A Study of Hot Metal Extru-Bending Process

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A Study of Hot Metal Extru-Bending Process

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ABSTRACT

The purpose of the present study is to propose a new way of manufacturing curved metal tubes with arbitrary sections and way of eliminating the conventional bending defects such as thinning and thickening in the wall of tube, distortion of the section, and wrinkling and folding on the surface by the extrusion bending process that can extrude and weld together one or more billets inside dies cavity, and can bend them during extrusion due to the gradient of extrusion velocities controlled by the eccentricity of the cavity sections between the entrance and the exit of the eccentric conical extrusion bending dies and conical plug, or by the relative size of the holes of multi-hole container, or by the relative moving velocity of multi-punches.

Key Words : Extrusion, Hot Metal, Bending, Extru-Bending, Multi-hole Container, Eccentric Conical Plug

1. INTRODUCTION

This study relates to the manufacturing devices of curved metal tubes with arbitrary sections. In details, it relates to the devices such that a curved hollow tube with various sections like as polygon and longitudinal fins can be extruded and bended very easily with needed curvature by the extrusion bending process.

Generally, curved metal tubes have been bended by the second bending process after the first extruding of straight tubes by the extrusion process. However, it is difficult to get precious and standard curved products, because the bending process make changes of the uniform section of extruded product due to the deformation by bending.

So, It has been concerned about that it is possible to manufacture the curved tubes without defects such as wrinkling and folding on the surface, and such as distortion in the section, and thickness change of the wall to be occurred easily when the non-symmetric hollow tubes with longitudinal fins should be bending. And the present study is attributed to the eliminating of the defects and the increasing of the productivity by combining extrusion process and bending process, so that the cost of production should be decreased by manufacturing curved metal products simultaneously in the one extrusion bending process.

2. EXTRUSION BENDING PRINCIPLE

The extrusion bending process can extrude curved metal tubes with arbitrary sections by welding together one or more billets inside dies cavity, and the curvature

of tube can be controlled during extrusion due to the gradient of extrusion velocities controlled by the eccentricity of cavity sections between the entrance and the exit of the conical extrusion bending dies, or by the relative size of the holes of the multi-hole container, or by the relative moving velocity of multi-punches

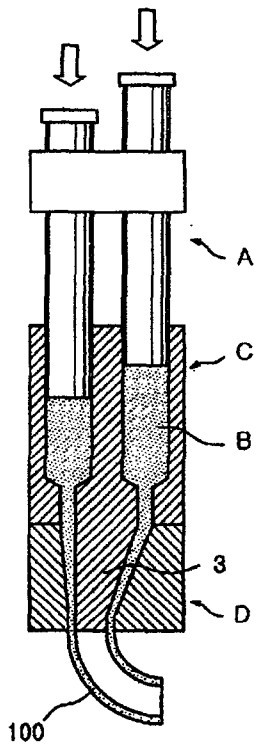

Fig. 1 A cross-sectional view for the extrusion bending of the curved metal tube by pushing hot metal billets with each different velocity into the multi-hole container by extrusion punches;

Figure 1 shows a view of the extrusion bending device for extruding the curved metal tube(100) with rectangular section. And it consists of the extrusion punch(A) with one or more punches; one or more hot metal billets(B); the multi-hole container(C) with the eccentric rectangular conical plug(3) and with multi-holes inserting one or more hot metal billets(B); and the eccentric conical extrusion bending dies(D) with the eccentric rectangular conical cavity to be able to insert an eccentric rectangular conical plug(3).

The extrusion punch(A) consists of one or more punches which can be assembled together to push the hot metal billets(B) with same velocity or can be separated individually to push the each billet with each different velocity.

The hot metal billet(B) is an arbitrary metal billet heated to the temperature used generally in the hot extrusion process. The upper part of multi-hole container(C) has one or more holes through which the one or more hot metal billet(B) can pass, and in order to control the bending curvature of curved tubes or rods, the relative diameter of the holes can be adjusted to control the gradient of extrusion velocity at dies exit due to the different amount of billets in each hole,

And the lower part of multi-hole container(C) has one circumferential groove passed through and connected to one or more holes, and has the eccentric conical plug(3) surrounded by the ruled surface connecting the inner circular contour of the circumferential groove at the bottom of plug(3) with the rectangular contour of the section at the end of plug(3).

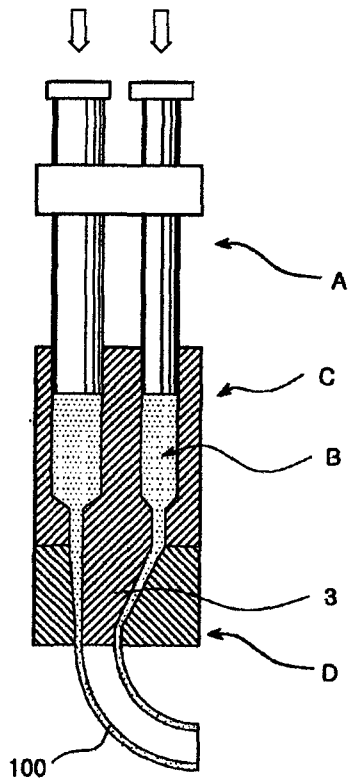

Fig. 2 A cross-sectional view for the extrusion bending of the curved metal tube by pushing hot metal billets with each same velocity into the container with different size holes

The eccentricity of eccentric conical plug(3) means that the center of section enclosed by the inner circular contour of the circumferential groove at the bottom of plug(3) does not lie on the same line as the perpendicular line passing through the center of the rectangular section or an arbitrary section at the end of plug(3).

And an arbitrary section means that it includes one of the various sections of extruded products, for example, the polygonal section like as rectangular tube and rod, the cylindrical or half cylindrical section, the section with longitudinal fins inside or outside the wall of tube, and H-section, and so on, as shown in Figure 3.

Fig. 3 A view of examples of the products of curved metal tubes that can be manufactured by the extrusion bending process.

The extrusion bending dies(D) has the eccentric conical cavity surrounded by the ruled surface connected the contour of a circular cavity section at the conical dies(D) entrance with the contour of a rectangular or an arbitrary cavity section at the conical dies(D) exit.

And the eccentricity of the eccentric conical cavity means that the center of the circular cavity section at the conical dies(D) entrance does not lie on the same line as the perpendicular line passing through the center of the rectangular or an arbitrary cavity section at the conical dies(D) exit.

3. EXPERIMENT

3.1 Extrusion bending machine

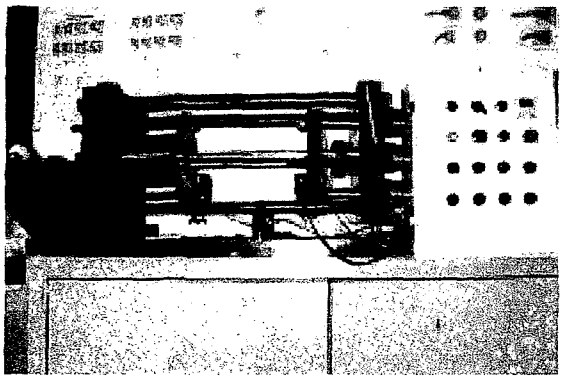

Fig. 4 The hot metal extrusion bending machine of the curved metal tube.

The extrusion bending machine is consisted of the eccentric conical extrusion bending dies(D) and conical plug(3), of multi-hole container(C) with the different holes(2), and of the relatively moving multi-punches in order to control the curvature

3.2 Experimental method

For more explanation of the detailed manufacturing process, the four round bar of plasticine materials are inserted into the multi-hole container(C) with four holes, are pushed and moved by four punches loaded with the compressive force, and are extruded to one circular tube welded together in the circumferential groove passed through and connected to the four holes at the lower part of multi-hole container(C) as shown in Figure 4,5,6.

Next, the one extruded circular tube welded in the circumferential groove is pushed and passed through into the cavity between the inner surface of the eccentric conical extrusion bending dies(D) and the outer surface of the eccentric conical plug(3).

Fig. 5 A front view of the multi-hole container with conical plug.

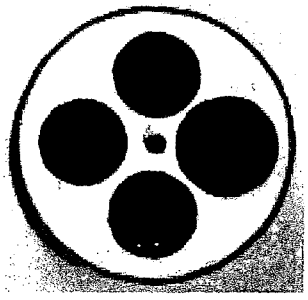

Fig. 6 A side view of the multi-hole container with difference of hole diameter.

And the gradient of the extrusion velocity on the exit cavity section of conical extrusion bending dies(D) due to the eccentricity in the conical plug(3) and in the conical extrusion bending dies(D) should make bending in the extruded product to the opposite direction of the eccentricity of the conical extrusion dies(D), as shown in Figure 1.

And the curvature of the extruded product, that is, the amount of bending of rectangular curved tube(100) can be controlled by the eccentricity between the circular cavity section in the circumferential groove at the dies entrance and the rectangular cavity section at the dies exit, or it can be controlled by the changing the

relative diameter of the two symmetric holes of the multi-hole container(C) as shown in Figure 2, or it can be controlled by the relative moving velocity of two symmetric punches inserted into the four hole, as shown in Figure 1.

And it is possible to manufacture the curved metal tube(100) whose curvature varies on the length of extruded product due to the gradient of the moving velocities of each billet controlled by the relative moving velocity of two symmetric punches during the extrusion process as shown in Figure 1.

In brief summarization of the extrusion bending process of curved tubes, first, the four hot metal billet(B) are welded together in the circumferential groove and they are extruded to one circular tube, when one circular tube is pushed and passed through into the die cavity between the dies surface and the plug surface, and then the bending should happen due to the gradient of extrusion velocity during the extrusion such that the moving velocity in left side is faster than the velocity in right side as shown in Figure 1. The curvature of the curved product can be controlled by the eccentricity or by the relative diameter of four holes or by the relative velocity of four punches, as shown in Figure 7,8,9.

Although the present example for the embodiment is illustrated in the case of the manufacturing of rectangular curved metal tube(100), however, according to the shape of the end of conical plug(3) connected to the multi-hole container(C) and to the shape of opening of the conical extrusion dies(D), it is possible to manufacture easily the products like as cylindrical and polygonal thin curved tube(100) with longitudinal fins inside or outside of tube wall, and the curvature of the products can be controlled preciously in a variety of range by the eccentricity or by the relative size of multi-holes or the relative moving velocity of multi-punches.

Although the exemplary embodiments are illustrated as desirable examples of the case of the extrusion bending process with four hot billets(B) and four punches and four-hole container(C), however, the fulfillment with the technically applicable range of the present study can be made in any other case of the extrusion bending process using with one or more billets(B), with one or more punches, and with one or more holes.

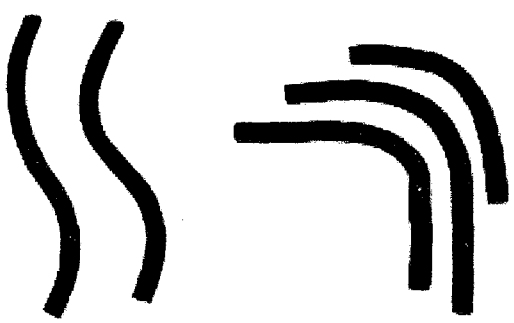

Fig. 7 A view of experimental results of the products of curved cylindrical tubes that can be manufactured by the extrusion bending process

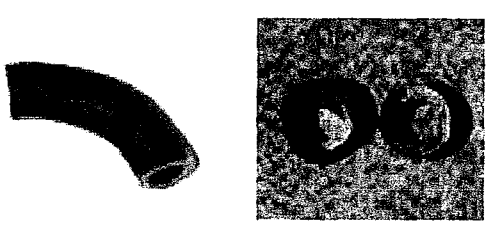

Fig. 8 A sectional view of the products of curved tubes without any bending defects

Fig. 9 A view of results of the products of curved rectangular tubes that can be manufactured by the extrusion bending process

4. Conclusion

1. The experimental results show that the curved tube with an arbitrary section can be extruded by the extrusion bending machine with a Plasticine of a kind of simulation materials. The machine consists of the extrusion punch with four punches; four hot metal billets; the four-hole container connected with the eccentric conical plug; and the eccentric conical extrusion bending dies inserting the eccentric conical plug inside the eccentric conical cavity.

2. The curvature of curved tube can be controlled by the eccentricity of the cavity sections between the entrance and the exit of the eccentric conical extrusion bending dies and conical plug, or by the relative size of the holes of multi-hole container, or by the relative moving velocity of multi-punches.

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