rolls due to the rotating forging effect acting upon the material (actually this effect is the principal one for piercing in the manner above described), thus making it impossible to adequately check the rotating forging effect at the entry side of the piercing rolls. It is possible to analyze only the reducing process of the rear half on the exit side of the piercing roll.

In the above described prior method of testing by piercing without utilizing the piercing plug, the same roll setting was used as in the case of piercing with the plug. When using these prior art methods there results a considerably large difference in the material feed speed when the piercing plug was located in position.

Accordingly, it is the object of this invention to provide a novel method of testing for readily and accurately determining the rotating forging effect at the entry side of the piercing rolls and to obtain the optimum working conditions under which the actual piercing operation is to be carried out.

SUMMARY OF THE INVENTION

In carrying out this invention, use is made of a Mannesmann type piercer wherein a pair of working rolls is employed each comprising two oppositely inclining conical surfaces and the test piece is fed into a gap between these working rolls to form a center hole by the rotating forging effect afforded thereby without utilizing the piercing plug. The delivery angle of said work rolls with respect

2

to the pass line of the material is varied to determine the minimum rate of reduction at a piercing point, and the piercing workability of the test piece is determined in accordance with the minimum rate of reduction.

The delivery angle of the working rolls is selected to provide the same spiral feed speed of the material in the absence of the piercing plug as that of the material when the piercing plug is utilized. By examining the resulting seamless tube, it is possible to determine optimum values of the working temperature, rate of reduction, and spiral feed speed required to produce seamless tubes of excellent quality.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a front view of the piercing rolls;
FIG. 2 is a plan view of the rolls shown in FIG. 1;
FIG. 3 is a schematic side view, partly in section, showing the conventional method of manufacturing a seamless metal tube by utilizing a piercing plug;
FIG. 4 is a schematic side view showing the method of manufacturing a seamless metal tube without utilizing the piercing plug; and
FIG. 5 is a longitudinal sectional view of a tapered billet subjected to the rotating forging effect provided by the working method shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to have better understandings of this invention, the method of manufacturing a seamless steel tube by means of the Mannesmann piercer will be outlined hereunder. As shown in FIG. 1 and FIG. 2 the piercing rolls utilized in this type of piercer comprise two symmetrical conical work rolls each having two oppositely inclined conical faces inclined at an angle α . Each roll is inclined at a delivery angle θ with respect to the pass line of the material (hereafter designated as the roll delivery angle). When a billet being worked 4 is fed between piercing rolls 1 and 2 while they are rotated in the same direction as shown in FIG. 3, material 4 will rotate and advance with the peripheral velocity of the work rolls to reduce its cross-section until the maximum roll diameter portion or the gouge portion is reached. The rotating forging effect afforded by the rolls loosens the structure of the core portion of the material so that a piercing plug 3 set near the gouge portion enlarges the central hole and reduces the thickness of the tube wall, thereby producing a seamless tube. During this piercing process said rotating forging effect plays a most important role. The piercing or working rolls 1 and 2 constantly apply pressure to the material 4 from its periphery, and the magnitude of this pressure has a large influence upon the internal finish of the resulting seamless metal tube. The rate of reduction is also dependent upon the characteristics of the material, working temperature and other parameters. For example, in the case of high grade tubes of stainless steel, alloy steel or the like, numerous cracks are formed on the internal surface of the tube so that even when the internal surface is subjected to finishing working by the piercing plug, it is still coarse, thus producing unsatisfactory products. Accordingly, to obtain tubes having an excellent internal finish, it is essential to optimize the rotating forging effect on the entry side of piercing rolls to obtain a desired rate of reduction. It is also necessary to determine the working temperature most suitable for the particular material.

As has been described hereinabove, utilization of the piercing plug 3 is effective to form a hole, but it has been impossible to properly check the result caused by the rotating forging effect as the piercing is performed by the combined action of the rotating forging effect and the piercing action of the plug. If the hole were formed with-

out using the plug the delivery speed provided by piercing rolls 1 and 2 would greatly differ from the delivery speed in the actual piercing operation wherein the delivery speed is decreased by the resistance afforded by the plug 3. More specifically, in the actual piercing operation utilizing the piercing plug, a tube is manufactured at an entry speed V_1 and exit speed V_2 , as shown in FIG. 3. When the piercing plug is not used the tube is manufactured at an entry speed v_1 and an exit speed v_2 , as shown in FIG. 4. In the piercing operation utilizing the piercing plug 3 the resistance due to the piercing plug 3 reduces the entry speed so that $v_1 > V_1$. In other words, the delivery speeds in the two cases is much different. This results in the delivery pitch becoming large in the case of not utilizing the piercing plug 3 than in the case when the plug 3 is utilized. For this reason, in the case of utilizing the piercing plug 3 the reduction is gradually applied whereas in the other case the reduction is rapidly increased, thus resulting in a large difference in the rotating forging effect imparted to the material 4. Therefore, the prior art testing methods are not capable of providing accurate enough results.

In accordance with this invention, the delivery angle θ of piercing rolls 1 and 2 with respect to the pass line of the material being worked is changed so that the rotating forward motion of the material 4 at the entry side of rolls 1 and 2 in the case where the piercing 3 is not utilized is made equal to that of the material in the actual case (i.e., under actual operating conditions) where the piercing plug 3 is utilized.

In the following, a theoretical analysis of the present invention is given with respect to actually measured data. Where a billet of the dimensions 2,800 mm. long and 120 mm. diameter is pierced into a tube of 8,500 mm. long and 127 mm. diameter, the average piercing time when using piercing plug 3 was measured to be about 11 seconds. The parameters of the rolls utilized in this measurement were:

Dia. of work rolls— $D=915$ mm.
Peripheral velocity of work rolls— $V=5$ m./sec.
Rates of rotation of the work rolls— $n=100$ r.p.m.
Angle of delivery of the work rolls— $\theta=9^\circ$

In the absence of the piercing plug 3 the billet can freely rotate and advance without being impeded by the resistance afforded by the piercing plug. In this case the axial forward speed v imparted by the piercing rolls is given by the following equation.

$$v = \frac{n}{60} \times D \times \eta \times \sin \theta \quad (1)$$

Substituting the above data in Equation 1:

$$v = \frac{100}{60} \times 0.915 \times 3.14 \times 0.156 = 750 \text{ (mm./sec.)}$$

Thus the time T required for working a billet having a length of 2,800 mm. without utilizing the piercing plug is:

$$T = 1/v = 2,800/750 = 3.7 \text{ (sec.)}$$

Since the actual piercing time with plug 3 is 11 seconds, the ratio of the forward speeds of the billet is 3:1. Assuming that $\theta=3^\circ$, then the value of $\sin 3^\circ$ is equal to about $\frac{1}{3}$ of that of $\sin 9^\circ$. Thus, when a value $\theta=3^\circ$ is substituted in Equation 1 the resulting speed is $v=250$ mm./sec. which corresponds to a piercing time of 11 sec. Thus when the piercing plug 3 is not used (during testing) the angle θ is set to 3° to equalize the feed speed. This means that the rotating forging effect in the case where the piercing plug is not utilized is made equal to the forging effect at the extremely low value of roll delivery angle θ of 3° . Such low roll delivery angles have not heretofore been utilized by any prior piercer to the best of applicant's knowledge. This is because such low roll delivery angles (such as 3°) result in rupture of the material. Therefore, the use of such low roll delivery angles was avoided by those in the art. The minimum limit of the roll

delivery angle has long been recognized to be $\theta=5^\circ$. In accordance with this invention it has been found that such low delivery angles could be advantageously used to obtain optimum piercing conditions under which the actual manufacture should take place.

As has been discussed hereinbefore, according to this invention, a particular value of the roll delivery angle θ is selected in order to obtain the same feed speed without utilizing the piercing plug as the spiral feed speed of the material in the actual piercing operation. After selecting an appropriate value of the roll delivery angle θ , the test piece is fed between piercing rolls (which are rotating in the same direction) to subject it to the rotating forging action. By observing the resulting seamless tube, proper values of the working temperature, rate of reduction, delivery speed of the material and other parameters required to obtain seamless tube having excellent internal surface quality can be determined. Then the roll delivery angle is reset to provide the same feed speed with the piercing plug, the piercing plug is placed in position and the actual piercing operation can be carried out.

As a means for readily determining the adequate value of the rate of reduction, a tapered billet was used in this example as the test piece. In the case of using tapered billet of dimensions 25 mm. dia. x 30 mm. dia. x 150 mm., the billet was inserted in the piercing roll gap of 25 mm. with the smaller diameter portion inserted first. The billet is subjected to the rotating foregoing action without utilizing the piercing plug. As shown in FIG. 5, which shows a longitudinal section of the billet, the rate of reduction is 0% at one end of the blank 11 (corresponding to the end of the tapered billet having the diameter of 25 mm.) whereas that of the other end is 20%. At portions intermediate these ends the rate of reduction varies from 0 to 20%. The numeral 12, denoting the point at which the rupture begins to form, corresponds in this example to the point of 10% reduction. It was found that, in order to provide a satisfactory internal surface, the rate of reduction should be lower than the rate of reduction at the point 12 at which the rupture begins to occur (hereinafter designated as the critical rate of reduction). Thus, it becomes possible to determine the optimum piercing conditions from this critical rate of reduction. Accordingly, it can be readily noted that a desired rate of reduction for the billet is less than 10%.

As has been pointed out hereinabove, by the prior method of hot twist testing, it has been impossible to properly check the rotating rolling effect at the entry side of the piercing rolls. In accordance with this invention, the roll delivery angle is varied to provide the same delivery speed of the billet in the absence of the piercing plug as that of the actual piercing operation utilizing the piercing plug. This invention makes it possible to determine whether the central hole which is formed by the actual rotating forging effect at the entry section of the piercing rolls is acceptable or not. Consequently, it is now possible, by means of the present invention, to readily determine the optimum rate of reduction of various steel stocks at their actual working temperatures. When the actual piercing operation is carried out under the optimum operating conditions obtained in accordance with the present invention, it is possible to produce seamless metal tubes having excellent internal surface properties. While above description mainly refers to the production of seamless teel tube by using the Mannesmann type piercer, it has been found that this invention can be applied with equally satisfactory results to the production of tubes of other metals such as stainless steel, bearing steel, copper, brass, aluminum and the like.

What is claimed is:

1. A method for obtaining in the absence of a mandrel the optimum operating conditions for producing seamless metal tubes having desired characteristics with a mandrel in a conventional piercer, such as Mannesmann piercing machine which includes piercing rolls for feeding a billet over a mandrel, the optimum operating conditions which

5

are obtained in the absence of a mandrel also being the optimum operating conditions for carrying out the piercing operation when using a mandrel in the normal manner, comprising the steps of:

varying the delivery angle of said piercing rolls to make the delivery speed of said piercing machine in the absence of the mandrel substantially equal to the desired delivery speed during said normal piercing operation wherein a mandrel is used;

passing a testing billet through said piercing machine in the absence of said mandrel;

varying the operating conditions under which the piercing operation is carried out until the produced tube has said desired characteristics to obtain said optimum operating conditions, and passing a billet through said piercing machine in the presence of a

5

10

15

6

mandrel at said desired delivery speed under said optimum operating conditions.

2. The method according to claim 1 wherein the step of varying the operating conditions includes varying the position of said piercing rolls to a point at which metal rupture occurs in the center of said billet, thereby arriving at the minimum rate of reduction.

References Cited

UNITED STATES PATENTS

389,585 9/1888 Mannesmann et al. ----- 72—97

JERRY W. MYRACLE, Primary Examiner

U.S. CI. X.R.

72—97