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

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.
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.

[Technical Field]

[0001] 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.

[Background Art]

[0002] 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.

[0003] 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.

[0004] 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.

[0005] To address these problems, 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.

[0006] 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.

[0007] 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.


[Technical Problem]

[0009] 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]

[0010] 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.

[0011] 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]

[0012] 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]

[0013] FIG. 1 is a schematic view illustrating a hot press forming (HPF) device and method of the related art. FIG. 2 is a view illustrating a shaped portion of a formed product manufactured by an HPF method of the related art.

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

FIG. 4 is a schematic view illustrating an exemplary HPF device and method according to an exemplary
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.

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.

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.

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

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.

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

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.

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.

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.

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

FIG. 5 illustrates plastic strain in a formed product manufactured according to the other exemplary embodiment of the present disclosure.
uct 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 embodiment 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] According to the HPF method of the exemplary embodiment of the present disclosure, a prepared blank is heated and formed in an HPF device.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

Claims

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.
FIG. 1

[Diagram showing Upper Die, Blank, and Lower Die]
FIG. 5

PLASTIC STRAIN

1.000e-01
9.000e-02
8.000e-02
7.000e-02
6.000e-02
5.000e-02
4.000e-02
3.000e-02
2.000e-02
1.000e-02
0.000e+00
FIG. 7

(a) PLASTIC STRAIN

(b) PLASTIC STRAIN
FIG. 8

(a)

(b)
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
B21D 37/16(2006.01)i, B21D 53/04(2006.01)i, B30B 15/3(2006.01)i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
B21D 37/10; B21D 37/08; B82B 3/00; B30B 11/02; B21D 5/01; B21D 22/00; B30B 15/34; B21D 24/04; C21D 7/13; B21D 53/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models; IPC as above
JPO Utility models; IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: hot, press, molding, mold, die, cam

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>JP 2009-101421 A (PRESS KOGYO CO., LTD.) 14 May 2009 See paragraphs [0012], [0013]; claims 1, 2, and figures 1, 6-9.</td>
<td>1-4</td>
</tr>
<tr>
<td>Y</td>
<td>KR 10-1033616 B1 (HYUNDAI HYSCO CO., LTD.) 09 May 2011 See paragraphs [0046], [0049]; claim 1; and figure 6.</td>
<td>5-9</td>
</tr>
<tr>
<td>A</td>
<td>JP 2013-039696 A (IHI AEROSPACE CO., LTD. et al.) 28 February 2013 See paragraphs [0021]-[0026]; and figure 2.</td>
<td>1-9</td>
</tr>
<tr>
<td>A</td>
<td>JP 2009-023000 A (KOBE STEEL LTD.) 05 February 2009 See paragraph [0048]; and figure 18.</td>
<td>1-9</td>
</tr>
<tr>
<td>A</td>
<td>KR 10-2013-0015633 A (PUSAN NATIONAL UNIVERSITY INDUSTRY-UNIVERSITY COOPERATION FOUNDATION) 14 February 2013 See paragraphs [0035]-[0040], [0057]-[0059]; and figures 2, 4.</td>
<td>1-9</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search 26 MARCH 2014 (26.03.2014)

Date of mailing of the international search report 26 MARCH 2014 (26.03.2014)

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
Government Complex-Daejeon, 389 Seoumunsan-ro, Daejeon 305-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer

Telephone No.
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP 2009-101421 A</td>
<td>14/05/2009</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>KR 10-1033861 B1</td>
<td>09/05/2011</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>JP 2013-039696 A</td>
<td>28/02/2013</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2004-154859 A</td>
<td>03/06/2004</td>
</tr>
<tr>
<td>KR 10-2013-0015633 A</td>
<td>14/02/2013</td>
<td>NONE</td>
<td></td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (patent family annex) (July 2009)
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

• US 6296805 B [0008]