A method for processing a metal pipe 1 to make part of the metal pipe 1 in an axial direction thereof into a thick portion 10, the method includes: forming a shoulder as a stress concentration portion in an axial center of the metal pipe 1 to concentrate a stress thereon; setting the metal pipe 1 in an outer die 20; and forming the thick portion 10 by inserting an inner die 25 in the metal pipe 1 to provide space S for forming the thick portion 10 between the inner and outer dies 25 and 20, and applying the axial pressure to the metal pipe 1 to concentrate the stress on the shoulder to deform the shoulder after the forming and the setting, thereby forming the thick portion 10 from the deformed stress concentration portion as a starting point.
METAL PIPE, AND METHOD AND DEVICE FOR PROCESSING THE SAME

TECHNICAL FIELD

[0001] The present invention relates to metal pipes, part of which is made thicker than the other part, and a method and a device for processing the metal pipes.

BACKGROUND ART

[0002] For example, metal pipes have been used in part of exhaust systems of internal combustion engines mounted in automobiles. The metal pipe repeatedly receives heat of exhaust gas, and stress is concentrated on a junction between the metal pipe and the other component due to vibrations of the internal combustion engine and a vehicle body. Thus, the metal pipe, particularly the junction, is likely to break. To prevent the break, the metal pipe may be thickened, or may be made of a material having higher strength.

[0003] When the pipe is thickened, part of the pipe on which the stress is not concentrated, i.e., part of the pipe which is less likely to break, is also thickened. This unnecessarily increases weight of the metal pipe. Even when the material is changed, the weight of the metal pipe hardly changes.

[0004] As disclosed by Patent Document 1, for example, reduction of the weight of the metal pipe has been attempted while preventing the break by making part of the metal pipe on which the stress tends to concentrate thicker than the other part. According to Patent Document 1, a metal pipe of a uniform thickness is heated to a high temperature of about 1200°C to reduce deformation resistance, and then the metal pipe is pressed in an axial direction thereof using a die and a mandrel to form a thick portion in the metal pipe.

CITATION LIST


SUMMARY OF THE INVENTION

Technical Problem

[0006] According to Patent Document 1, the metal pipe needs to be heated to high temperature. The heating takes time, and reduces production efficiency. Further, the processing consumes much energy.

[0007] When the metal pipe processed at high temperature is cooled to room temperature, thermal contraction does not always occur uniformly. This reduces dimensional accuracy of the metal pipe.

[0008] In view of the foregoing, the present invention has been achieved. The present invention is concerned with providing a metal pipe having a thick portion with high production efficiency, high precision, and reduced energy consumption.

Solution to the Problem

[0009] In view of the above concern, a first aspect of the invention is directed to a method for processing the metal pipe by providing a stress concentration portion in an axial center of the metal pipe, applying an axial pressure to the metal pipe to concentrate stress on the stress concentration portion to deform the stress concentration portion, and forming a thick portion from the deformed portion as a starting point.

[0010] The first aspect of the invention provides a method for processing a metal pipe to make part of the metal pipe in an axial direction thereof into a thick portion thicker than a different portion, the method includes: forming a stress concentration portion in an axial center of the metal pipe to concentrate a stress on the stress concentration portion when an axial pressure is applied to the metal pipe; setting the metal pipe in an outer die for holding an outer peripheral surface of the metal pipe; and forming the thick portion by inserting an inner die in the metal pipe to provide space for forming the thick portion between the inner die and the outer die, and applying the axial pressure to the metal pipe to concentrate the stress on the stress concentration portion to deform the stress concentration portion after the forming of the stress concentration portion and the setting of the metal pipe, thereby forming the thick portion from the deformed stress concentration portion as a starting point.

[0011] With this configuration, the stress is concentrated on the stress concentration portion of the metal pipe when the pressure is applied to the metal pipe. Thus, unlike the conventional example, deformation of the metal pipe starts without reducing the deformation pressure by heating the pipe. The deformation of the metal pipe occurs in the space between the outer die and the inner die from the first deformed portion as the starting point. Thus, the thick portion is formed in the metal pipe between the outer die and the inner die.

[0012] According to a second aspect of the invention related to the first aspect of the invention, a shoulder is formed in the metal pipe in the forming of the stress concentration portion to use the shoulder as the stress concentration portion.

[0013] With this configuration, stress concentration can reliably be caused when the axial pressure is applied to the metal pipe by forming the shoulder.

[0014] According to a third aspect of the invention related to the second aspect of the invention, the shoulder is formed by expanding the metal pipe in the forming of the stress concentration portion.

[0015] This configuration allows easy provision of the shoulder by the expansion.

[0016] A fourth aspect of the invention is directed to a device for processing a metal pipe, wherein a stress concentration portion is formed in an axial center of the metal pipe using a stress concentration portion formation device, and an inner die is pressed in the axial direction of the metal pipe by a drive to apply an axial pressure to an end of the metal pipe.

[0017] The fourth aspect of the invention provides the device for processing the metal pipe to make part of the metal pipe in an axial direction thereof into a thick portion thicker than a different portion, the device including: a stress concentration portion formation device for forming a stress concentration portion in an axial center of the metal pipe to concentrate a stress on the stress concentration portion when an axial pressure is applied to the metal pipe; an outer die for holding an outer peripheral surface of the metal pipe; an inner die which is inserted in the metal pipe to provide space for forming the thick portion between the outer die and the inner die, and comes into contact with an end of the metal pipe; and a drive which press the inner die in the axial direction of the metal pipe to apply an axial pressure to the end of the metal pipe.

[0018] With this configuration, the metal pipe provided with the stress concentration portion can be held by the outer
According to a fifth aspect of the invention related to the fourth aspect of the invention, the inner die includes a first die which is inserted in part of the metal pipe except for part of the metal pipe for forming the thick portion, and a second die which is separated from the first die, and is inserted in the part of the metal pipe for forming the thick portion, and the second die is driven by the drive.

According to the fifth aspect of the invention, the first die is inserted in the part of the metal pipe except for the part of the metal pipe for forming the thick portion, the second die is inserted in the part of the metal pipe for forming the thick portion, and the second die is driven by the drive. This can prevent the inner peripheral surface of the metal pipe from damage or deformation in thickening the metal pipe.

**BRIEF DESCRIPTION OF THE DRAWINGS**

- FIG. 1 is a cross-sectional view illustrating a metal pipe according to a present embodiment fixed to a flange component.
- FIG. 2 is a cross-sectional view illustrating an enlargement of an upstream part of the metal pipe.
- FIG. 3 is a cross-sectional view of a processing device.
- FIG. 4 is a cross-sectional view of a metal pipe before processing.
- FIG. 5 is a cross-sectional view of the metal pipe after expansion.
- FIG. 6 is a cross-sectional view of an outer die.
- FIG. 7 is a side view of a first die.
- FIG. 8 is a side view of a second die.
- FIG. 9 is a view corresponding to FIG. 3 illustrating the expanded metal pipe set in a die.
- FIG. 10 is a view corresponding to FIG. 3 illustrating the metal pipe provided with a thick portion.
- FIG. 11 is a cross-sectional view of the metal pipe after processing.
- FIG. 12 is a side view of an inner die according to an alternative.
- FIG. 13 is a cross-sectional view illustrating a metal pipe provided with a stress concentration portion according to an alternative.

**DESCRIPTION OF EMBODIMENTS**

An embodiment of the present invention will be described in detail below with reference to the drawings. The embodiment will be set forth merely for the purposes of preferred examples in nature, and is not intended to limit the scope, applications, and use of the invention.

FIG. 1 shows a metal pipe 1 of an embodiment of the present invention fixed to a flange component 2. The metal pipe 1 constitutes a pipe of an exhaust manifold, which is part of an exhaust system of an internal combustion system mounted in an automobile (not shown).

In the description of the present embodiment, an upstream part of the metal pipe 1 in a direction of an exhaust stream will be simply referred to as an “upstream part”, and a downstream part of the metal pipe 1 in the direction of the exhaust stream will be simply referred to as a “downstream part” for the sake of easy description.

As shown in FIG. 2, the upstream part of the metal pipe 1 is inserted in a through hole 2α formed in the flange component 2. An outer peripheral surface of the upstream part of the metal pipe 1 is entirely welded to a rim of the through hole 2α of the flange component 2. A reference character C shown in FIGS. 1 and 2 designates weld bead. The flange component 2 forms a flange on the metal pipe 1, and is able to be connected to the other component.

The metal pipe 1 is made of a steel pipe. As shown in FIG. 4, the metal pipe 1 before processing has a uniform
thickness from an end to the other end thereof. The thickness of the metal pipe of the present embodiment is 1.2 mm.

[0045] As shown in FIG. 1, a predetermined portion of the upstream part of the metal pipe 1 is formed as a thick portion 10 which is thicker than the other portion. The thick portion 10 is obtained by a processing method described later. The thick portion 10 is 2.0 mm in thickness.

[0046] An outer diameter of part of the metal pipe 1 corresponds to the thick portion 10 and is larger than an outer diameter of the other part. Thus, the thick portion 10 is thickened to bulge outward from the metal pipe 1. As shown in FIG. 2, part of the outer peripheral surface of the metal pipe 1 at a start end of the thick portion 10 (a downstream end of the thick portion 10) is tapered to increase the outer diameter toward the upstream side to form a diameter-increasing portion 10a. Through the diameter-increasing portion 10a, the thickness of the metal pipe 1 gradually increases.

[0047] A surface 10b which is part of the outer peripheral surface of the metal pipe 1 upstream of the diameter-increasing portion 10a, extends substantially parallel to an axis of the pipe. An axial dimension of the diameter-increasing portion 10a is sufficiently smaller than an axial dimension of the surface 10b.

[0048] A surface 1a which is part of the outer peripheral surface of the metal pipe 1 except for the thick portion 10 extends substantially parallel to the axis of the pipe. A curved surface 1b is formed between the surface 1a and the diameter-increasing portion 10a, and the surface 1a and the diameter-increasing portion 10a are continuously connected through the curved surface 1b. A radius of curvature of the curved surface 1b is 5 mm to 15 mm, both inclusive. The provision of the curved surface 1b reduces the occurrence of stress concentration. When the radius of curvature of the curved surface 1b is smaller than 5 mm, stress generated near the curved surface 1b increases, thereby reducing reliability of the metal pipe 1. When the radius of curvature of the curved surface 1b is larger than 15 mm, a total length of the metal pipe 1 increases, thereby reducing ease of layout.

[0049] An angle α formed by an extension line of the surface 1a of the metal pipe 1 (a dotted line shown in FIG. 2) and the diameter-increasing portion 10a is set to 5° to 25°, both inclusive. When the angle α is smaller than 5°, part of the metal pipe where the thickness gradually increases (a gradually thickening part) becomes longer, thereby reducing the ease of layout of the metal pipe 1. When the angle α exceeds 25°, stress is concentrated too much on part A, and the stress generated at part A exceeds a stress generated at part B. Thus, the angle is preferably set in this range.

[0050] A large diameter portion 1c having a larger diameter than a downstream portion is formed in an inner peripheral surface of an upstream end of the metal pipe 1. Part of the inner peripheral surface downward of the large diameter portion 1c is tapered to form a diameter-reducing portion 1d which has an inner diameter reduced toward the downstream side, and is continuous with the large diameter portion 1c. With the provision of the diameter-reducing portion 1d, the thickness of the upstream end of the metal pipe 1 is gradually reduced toward the large diameter portion 1c. Since the diameter-reducing portion 1d is formed to gradually change the thickness, stress concentration is less likely to occur. An axial dimension of the large diameter portion 1c and an axial dimension of the diameter-reducing portion 1d are significantly smaller than an axial dimension of the thick portion 10.

[0051] A method for processing the metal pipe 1 to provide the thick portion 10 will be described below.

[0052] The metal pipe 1 has a round cross-section before processing. The unprocessed metal pipe 1 has a thickness of 1.2 mm, and an outer diameter of about 40 mm. The unprocessed metal pipe 1 has a length of about 120 mm. The thickness, the outer diameter, and the length of the unprocessed metal pipe 1 described above are merely examples, and are not limited to the above examples.

[0053] As shown in FIG. 5, the metal pipe 1 is expanded. Specifically, part of the metal pipe 1 for forming the thick portion 10 is expanded. Thus, the expansion starts from the part for forming the diameter-increasing portion 10a (shown in FIG. 2), and is finished at the upstream end of the metal pipe 1.

[0054] The expansion is performed using a known expansion device 15. Thus, a shoulder 100 is formed in an axial center of the metal pipe 1. The shoulder 100 is a stress concentration portion of the present invention. In this way, the stress concentration portion is formed, and the expansion device 15 is a stress concentration portion formation device.

[0055] The expanded metal pipe 1 is set in an outer die 20 as shown in FIG. 9. The outer die 20 can be divided into a first member 21 and a second member 22. The first member 21 is provided with a recessed surface 21a which extends along half of the outer peripheral surface of the metal pipe 1 in a circumferential direction. The second member 22 is provided with a recessed surface 22a which extends along the other half of the outer peripheral surface of the metal pipe 1 in the circumferential direction. The first and second members 21 and 22 are fastened and integrated by a fastening member which is not shown with the recessed surfaces 21a and 22a facing to each other. In this state, the recessed surfaces 21a and 22a form a through hole 20a extending in the vertical direction. An inner diameter of an upper half of the through hole 20a is the same as an outer diameter of the expanded portion of the metal pipe 1, and an inner diameter of a lower half of the through hole 20a is the same as an outer diameter of part of the metal pipe 1 except for the expanded portion.

[0056] As shown in FIG. 3, a lower end of the outer die 20 is fixed to a base plate 23. A through hole 23a communicating with a lower end of the through hole 20a of the outer die 20 is formed in the base plate 23 to penetrate the base plate 23 in the vertical direction. An inner diameter of the through hole 23a of the base plate 23 is smaller than an inner diameter of the lower half of the through hole 20 of the outer die 20. As shown in FIG. 9, a downstream end of the metal pipe 1 is brought down from above to be contacted with a rim of the through hole 23a of the base plate 23. The metal pipe 1 is supported by the base plate 23 in this state. The base plate 23 is provided with a recess 23b in which a lower end of the outer die 20 is fitted.

[0057] When the metal pipe 1 is inserted in the outer die 20 with the expanded portion facing upward, the entire outer peripheral surface of the metal pipe 1 is held by the outer die 20. Thus, the pipe is set.

[0058] An inner die 25 is inserted in the metal pipe 1 after the expansion and the setting of the pipe.

[0059] Either of the expansion and the setting of the pipe may be performed first. Specifically, the expansion may be performed after the setting of the pipe.

[0060] As shown in FIGS. 3 and 9, the inner die 25 includes a first die 27 which is inserted in part of the metal pipe 1 except for part of the metal pipe 1 for forming the thick portion 10, a second die 28 which is separated from the first
die 27, and is inserted in the part of the metal pipe 1 for forming the thick portion 10, and a spring 29 provided between the first and second dies 27 and 28.

[0061] The first die 27 is in the shape of a vertically extending column. As shown in FIG. 7, an outer diameter of the first die 27 is substantially the same from an upper end to a lower end thereof, and is substantially the same as an inner diameter of an unexpanded part of the metal pipe 1. Thus, as shown in FIG. 3, the lower end of the first die 27 is inserted in the through hole 23a of the base plate 23. The first die 27 is longer than the unexpanded part of the metal pipe 1.

[0062] As shown in FIG. 7, a tapered portion 27a is formed at the lower end of the first die 27. The first die 27 is provided with a center hole 27b extending along an axis thereof. The center hole 27b is formed to penetrate the first die 27 in the vertical direction. A receiver portion 27c protruding inward of the center hole 27b is formed in part of an inner peripheral surface of the center hole 27b near a vertical center thereof to receive a lower end of the spring 29.

[0063] The second die 28 is also in the shape of a column. As shown in FIG. 8, a first small diameter portion 28a is formed in a lower end of the second die 28. An outer diameter of the first small diameter portion 28a is substantially the same as the outer diameter of the first die 27. A tapered portion 28b which has a diameter reducing downward, and is continuous from the first small diameter portion 28a is formed upward of the first small diameter portion 28a of the second die 28. A second small diameter portion 28c is formed upward of the tapered portion 28b of the second die 28. The second small diameter portion 28c has a larger diameter than the first small diameter portion 28a.

[0064] An outer diameter of a body 28d of the second die 28 upward of the second small diameter portion 28c is substantially the same as an inner diameter of an upper part of the through hole 20a of the outer die 20. A step 28e is formed between the body 28d and the second small diameter portion 28c. The upstream end of the metal pipe 1 is fitted in the step 28e.

[0065] The second die 28 is provided with a threaded hole 28f extending along an axis thereof. The threaded hole 28f is opened in an upper end surface of the second die 28. A spring insertion hole 28g is formed in a lower part of the second die 28 in which the spring 29 is inserted. An upper end of the spring 29 abuts a bottom of the spring insertion hole 28g.

[0066] As shown in FIG. 3, a plate 30 is fitted to an upper end of the second die 28 with a bolt 31. A bolt insertion hole 30a in which the bolt 31 is inserted is formed in a center of the plate 30. The bolt 31 inserted in the bolt insertion hole 30a is screw-fitted to the threaded hole 28f of the second die 28.

[0067] A drive 33 is coupled to the plate 30. The drive 33 is provided to move the second die 28 in the vertical direction. In inserting the inner die 25 in the metal pipe 1, the first die 27 is inserted in the metal pipe 1, and then the second die 28 is inserted. As the second die 28 is inserted, the spring 29 is pressed downward, thereby pressing the first die 27 downward. Thus, the lower end of the first die 27 is inserted in the through hole 23a of the base plate 23.

[0069] When the inner die 25 is inserted in the metal pipe 1, space S for forming the thick portion 10 is provided between the inner die 25 and the outer die 20 as shown in FIG. 9.

[0070] When the second die 28 is pushed downward by the drive 33 as indicated by an outline arrow in FIG. 9, a downward pressure is acted on the upper end of the metal pipe 1. The pressed metal pipe 1 generates a compressive stress. However, since the cross section of the metal pipe 1 is not uniform, but is partially changed by forming the shoulder 100 through the expansion, high stress is concentrated on the shoulder 100. As a result, the shoulder 100 starts to be deformed. The provision of the shoulder 100 makes a force required to start the deformation smaller as compared with the case where the shoulder 100 is not formed. Thus, unlike the conventional examples, the metal pipe 1 can be deformed without reducing the deformation pressure by heating the pipe. Specifically, there is no need to heat the pipe to a temperature of about 300° C. or higher for easy processing, i.e., so-called cold processing can be performed.

[0071] When the second die 28 is further moved downward by the drive 33, deformation of part of the metal pipe upward of the shoulder 100 starts from the deformed shoulder 100. The deformation occurs in the space S between the outer die 20 and the inner die 5, and the deformed part of the metal pipe 1 is molded between the inner peripheral surface of the outer die 20 and the outer peripheral surface of the inner die 25 to become the thick portion 10. FIG. 11 shows the processed metal pipe 1.

[0072] A thickness of part of the metal pipe 1 except for the expanded part is not greatly changed for the following reasons. Specifically, a small clearance is provided between the outer die 20 and the outer peripheral surface of the metal pipe 1, and between the inner die 25 and the inner peripheral surface of the metal pipe 1 in view of moldability. In forming the shoulder 100 as the stress concentration portion, the pressure is used to form the shoulder 100. Thus, a stress caused in part of the metal pipe 1 downward of the shoulder 100 is reduced, and change in thickness of the part of the metal pipe 1 except for the expanded part is reduced.

[0073] The drive 33 moves the second die 28 only, and the first die 27 is kept stationary. Thus, the first die 27 does not axially rub part of the inner peripheral surface except for part thereof for forming the thick portion 10. This can prevent the part of the metal pipe 1 except for the part for forming the thick portion 10 from damage or deformation.

[0074] The expansion device 15, the outer die 20, the inner die 25, the base plate 23, the plate 30, and the drive 33 constitute a processing device of the present invention.

[0075] As shown in FIG. 1, the upstream end of the metal pipe 1 processed as described above is inserted in the through hole 2a of the flange component 2, and is welded to the rim of the through hole 2a of the flange component 2.

[0076] When a downward load is applied to the downstream end of the metal pipe 1 with the metal pipe 1 fixed to the flange component 2, a stress is generated in every part of the metal pipe. At this time, parts enclosed with circles A and B in FIG. 2 tend to experience a high stress. Since the angle α formed between the diameter-increasing portion 10a and the surface 1a of the metal pipe 1 is set to 25° or smaller, the stress caused at the part enclosed with circle A is smaller than the stress caused at part B. Specifically, as compared with the stress caused at the welded part of the metal pipe 1 (the part enclosed with circle B), a stress caused at the other part (the part enclosed with circle A) is smaller. Thus, in use, the other part does not break earlier than the welded part.

[0077] According to the present embodiment described above, the metal pipe 1 including the shoulder 100 formed in the axial center of the metal pipe 1 is set in the outer die 20, and an axial pressure is then applied to the metal pipe 1 with the inner die 25 inserted in the metal pipe 1 to concentrate the stress on the shoulder 100 to deform the shoulder 100. Then,
the thick portion 10 is formed from the deformed portion as a starting point. Thus, unlike the conventional examples, there is no need to heat the metal pipe 1 to high temperature to reduce the deformation resistance. This can improve production efficiency and dimensional accuracy, and can reduce energy consumption. Thus, the metal pipe which is lightweight, and has a required strength in a required portion can be obtained with high precision at low cost.

[0078] The shoulder 100 is formed in the metal pipe 1, and the shoulder 100 is used as the stress concentration portion. Thus, the stress concentration can reliably be caused when the pressure is applied, and the thick portion 10 can be formed as desired.

[0079] Since the shoulder 100 is formed by expanding the metal pipe 1, the shoulder 100 can easily be obtained, and the metal pipe 1 can be obtained at lower cost.

[0080] In the above embodiment, the inner die 25 is configured to be dividable into the first die 27 and the second die 28. However, the inner die 25 is not limited thereto, and the first die 27 and the second die 28 may be integrated as those of an alternative shown in FIG. 12. The inner die 25 of the alternative is also provided with a step 25s in which the upstream end of the metal pipe 1 is fitted. The integrated inner die 25 of this alternative can reduce the parts count, and can reduce the cost. Further, the metal pipe 1 can be molded with higher precision because misalignment between the first die 27 and the second die 28 does not occur.

[0081] In the above-described embodiment, the shoulder 100 is formed in the metal pipe 1, and the shoulder 100 is used as the stress concentration portion. However, the stress concentration portion is not limited to the shoulder. For example, as shown in FIG. 13, a protrusion 101 may be formed as the stress concentration portion. The protrusion 101 may be replaced with a recess. Alternatively, a thin portion may be formed as the stress concentration portion.

[0082] In the above-described embodiment, the thick portion 10 is formed to bulge outward from the outer peripheral surface of the metal pipe 1. However, the thick portion 10 is not limited thereto, and may be formed to bulge inward from the inner peripheral surface of the metal pipe 1.

[0083] Materials of the metal pipe 1 are not limited as long as they can be used for deformation processing, and various types of materials can be used.

[0084] The metal pipe 1 can be used not only as a part of exhaust systems of automobiles, but can also be used as, e.g., air pipes, liquid pipes, etc.

[0085] The diameter of the metal pipe 1 is not particularly limited. For example, the diameter may be about several tens cm.

INDUSTRIAL APPLICABILITY

[0086] As described above, the present invention can be applied to, for example, metal pipes constituting an exhaust system of an automobile.

DESCRIPTION OF REFERENCE CHARACTERS

[0087] 1 Metal pipe
[0088] 2 Flange component
[0089] 10 Thick portion
[0090] 15 Expansion device (stress concentration portion formation device)
[0091] 20 Outer die
[0092] 25 Inner die
[0093] 27 First die
[0094] 28 Second die
[0095] 29 Spring
[0096] 33 Drive
[0097] 100 Shoulder (stress concentration portion)
[0098] 101 Protrusion (stress concentration portion)

1. A method for processing a metal pipe to make part of the metal pipe in an axial direction thereof into a thick portion thicker than a different portion, the method comprising:
   forming a stress concentration portion in an axial center of the metal pipe to concentrate a stress on the stress concentration portion when an axial pressure is applied to the metal pipe;
   setting the metal pipe in an outer die for holding an outer peripheral surface of the metal pipe; and
   forming the thick portion by inserting an inner die in the metal pipe to provide space for forming the thick portion between the inner die and the outer die, and applying the axial pressure to the metal pipe to concentrate the stress on the stress concentration portion to deform the stress concentration portion after the forming of the stress concentration portion and the setting of the metal pipe, thereby forming the thick portion from the deformed stress concentration portion as a starting point.

2. The method of claim 1, wherein a shoulder is formed in the metal pipe in the forming of the stress concentration portion to use the shoulder as the stress concentration portion.

3. The method of claim 2, wherein the shoulder is formed by expanding the metal pipe in the forming of the stress concentration portion.

4. A device for processing a metal pipe to make part of the metal pipe in an axial direction thereof into a thick portion thicker than a different portion, the device comprising:
   a stress concentration portion formation device for forming a stress concentration portion in an axial center of the metal pipe to concentrate a stress on the stress concentration portion when an axial pressure is applied to the metal pipe;
   an outer die for holding an outer peripheral surface of the metal pipe;
   an inner die which is inserted in the metal pipe to provide space for forming the thick portion between the outer die and the inner die, and comes into contact with an end of the metal pipe; and
   a drive which presses the inner die in the axial direction of the metal pipe to apply an axial pressure to the end of the metal pipe.

5. The device of claim 4, wherein the inner die includes a first die which is inserted in part of the metal pipe except for part of the metal pipe for forming the thick portion, and a second die which is separated from the first die, and is inserted in the part of the metal pipe for forming the thick portion, and the second die is driven by the drive.

6. A metal pipe processed by the method of claim 1.
7. A metal pipe processed by the method of claim 2.
8. A metal pipe processed by the method of claim 3.

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