PROCESS AND APPARATUS FOR PRODUCING CYLINDRICAL TUBULAR BODIES FROM BLOOMS

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5
This invention relates to a process and apparatus for producing cylindrical tubular bodies from metal blooms, and more particularly from blooms that are polygonal in cross section.

At present the manufacture of hollow metal bodies open at both ends is usually carried out with the aid of the Mannesmann cross-roll or roll-piercing mill, by piercing round or ingot holes of high tensile and shearing stresses applied to the inner and outer surfaces of the hollow body, the blank must be of outstandingly good metallurgical and physical quality. Casting defects, such as pores, inclusions or segregations, or on or below the surface of the bar or ingot, lead to cracks and laminations or pitting at the surface of the formed hollow or tubular body, stemming from the high tensile and shearing stresses created by this method of piercing and rolling. Moreover, uneven heating of the round bars in the furnace is likely to lead to the formation of eccentric holes and unequal wall thickness of the hollow bodies formed from the bars.

Another method of manufacturing cylindrical tubular bodies consists in piercing a plain square billet in a round container in a hydraulic piercing press, by pushing a punch through the center of the billet. In using this piercing process in a tapered cylindrical container, it has been observed that below the punch head in a plastic region, the height of which is determined by the depth of penetration of the bundle or gliding lines, there are two zones of different behavior. One of these is a lower zone, in which the material is freely deformed towards the exterior. The other is an upper zone, which is located directly below the punch head and is characterized by contact of the surface of the billet with the container wall. In the lower zone, compressive and upsetting stresses are created in the axial direction, while tensile stresses with lateral flow are produced in the tangential and radial directions. In the upper zone of contact, a state of three-axial compressive stresses is created, under which the material rises between the punch and the container wall. Shearing stresses are still formed in this zone, through the rise of the material against the container wall and the punch. The container must therefore be tapered and the punch head must be short in order to avoid dangerous values for poor materials or for those having visible or invisible defects or pre-existing seams. The two zones just mentioned move downwards after the entrance of the punch into the billet. This method of piercing gives rise to numerous disadvantages, such as the following:

(1) During the piercing operation the scale adhering to the billet surface is detached as a result of the tangential tensile stresses in the lower zone. The scale accumulates and moves with the surface of the billet during the billet's rise along the container wall, and often forms dangerous scores on the outside surface of the hollow body, which produce defects during the subsequent rolling process, for instance on seamless tubes.

(2) Towards the end of the piercing stroke, at the moment when the bundle of gliding lines, inclined by about 45°, reaches the bottom of the container, the lower zone vanishes, so that near the end of piercing an appreciable increase of axial pressure stress is created. This often leads to a double piercing power and consequently to an over-dimensioned press, and to a costly and dangerous wear of the punch head and the container.

(3) The punch piercing is never complete, and the residual bottom of the hollow bottle or billet must be eliminated either by extrusion and cutting off or by a further piercing through on a cross-roll elongator. This last operation is likely to produce external or internal cracks and laminations, which lead to the rejection of the finished rolled product.

(4) The pierced hollow body has a tapered form, with a somewhat square section at the open upper end at which the punch is first introduced. These two circumstances represent an unfavorable condition for further processing of the hollow body, leading to loss of material in the final step of finishing to a rolled pipe.

(5) The introduction of the square billet into the press container, and the retraction of the pierced hollow and of the punch from the same end of the container after piercing, give rise to a loss of time, which limits the operating cycles and consequently the hourly output of piercing presses of this type.

(6) The punch head, which is already highly stressed during the last phase of piercing, remains in contact with the hot material during extraction of the hollow body from the die and extraction of the punch from the hollow, so it becomes very hot and requires a long time to cool. These facts lead in their turn to long operating cycles and to heavy wear and a tendency for the punch head to crack, so that the punch head often has to be replaced by new ones.

(7) The outside skin of the hollow body is cooled by the rather long contact of the material with the cold press container, so the hollow has to be reheated before further processing, especially if it is to be cross-rolled in an elongator-equalizer.

(8) Owing to the expansion of the flat surfaces of the square billet into the round form of the hollow body in the lower zone as explained above, these surfaces are subjected to tangential tensile stresses of maximum value, so that metallurgical defects or pre-existing rolling seams show up as bad longitudinal cracks or seams in the material.

(9) The unequal heating of the bloom cross-section in the heating furnace is likely to lead to eccentricity of the wall thickness of the hollow body, especially if the piercing ratio, viz. the ratio of the length of the hollow body to its internal diameter, is greater than 6.

All of these disadvantages create an appreciable reduction in the yield of the material processed, and a large increase in the cost of converting a plain billet into a finished tubular product.

It also has been proposed to pierce square billets by the press-piercing mill process, according to which a square bloom, e.g. an ingot, is pushed by a high pressure ram through a centering guide onto a pre-nose of a piercing plug fixed on a plug-holding bar concentric with the ram to produce a hole in the leading end of the bloom. The pre-pierced and expanded square ingot is subsequently gripped by a pair of driven rolls provided with round rolling grooves, which roll the material over the larger end of the tapered piercing plug located in the roll pass, thus forming the pre-pierced and pre-expanded square blank to a cylindrical tubular body. These operations of pre-piercing by axial pressure and of longitudinally rolling over the end of the piercing plug in the roll pass are successive and simultaneous operations, resulting in one continuous piercing operation. By this method of piercing, all of the disadvantages 1 to 7 mentioned above can be avoided, but the disadvantages numbered 8 and 9 still exist because the expansion of the flat sides of the
square bloom during the free pre-piercing by the nose of the piercing plug prior to the rolling action in the roll grooves and faces the bloom stress on the formerly flat surfaces. These stresses may create cracks or breakdown of material, or may appreciably enlarge existing cracks or seams at the surface of the bloom.


Moreover, such a process leads to unequal wall thickness in the hollow body, as also happens in the cross-roll piercing of conventional hydraulic piercing press, when, through unequal heating of the blank and/or from the lack or the vanishing efficiency of the centering guide of the plug-holder bar, the piercing plug gradually follows the direction of lesser resistance along the thermal axis of the blank and in this way produces an eccentric hole in the hollow.


It is an object of this invention to provide a process and apparatus for producing cylindrical tubular bodies, which avoid all of the disadvantages listed above.


The preferred embodiment of the invention is illustrated in the accompanying drawings, in which:


FIG. 1 is a longitudinal section with the center portion broken away, through a square metal bloom having concave sides;


FIG. 2 is a cross-section of the bloom taken on the line I—I of FIG. 11.


FIG. 3 is a vertical section through a press-piercing mill, showing the bloom about to be pierced;


FIGS. 4 and 5 are cross-sections taken on the lines IV—IV and V—V, respectively, of FIG. 1;


FIG. 6 is a section similar to FIG. 3, but showing the endmill of the piercing operation; and


FIGS. 7 and 8 are cross-sections taken on the lines VII—VII and VIII—VIII, respectively, of FIG. 6.


Referring to the drawings, two or more driven rolls j are each provided with annular grooves which are shaped transversely as arcs of circles. The rolls cooperate to provide a circular roll pass between them (FIG. 7). Rigidly mounted in any suitable manner at the entrance to the roll pass is a bloom guide f that has a horizontal passage through it shaped to receive the polygonal steel or non-ferrous bloom a that is to be processed. Preferably, as shown in FIGS. 2 and 4, the bloom has a generally square cross-section (although it could have more than four sides) and is slidably supported in the guides in such a manner that it cannot turn on its axis, but must remain properly oriented relative to the roll pass.


Disposed between the rolls in their grooves is a tapered or conical plug l. Being a piercing plug, its small or pointed end faces the bloom guide f. The opposite end of the plug is supported by one end of a mandrel bar b that extends outwardly away from the delivery side of the roll pass to a suitable retractable support (not shown). The bar centers the larger end of the plug in the circular roll pass. The plug and mandrel bar may be water cooled. The plug end of the bar is supported in axial alignment with the circular roll pass by a guide block g slidably mounted on the bar and slidably supported in a guiding die that is rigidly mounted at the delivery side of the roll pass. The guiding die extends into the roll grooves to a point close to the roll pass and may be formed from an upper and lower die segments k mounted in rigid supports m. The opposed faces of the two die segments form arcs of a circle having the same size as the roll pass and coaxial therewith (FIG. 8).


Before a bloom is inserted in its guide f, one end of the bloom preferably is provided with an axial centering hole c, which may be filled with a material acting as a lubricant and as a protection against oxidizing after piercing. The hole also makes it certain that the initial piercing of the bloom will be along its axis. The bloom has a centering recess b in its opposite end. This hole preferably tapers inwardly of the bloom and has an area at its outer end about equal to 20% of the cross sectional area of the bloom.


After the bloom has been heated and placed in the guide with the centering hole c at the front, a tubular pusher or ram d is moved forward against the rear end of the bloom. The front part of the roll grooves 2, 3, 5. The centering hole c at the front end of the bloom receives the plug and therefore centers the bloom on the plug. As the ram and plunger continue to push the bloom ahead, it is forced over the piercing plug, aided by the rolls which compress the corners of the bloom toward the plug as the bloom is expanded between its corners by the plug. As the bloom enters the circular roll pass the rolls roll the polygonal bloom into circular shape around the larger end of the plug. That is, the pushing force exerted by the ram axially on the bloom, the axial piercing by the plug, and the radial force exerted by the rolls, simultaneously and in combination transform the polygonal centered bloom into a cylindrical tubular body having a wall of uniform thickness. Very shortly after the front end of the hollow or cylindrical body thus being formed leaves the plug it enters the guiding die k, pushing the guide block g along the mandrel bar ahead of it. The cylindrical body then is held coaxially by the roll pass and, in case of a guiding die, and the piercing plug and mandrel bar are held in axial alignment with the pass by means of the cylindrical body as the latter pushes the guide block out of the die. The length and diameter of centering hole c are such that the hole maintains the piercing plug centered in axial alignment with the bloom axis until the front end of the hollow body leaving the roll pass can enter the guiding die. For this reason, the length of the centering hole preferably is not less than the length of the tapered portion of the piercing plug.


When the bloom has been advanced by the ram and the plunger so far that the latter is only a short distance from the piercing plug movement of the plunger is stopped while the ram continues to move forward around the plunger until the ram substantially engages the piercing plug, as shown in FIG. 6. By this time the plug will have entered the roll pass and recess b in the bloom and emerged from the back of the bloom and become engaged by the front end of the ram. Due to recess b, no metal is carried out of the bloom and into the front end of the ram. Since the bloom has now been pierced completely through, the rolls can move the hollow body forward over the rest of the plug and, with the help of the ram, to complete the formation of the cylindrical body. The mandrel bar and the cylindrical body then are withdrawn from the outer end of the guiding die, and the mandrel bar is subsequently extracted from the body. Thereafter, a new piercing cycle can start as soon as the piercing plug has been returned to its operative position in the roll pass.


Another feature of this invention is that the sides of the bloom preferably are concave transversely, by reason of which the creation of tensile stresses is reduced through the deformation of the concave shape of the bloom sides to a convex shape in my process. Furthermore, when casting blooms in a continuous mold, it is preferable to form the blooms with concave sides, so as to use the process of this invention, such blooms can be used directly after casting without further work. The concave sides of the bloom also contribute to better quality, and higher output capacity of a continuous casting plant, and this cheap raw material can be converted into high quality pipe by avoiding excessive tensile and shearing stresses on the metal.


The piercing of the bloom by axial pressure forces starts at about the same time as the rolling action of the rolls on the corners of the bloom. During the rolling phase, the area of contact of the rolls with the bloom gradually increases until the bloom is engaged by the rolls for 360°
around it. The blooms are deformed solely by compressive forces on the outer and inner surfaces of the hollow bodies being formed, in order to reduce the tensile and shearing stresses on the material during the piercing.

Using the process of this invention, it is possible to manufacture great lengths of round-section hollow bodies, with cylindrical internal and external surfaces, having uniform wall thicknesses and regular circular flat front surfaces, so that seamless tubes can be rolled starting from polygonal blooms of carbon or high-alloy steel, especially from continuously cast square concave sided blooms. In addition, it is possible to obtain a high output rate at a high exit temperature of the hollow body from the mill, with a low consumption of power, tools and man power, thereby improving and reducing the cost of seamless pipes.

The inconveniences for the lower deforming zone mentioned in connection with hydraulic press-piercing are eliminated in my method by the simultaneous piercing and rolling actions because, through the existence of a rolling pressure at the start of the piercing operation there results, besides the small longitudinal deformation, a high transverse flow of the material. This flow creates in the transverse direction compressive stresses opposed to expanding stresses, thereby nullifying or reducing the tendency of the stresses to form longitudinal cracks at the surface of the hollow body.

The upper zone of deformation previously mentioned can be reduced materially in extent by my method by the characteristic features of the press-piercing mill. The shearing stresses created by this method act on a much reduced contact surface and the shearing forces assume limited values. Since the scale can be reduced or eliminated at the same time by water jets, it is clear that scratches can be avoided or greatly reduced. The degree of yield of the deforming operation is thus favorably influenced.

I claim:

1. Apparatus for producing cylindrical tubular bodies from polygonal cross-section metal blooms, comprising driven grooved rolls forming a circular roll pass, a tapered piercing plug, a mandrel bar at the outlet end of the pass supporting the plug in the center of the pass, means engaging with one end of a polygonal bloom for forcing the bloom forward over said plug and mandrel bar as the bloom is rolled into cylindrical shape in said pass, whereby a cylindrical tubular body will move along the mandrel bar, and a guiding die rigidly mounted at the outlet of the pass for receiving said body and engaging the outside of it as it moves along the mandrel bar.

2. Apparatus according to claim 1, including a guide block slidably mounted on said mandrel bar and slidably supported by said guiding die to support said bar, the guide block being adapted to be engaged and moved along the bar by the leading end of said tubular body.

3. Apparatus for producing a cylindrical tubular body from a substantially square metal bloom having a centering hole in its leading end, comprising a pair of driven grooved rolls forming a circular roll pass, a tapered piercing plug, a mandrel bar at the outlet end of the pass supporting the plug in the center of the pass, means engaging with the trailing end of said bloom for forcing the bloom forward over said plug and mandrel bar as the bloom is rolled into cylindrical shape in said pass, whereby a cylindrical tubular body will move along the mandrel bar, said mandrel bar holding said plug in a position where the plug will be engaged by the edge of said bloom centering hole substantially simultaneously with first contact of the corners of the bloom with said rolls, and a stationary guiding die at the outlet of the pass surrounding said mandrel bar for receiving said tubular body and engaging the outside of it as it moves along the mandrel bar.

4. A process for producing cylindrical tubular bodies from polygonal cross-section metal blooms, comprising applying axial pressure to such a bloom to force it onto and over a tapered piercing plug, substantially simultaneously with the first contact of the bloom with the plug applying radial pressure to the corners of the bloom to compress them toward the plug as the advancing bloom is expanded between its corners by the plug, continuing and controlling said simultaneous compression and expansion of the advancing bloom to form it into a cylindrical tubular body having a uniform wall thickness, whereby the entire portion of the bloom passing over the plug is subjected to circumferential compressive forces from substantially the moment the bloom engages the plug, and entering the leading end of said tubular body into a guiding die as said body leaves said piercing plug.

5. A process for producing cylindrical tubular bodies from substantially square blooms with transversely concave sides, comprising providing one end of such a bloom with a centering hole, applying pressure to the opposite end of the bloom axially thereof to force the bloom onto and over a bar-supported tapered piercing plug having a maximum diameter greater than the maximum diameter of said hole, substantially simultaneously with the first contact of the bloom with the plug applying radial pressure to the four corners of the bloom to compress them toward the plug as the advancing bloom is expanded between its corners by the plug, continuing and controlling said simultaneous compression and expansion of the advancing bloom to form it into a cylindrical body having a uniform wall thickness, and entering the leading end of said cylindrical body into a guiding die as it leaves said piercing plug to maintain the plug in axial alignment with the bloom.

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