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(54) **HOT PRESS FORMING DEVICE FOR COATED STEEL AND HOT PRESS FORMING METHOD USING SAME**

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(57) **ABSTRACT**

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The present invention relates to a hot press forming device for coated steel and a hot press forming method using the same, which can reduce the generation of fine cracks of a molding and can obtain uniform material properties.

§ 371 (c)(1),

(2) Date: **Oct. 16, 2015**

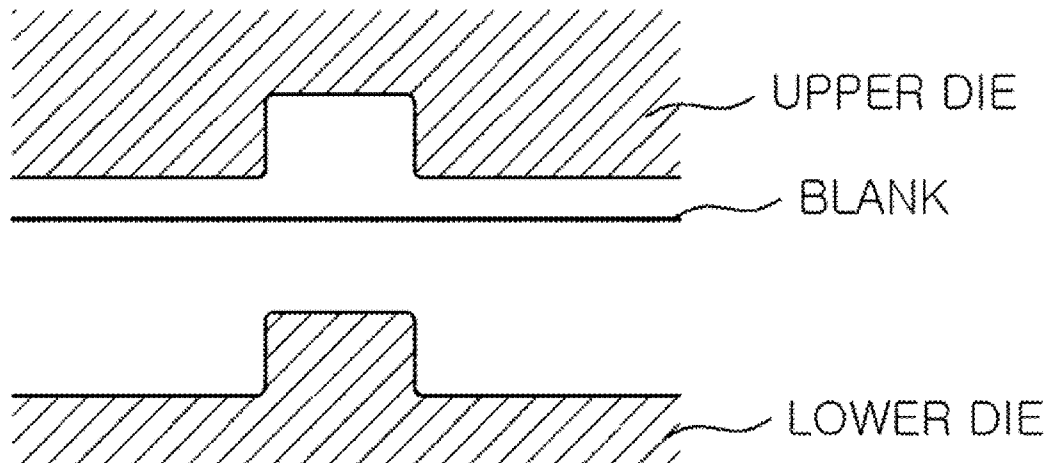


FIG. 1

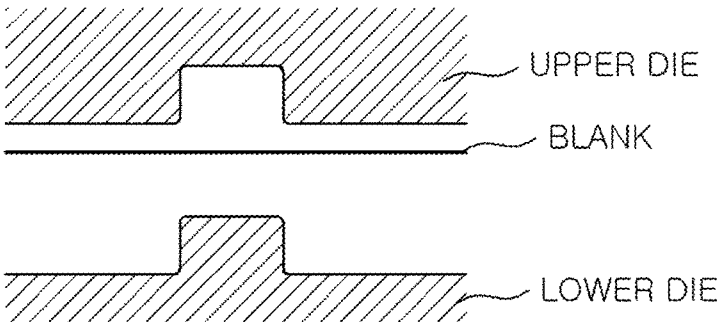


FIG. 2

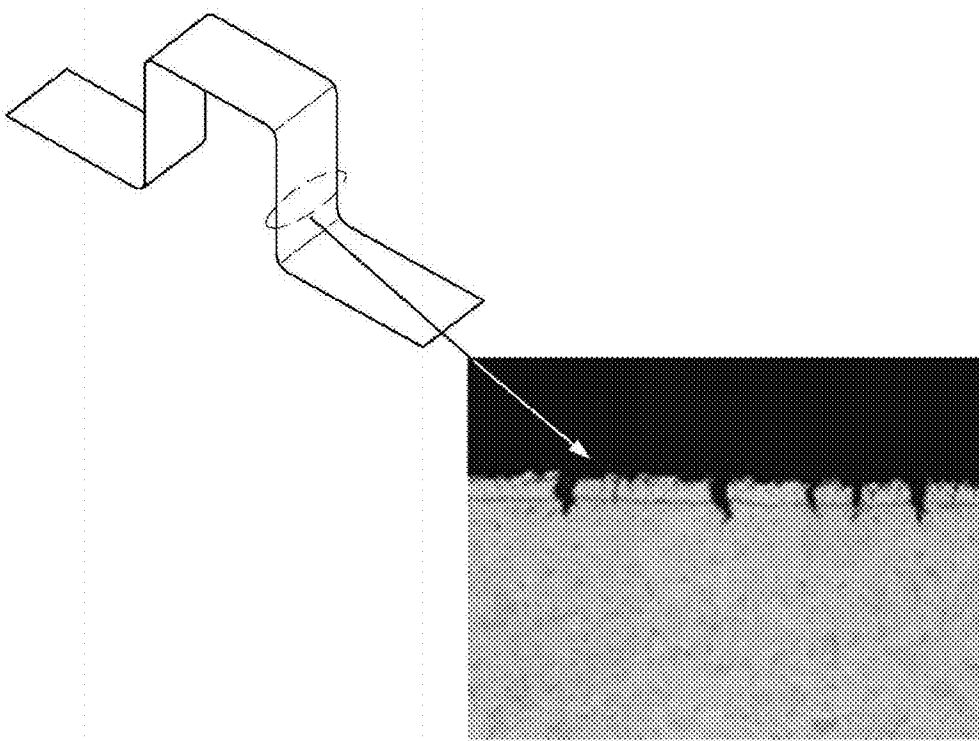


FIG. 3

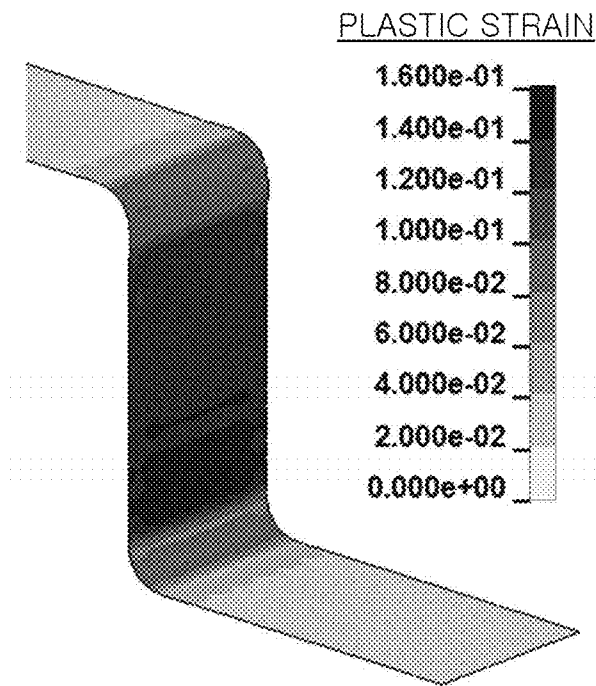


FIG. 4

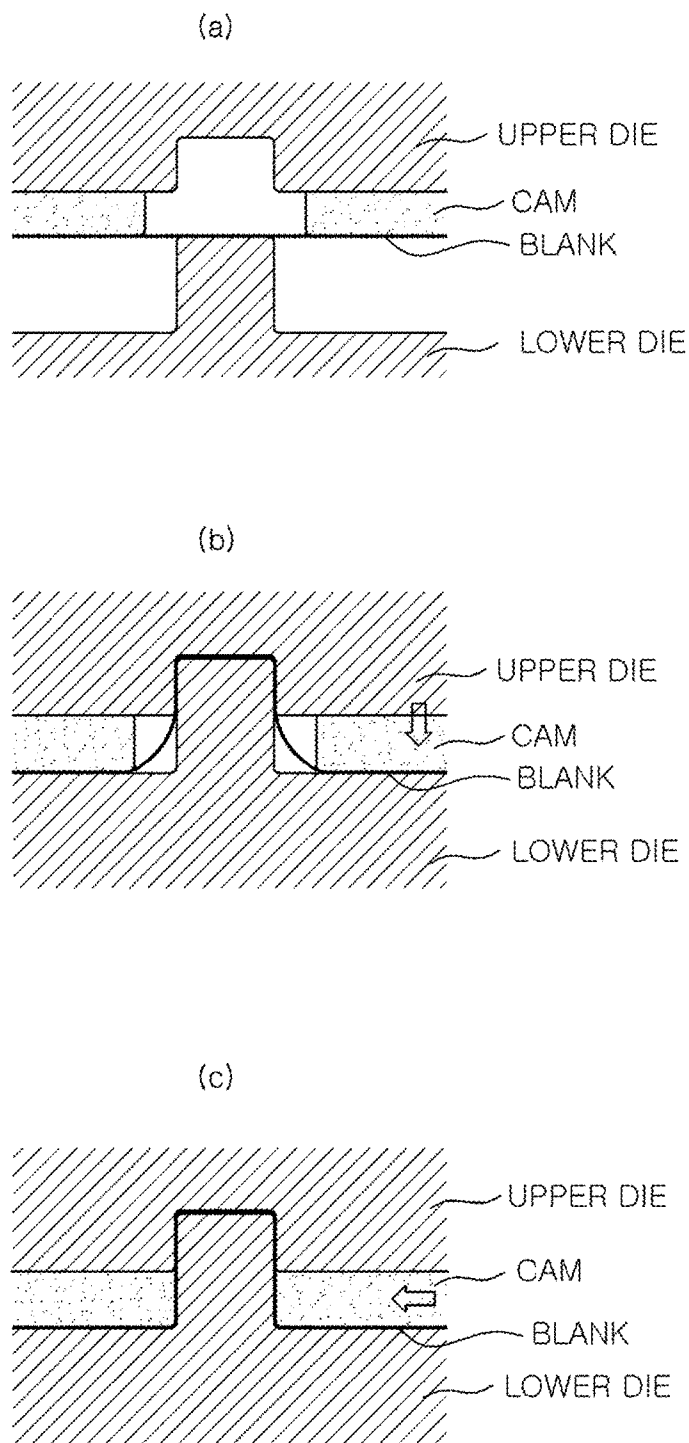


FIG. 5

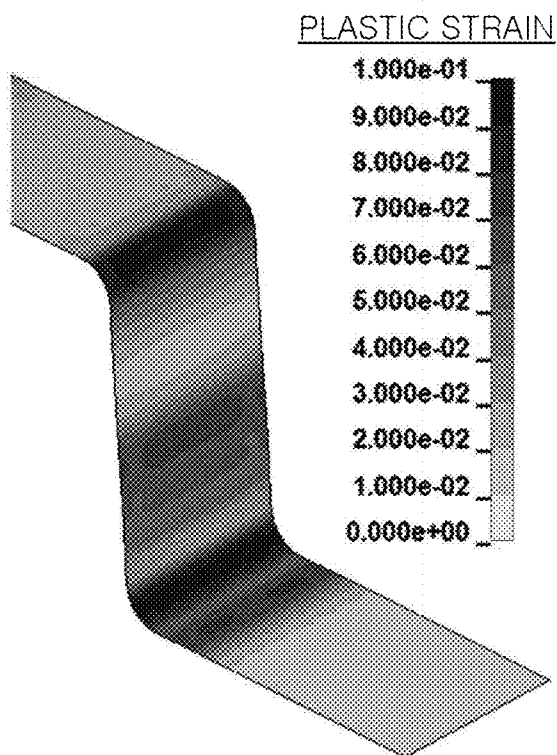


FIG. 6

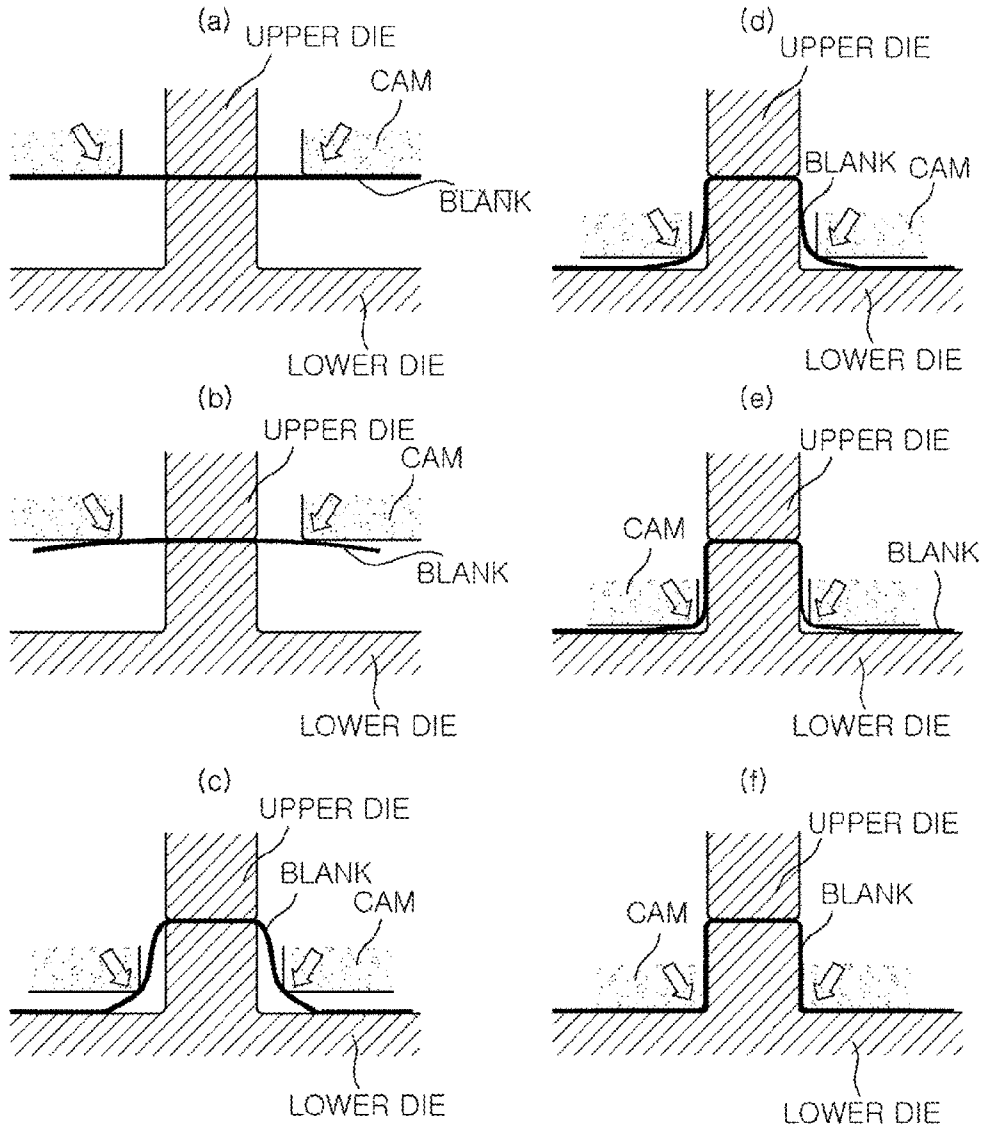


FIG. 7

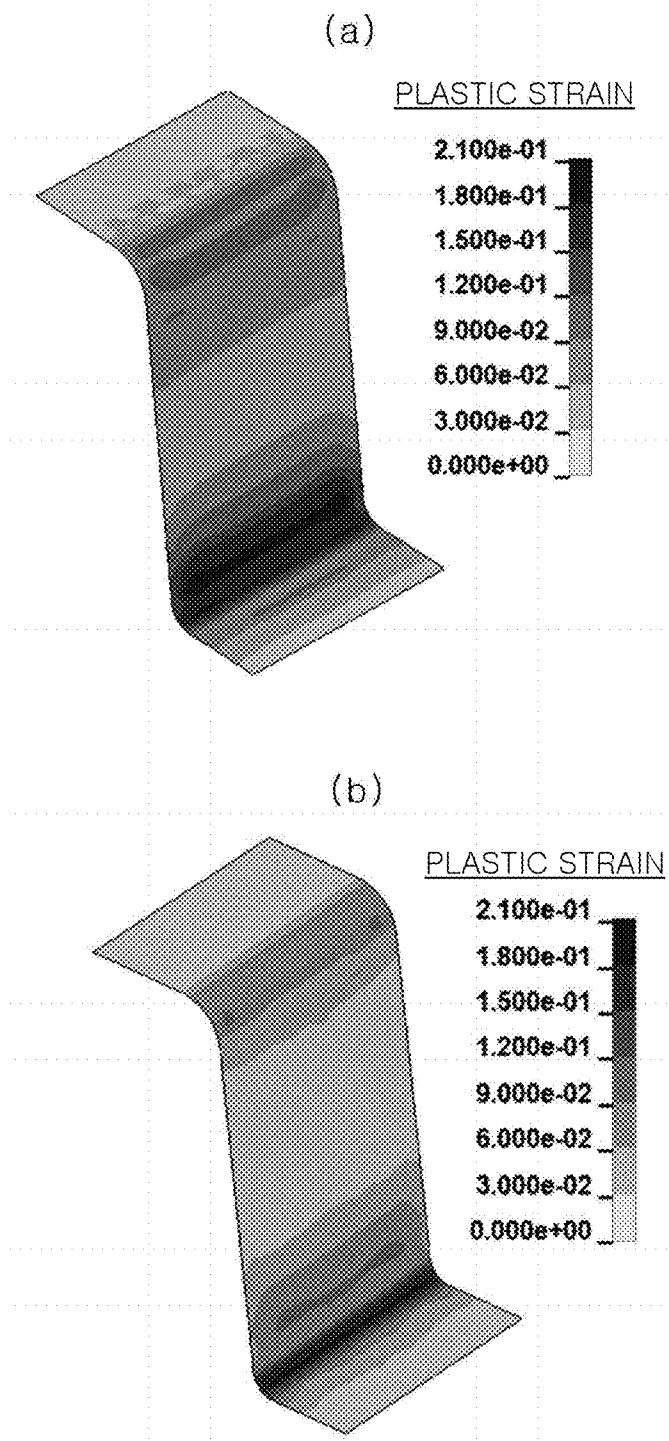
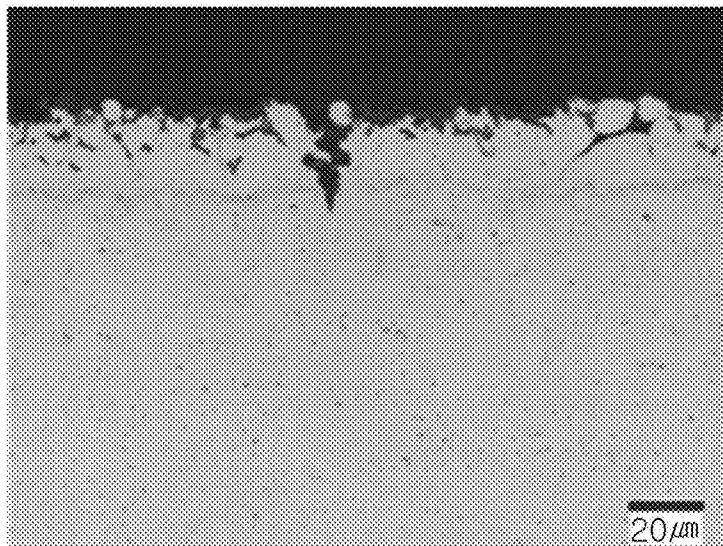
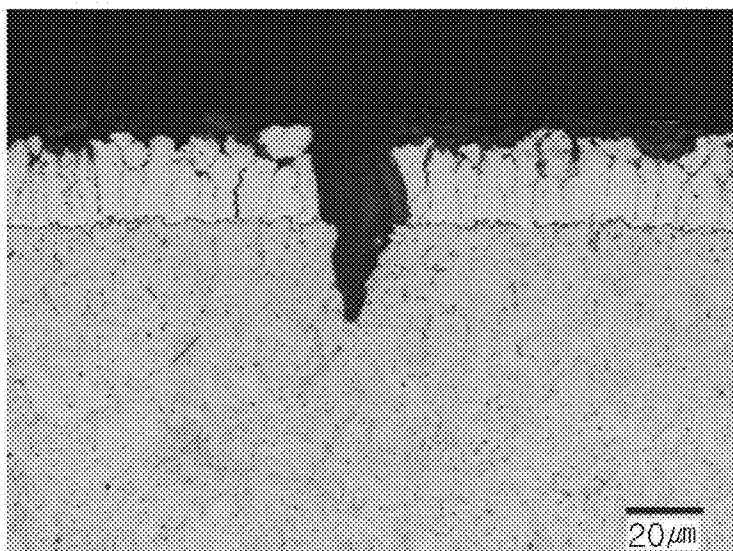


FIG. 8

(a)



(b)



HOT PRESS FORMING DEVICE FOR COATED STEEL AND HOT PRESS FORMING METHOD USING SAME

BACKGROUND

[0001] 1. Technical Field

[0002] The present disclosure relates to a hot press forming (HPF) device and an HPF method using the HPF device, and more particularly, to an HPF device and method for forming coated steel.

[0003] 2. Background Art

[0004] Recently, automobile manufactures have increased the use of high-strength materials in order to manufacture eco-friendly, fuel-saving, light automotive parts satisfying social needs. However, high-strength materials are difficult to form into desired shapes because of problems such as spring back and difficulty in maintaining dimensions, and thus the use of high-strength materials is limited.

[0005] These problems related with formability may be solved by manufacturing high-strength parts in a way of forming high-strength materials into desired shapes at high temperatures guaranteeing good formability, and rapidly cooling the formed high-strength materials in dies. This method is called "hot press forming (HPF)." Parts having a degree of strength equal to or greater than 1500 MPa may be manufactured by the HPF method.

[0006] In an HPF process of the related art, steel blanks are heated to 900° C. or higher and are then pressed. However, when steel blanks are heated, scale may form on the surfaces of the steel blanks due to oxidation. Therefore, after the HPF process, additional processes such as a shot blasting process may be performed to remove scale from formed products. In addition, the corrosion resistance of products manufactured by the HPF method is inferior to that of coated products.

[0007] To address these problems, U.S. Pat. No. 6,296,805 (Patent Document 1) has proposed a method of forming an aluminous coating layer on a steel sheet, the aluminous coating layer withstanding severe environments of a heating furnace, suppressing the oxidation of the steel sheet, and forming a corrosion resistant aluminum (Al) passive film on the steel sheet.

[0008] However, although such Al-coated materials have a high degree of resistance to high temperatures, the corrosion resistance of the Al-coated materials is inferior to the corrosion resistance of materials coated with zinc (Zn) by a sacrificial anode method, and the manufacturing costs of the Al-coated materials are high. Therefore, there has been increasing interest in methods of using Zn-coated materials.

[0009] However, if Zn-coated materials are heated to a high temperature and are then formed into parts, micro cracks having a size of about 10 μm to 30 μm may be formed in walls of the parts, thereby deteriorating the properties of the parts such as bendability. Therefore, the application of Zn-coated materials is limited.

DESCRIPTION

Technical Problem

[0010] Aspects of the present disclosure may provide a hot press forming (HPF) device for performing an HPF process on coated steel, particularly zinc (Zn)-coated steel while reducing the formation of microcracks in a formed product

and imparting uniform properties to the formed product, and an HPF method using the HPF device.

Technical Solution

[0011] According to an aspect of the present disclosure, a hot press forming (HPF) device for forming coated steel may include an upper die and a lower die, wherein the upper and lower dies may constrain a portion of a blank, and the HPF device may further include a cam configured to form another portion of the blank not constrained by the upper and lower dies in order to form a shaped portion.

[0012] According to another aspect of the present disclosure, an HPF method for forming coated steel may include: heating a blank; forming the heated blank using an HPF device; and cooling the formed blank, wherein in the forming of the heated blank, a portion of the heated blank may be constrained by upper and lower dies of the HPF device, and another portion of the heated blank not constrained by the upper and lower dies may be formed by a cam in order to form a shaped portion.

Advantageous Effects

[0013] According to the present disclosure, when coated steel such as zinc (Zn)-coated steel is processed through a hot press forming (HPF) process, the formation of micro cracks in formed products may be reduced, and the formed products may have a high degree of formability such as bendability. In addition, formed products having high quality may be produced, and particularly, shaped portions of the formed products may have uniform properties.

DESCRIPTION OF DRAWINGS

[0014] FIG. 1 is a schematic view illustrating a hot press forming (HPF) device and method of the related art.

[0015] FIG. 2 is a view illustrating a shaped portion of a formed product manufactured by an HPF method of the related art.

[0016] FIG. 3 is a schematic view illustrating plastic strain in the formed product manufactured by the HPF method of the related art.

[0017] FIG. 4 is a schematic view illustrating an exemplary HPF device and method according to an exemplary embodiment of the present disclosure.

[0018] FIG. 5 is a schematic view illustrating plastic strain in a formed product manufactured according to the exemplary embodiment of the present disclosure.

[0019] FIG. 6 is a schematic view illustrating an exemplary HPF device and method according to another exemplary embodiment of the present disclosure.

[0020] FIG. 7(a) is a schematic view illustrating plastic strain in a formed product manufactured by a method of the related art, and FIG. 7(b) is a schematic view illustrating plastic strain in a formed product manufactured according to the other exemplary embodiment of the present disclosure.

[0021] FIG. 8(a) is an image of a shaped portion of a formed product manufactured by a method of the related art, and FIG. 8(b) is an image of a shaped portion of the formed product manufactured according to the other exemplary embodiment of the present disclosure.

BEST MODE

[0022] The inventors have found that if coated steel, particularly zinc (Zn)-coated steel, is subjected to a hot press

forming (HPF) process, formed parts (formed products) have micro cracks (very small cracks or microcracks), and the properties of the formed products are not uniform because of non-uniform cooling at shaped portions of the formed products. Thus, the inventors have conducted research to solve these problems.

[0023] Exemplary embodiments of the present disclosure will now be described in detail with reference to the accompanying drawings. However, the accompanying drawings are for illustrative purposes only and are not intended to limit the scope of the present invention.

[0024] FIG. 1 is a schematic view illustrating an HPF process of the related art. As illustrated in FIG. 1, in an HPF process, a heated blank is placed between an upper die and a lower die and is then pressed using the upper and lower dies to produce a formed product.

[0025] FIG. 2 illustrates a surface of a shaped portion of coated steel after the coated steel is processed by an HPF method of the related art as illustrated in FIG. 1. As illustrated in FIG. 2, formed products made of coated steel through an HPF process of the related art had micro cracks in shaped portions of the formed products.

[0026] To analyze reasons for this, plastic strain in a formed product illustrated in FIG. 2 was analyzed, and results of the analysis are illustrated in FIG. 3. As illustrated in FIG. 3, the formed product produced using an HPF device of the related art had an excessive amount of plastic deformation at the shaped portion of the formed product, and micro cracks were formed in the shaped portion.

[0027] In detail, micro cracks were formed in a wall of the shaped portion, especially at a lower end portion of the wall of the shaped portion because of concentrated deformation on the lower end portion. The design shape of the formed product may be modified to reduce deformation. However, it may not be easy to modify the design shape of the formed product because of limitations to the change of design. Therefore, the inventors have invented a method of using a cam for reducing deformation and micro cracks.

[0028] In addition, when a blank is pressed between upper and lower dies, the thickness of the blank is reduced at a shaped portion of the blank, and a narrow gap is formed between the blank and the upper and lower dies. As a result, when the blank is cooled in the dies after the blank is pressed, the blank is not uniformly cooled, and thus properties of the shaped portion of the blank are deteriorated.

[0029] Therefore, the inventors have invented an HPF device configured to prevent the generation of micro cracks in formed products and impart uniform properties to formed products, and an HPF method using the HPF device.

[0030] First, the HPF device of the present disclosure will be described in detail.

[0031] The HPF device of the present disclosure includes: an upper die and a lower die configured to constrain a portion of a blank; and a cam configured to deform a non-constrained portion of the blank to form a shaped portion.

[0032] The cam forms a shaped portion while moving in a direction different from directions in which the upper and lower dies move.

[0033] FIG. 4 is a schematic view illustrating an exemplary HPF device according to an exemplary embodiment of the present disclosure. As shown in FIG. 4, the HPF device of the exemplary embodiment of the present disclosure includes upper and lower dies, and cams between the upper and lower dies. An HPF device of the related art such as that illustrated

in FIG. 1 includes no cam, and when a blank is pressed using the HPF device of the related art, upper and lower dies of the HPF device are used to constrain the blank.

[0034] However, when a blank is pressed using the HPF device of the exemplary embodiment of the present disclosure, the upper and lower dies constrain a portion of the blank, and a non-constrained portion of the blank is formed using the cams to form a shaped portion. In the HPF device illustrated in FIG. 4, the cams move in horizontal directions independent of the upper and lower dies moving in vertical directions, in order to form a shaped portion.

[0035] When the shaped portion is formed, the plastic deformation of the shaped portion is distributed by the cams. That is, as illustrated in FIG. 4, when a blank is pressed into a desired shape using the HPF device of the exemplary embodiment of the present disclosure, the upper and lower dies constrain and shape a portion of the blank, and the cams move to shape another portion of the blank not constrained by the upper and lower dies.

[0036] In the HPF device illustrated in FIG. 4, the cams are provided in addition to the upper and lower dies.

[0037] FIG. 5 illustrates plastic strain in a formed product manufactured using the HPF device illustrated in FIG. 4, the plastic strain being measured by analysis on forming. When the results shown in FIG. 5 are compared with the results shown in FIG. 3, the plastic deformation of a shaped portion of the formed product produced using the HPF device of the exemplary embodiments of the present disclosure is markedly reduced. Therefore, the formation of micro cracks may be markedly reduced in products manufactured using the HPF device of the exemplary embodiment of the present disclosure.

[0038] Another exemplary HPF device is illustrated in FIG. 6 according to another exemplary embodiment of the present disclosure. In the HPF device illustrated in FIG. 6, cams are provided separate from upper and lower dies.

[0039] In the HPF device illustrated in FIG. 6, the upper and lower dies constrain a blank to fix the blank, and forming of the blank is performed substantially by the cams. That is, the upper and lower dies fix the blank, and the cams form the blank while moving at predetermined angles.

[0040] FIG. 7(b) illustrates plastic strain in a formed product manufactured using the HPF device illustrated in FIG. 6, the plastic strain being measured by analysis on forming. FIG. 7(a) illustrates plastic strain in a formed product produced by a method of the related art. Referring to FIGS. 7(a) and 7(b), the plastic strain in the formed product (FIG. 7(b)) produced by the HPF device of the other exemplary embodiment of the present disclosure is much lower than the plastic strain in the formed product (FIG. 7(a)) produced by the related-art method.

[0041] In addition, FIG. 8(a) illustrates a surface of a shaped portion of the formed product manufactured using the HPF device illustrated in FIG. 6, and FIG. 8(b) illustrates a surface of a shaped portion of a formed product manufactured using an HPF device of the related art. Referring to FIG. 8(a), the formed product manufactured using the HPF device of the other exemplary embodiment of the present disclosure does not have a large micro crack developed to base steel. However, referring to FIG. 8(a), a large micro crack is formed in base steel of the formed product.

[0042] In addition, an exemplary embodiment of the present disclosure provides an HPF method for forming coated steel. Hereinafter, the HPF method will be described in detail.

[0043] According to the HPF method of the exemplary embodiment of the present disclosure, a prepared blank is heated and formed in an HPF device.

[0044] As illustrated in FIG. 4 and FIG. 6, upper and lower dies of the HPF device are used to constrain a portion of the blank, and cams of the HPF device are used to form a non-constrained portion of the blank to form a shaped portion.

[0045] In the example illustrated in FIG. 4, the upper and lower dies of the HPF device are used to constrain and form a portion of the blank, and the cams of the HPF device are used to form a non-constrained portion of the blank while moving to the non-constrained portion of the blank to complete forming. Unlike this, in the example illustrated in FIG. 6, although the upper die constrains the lower die, the upper and lower dies are not involved in forming, and the cams form a portion of the blank while being moved.

[0046] According to an HPF method of the related art as shown in FIG. 1, when a portion of a blank is formed, the portion of the blank continuously undergoes plastic deformation due to friction. Therefore, the portion has a large amount of plastic deformation after the forming, and thus micro cracks may be formed in the shaped portion. As a result, formed products having poor bendability and formability may be manufactured. Moreover, a shaped portion having undergone continuous deformation may have a more reduced thickness than the other portion. In this case, when the blank is cooled, since the shaped portion is not in uniform contact with the dies, the shaped portion may not be uniformly cooled, and thus may have non-uniform properties.

[0047] However, according to the HPF method of the exemplary embodiment of the present disclosure, as illustrated in FIGS. 4 and 6, when a portion of the blank is formed, the portion does not continuously undergo plastic deformation, thereby preventing the formation of micro cracks in the portion and a decrease in the thickness of the portion. In addition, since the cams push the portion against the dies, the portion and the dies may be reliably brought into contact with each other, and after the blank is cooled, the portion may have uniform properties.

[0048] Meanwhile, the blank may be uniformly heated to have the same temperature, or may be heated to a relatively high temperature in some region and a relatively low temperature in the other region in order to produce a multi-strength formed product.

[0049] In detail, the entire region of the blank may be heated to a temperature equal to or higher than an A3 temperature of the blank, or the blank may be heated to a temperature equal to or higher than the A3 temperature in a predetermined region and to a temperature equal to or lower than an A1 temperature of the blank in another region.

[0050] In the former case, the entire region of a product formed by the HPF method may have a high degree of strength, and in the latter case, a multi-strength product may

be formed by the HPF method. The multi-strength product may have a relatively high degree of strength in a region heated to a relatively high temperature and a relatively low degree of strength in a region heated to a relatively low temperature.

[0051] In the above, any heating method may be used. That is, any method used in the related art to heat steel may be used. For example, the blank may be heated in the atmosphere of a heating furnace or using an induction heating device.

[0052] After the blank is completely formed, the blank is cooled. For example, the blank may be indirectly cooled by cooling the dies of the HPF device. However, cooling of the blank is not limited thereto. In addition, cooling conditions generally used in an HPF method of the related art may be used.

1. A hot press forming (HPF) device for forming coated steel, the HPF device comprising an upper die and a lower die, wherein the upper and lower dies constrain a portion of a blank, and the HPF device further comprises a cam configured to form another portion of the blank not constrained by the upper and lower dies in order to form a shaped portion.

2. The HPF device of claim 1, wherein the cam is moved in a direction different from directions in which the upper and lower dies are moved.

3. The HPF device of claim 1, wherein the cam is disposed between the upper and lower dies.

4. The HPF device of claim 1, wherein the cam is separate from a portion of the upper die or the lower die.

5. An HPF method for forming coated steel, the HPF method comprising:

- heating a blank;
- forming the heated blank using an HPF device; and
- cooling the formed blank,

wherein in the forming of the heated blank, a portion of the heated blank is constrained by upper and lower dies of the HPF device, and another portion of the heated blank not constrained by the upper and lower dies is formed by a cam in order to form a shaped portion.

6. The HPF method of claim 5, wherein in the forming of the heated blank, the cam is moved in a direction different from directions in which the upper and lower dies are moved.

7. The HPF method of claim 5, wherein the cam is disposed between the upper and lower dies.

8. The HPF method of claim 5, wherein the cam is separate from a portion of the upper die or the lower die.

9. The HPF method of claim 5, wherein in the heating of the blank, the blank is entirely heated to a temperature equal to or higher than an A3 temperature of the blank, or the blank is heated to a temperature equal to or higher than the A3 temperature of the blank in a predetermined region and to a temperature equal to or lower than an A1 temperature of the blank in another region.

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