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Ichikawa

(54) STEEL SHEET HEATING DEVICE, METHOD FOR PRODUCING PRESS-FORMED PART, AND PRESS-FORMED PART

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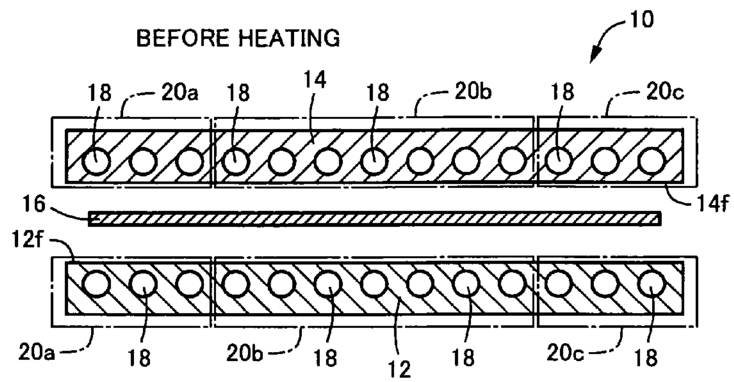
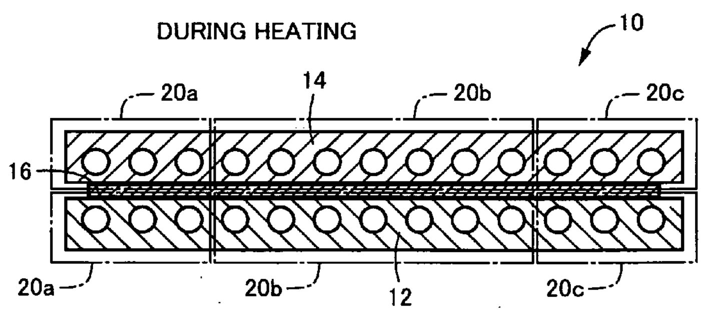
(52) **U.S. Cl.** .......... **148/645**; 266/249; 266/160; 148/320

(57) **ABSTRACT**

It is provided a steel sheet heating device that heats a flat steel sheet, including: a hot plate having a flat heating surface brought into close contact with the steel sheet; and a plurality of heating equipment able to heat a plurality of heating regions, formed by dividing the heating surface of the hot plate into a plurality of sections, to different heating temperatures at the same time, wherein the steel sheet is heated to different temperatures at various portions based on the heating temperatures of the plurality of heating regions of the heating surface, at the same time through a single heating treatment.



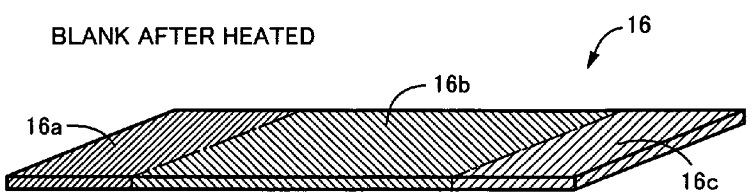



FIG.1A

BEFORE HEATING

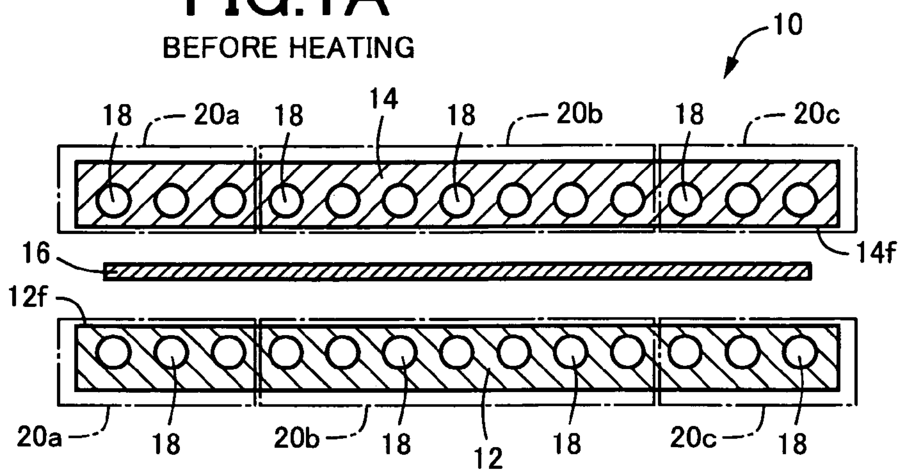



FIG.1B

DURING HEATING

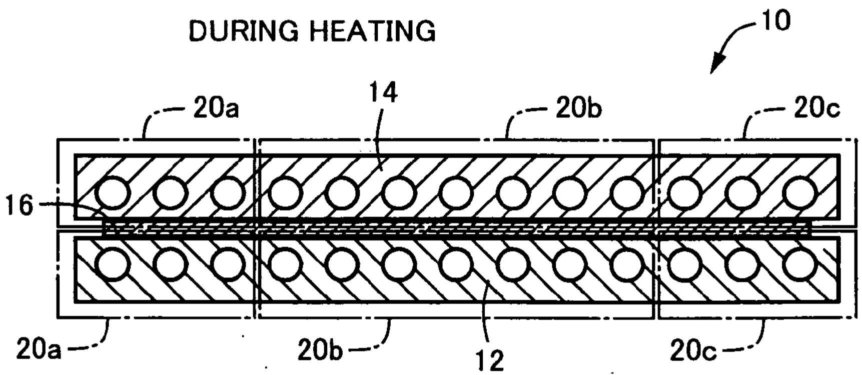



FIG.1C

BLANK AFTER HEATED

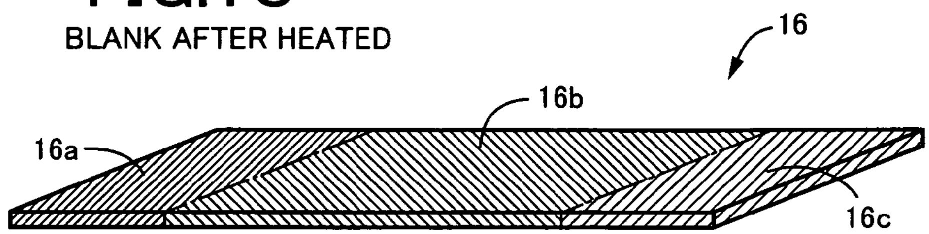


FIG.2A

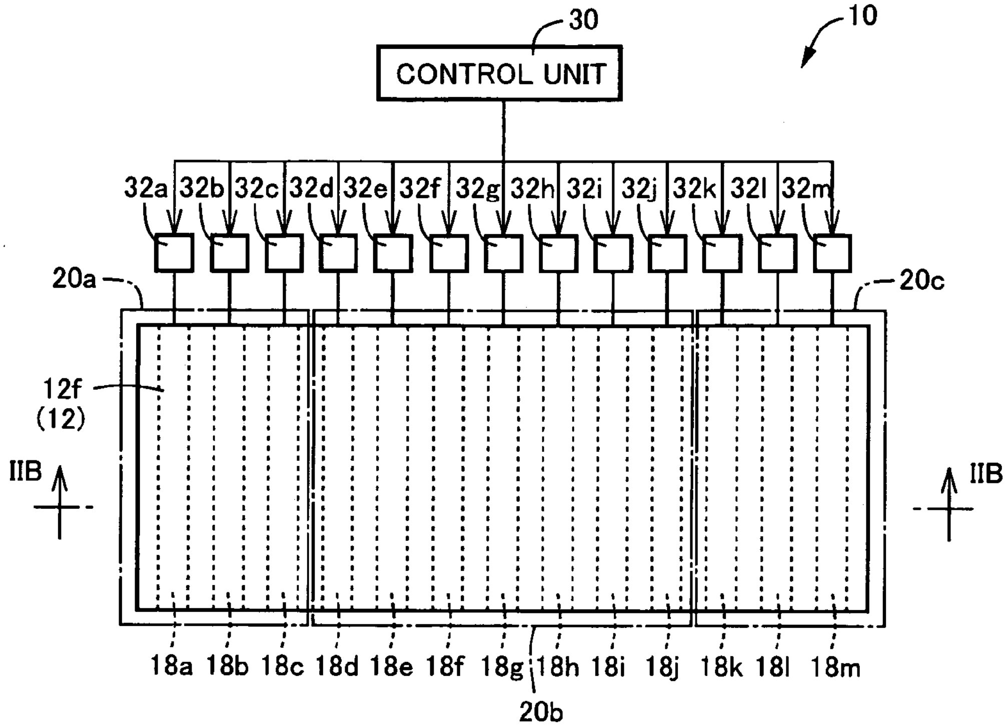
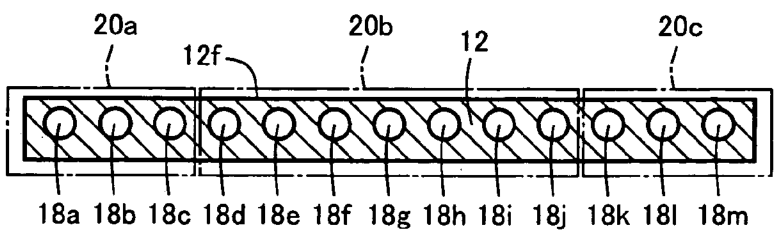

30
CONTROL UNIT
10
32a
32b
32c
32d
32e
32f
32g
32h
32i
32j
32k
32l
32m
20a
20c
12f
(12)
IIB
IIB
18a
18b
18c
18d
18e
18f
18g
18h
18i
18j
18k
18l
18m
20b

FIG.2B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20b
20c
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FIG.3A

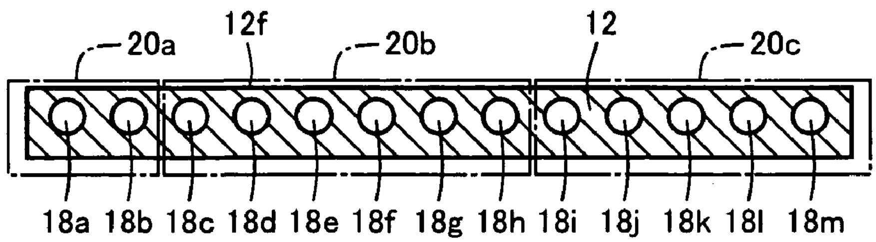


FIG.3B

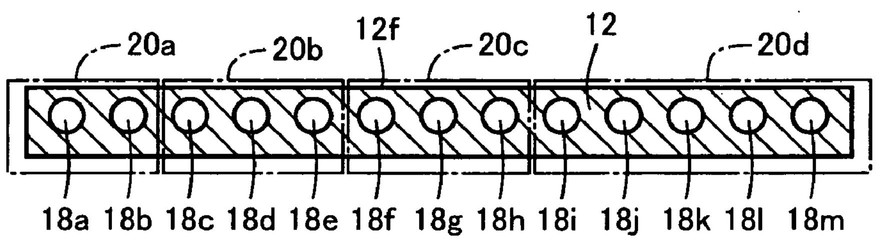


FIG.4

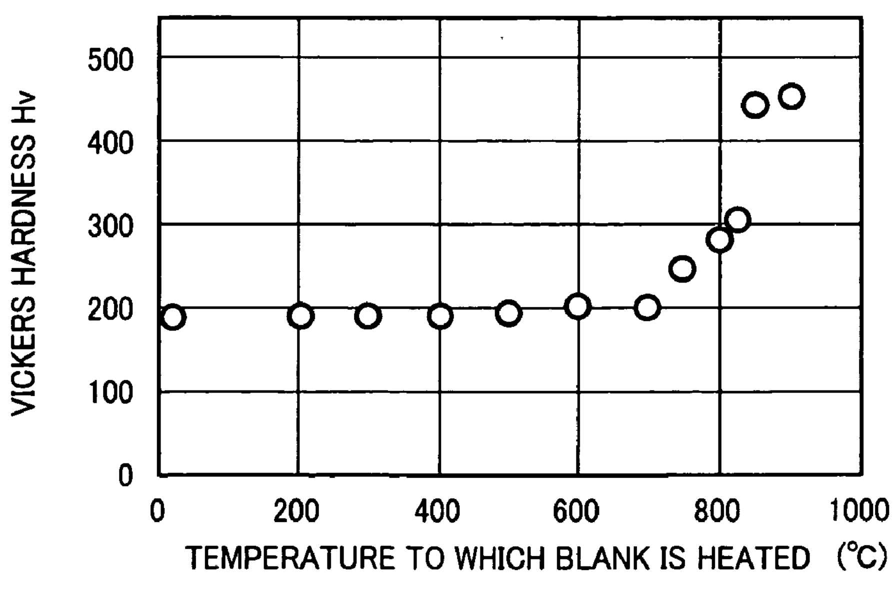

FIG.5A

TEMPERATURE TO WHICH BLANK IS HEATED

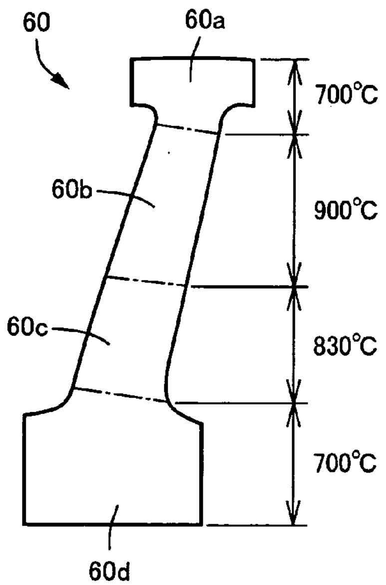


FIG.5B

STRENGTH AFTER QUENCHING (PRESS-FORMED PART)

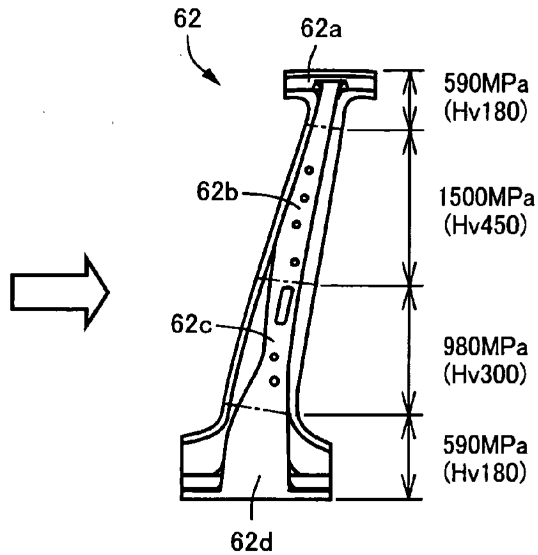

FIG.6A

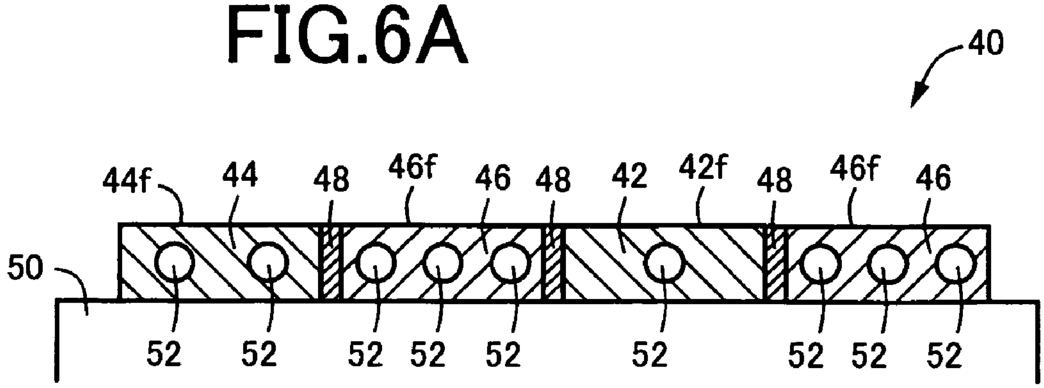
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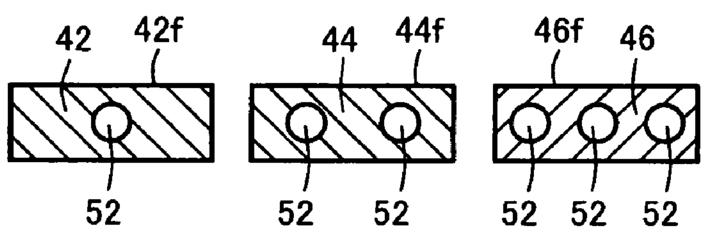
FIG.6B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42f
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44f
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# STEEL SHEET HEATING DEVICE, METHOD FOR PRODUCING PRESS-FORMED PART, AND PRESS-FORMED PART

## INCORPORATION BY REFERENCE

**[0001]** The disclosure of Japanese Patent Application No. 2010-133947 filed on Jun. 11, 2010 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

## BACKGROUND OF THE INVENTION

**[0002]** 1. Field of the Invention

**[0003]** The invention relates generally to a steel sheet heating device, a method for producing a press-formed part, and a press-formed part, and more specifically to a technique for producing a press-formed part which is made of a single steel sheet and in which the tensile strength varies at different portions.

**[0004]** 2. Description of Related Art

**[0005]** In order to ensure safety in the event of a vehicle side-impact collision, a center pillar is reinforced by fitting a reinforcement member (reinforcement) inside the center pillar that has a closed cross-section defined by an outer center pillar and an inner center pillar, and then integrally fixing the reinforcement member to the center pillar by welding. A press-formed part is widely used as the reinforcement member for the center pillar. The press-formed part is configured to have the tensile strength that varies at different portions, in order to improve impact energy absorption performance, facilitate partial forming of the reinforcement member, and reduce the weight of the reinforcement member. Japanese Patent Application Publication No. 2000-177630 (JP 2000-177630 A) describes an example of the reinforcement member. According to JP 2000-177630 A, a plurality of steel sheets that differ in sheet thickness are integrally welded together and subsequently formed into a predetermined shape by press-forming, whereby a reinforcement member is produced. Also, it is possible to produce a press-formed part in which the tensile strength varies at different portions, as taught in Japanese Patent Application Publication No. 2009-95869 (JP 2009-95869 A). According to JP 2009-95869 A, when a steel sheet is pressed into shapes through hot press-forming, the temperature to which the steel sheet is heated is varied at different portions and only part of the steel sheet is quench-hardened. Thus, it is possible to make the tensile strength vary at different portions of the press-formed part.

**[0006]** However, according to JP 2000-177630 A, the plurality of steel sheets that differ in sheet thickness need to be integrally welded together. Therefore, the number of production processes increases, which may increase the production costs. Further, the press-formability in pressing may be reduced due to the variation in sheet thickness of the steel sheets. According to JP 2009-95869 A, a portion to be provided with a high strength is heated by first heating means, and the overall steel sheet is subsequently heated by second heating means. Thus, only the portion to be provided with a high strength is heated to a temperature suitable for quenching. Accordingly, the heating work is cumbersome and time-consuming, which may increase the production costs, and controlling the temperature of the steel sheet may be difficult. In addition, the temperature to which the steel sheet is heated is varied in only two levels. Accordingly, it is not possible to satisfactorily improve various performances of a press-formed part. For example, it is not possible to vary the tensile strength in three or more levels, to reduce the weight of the press-formed part while ensuring the required strength at each portion, and to facilitate forming of the overall press-formed part. These problems may arise not only when a reinforcement member for a center pillar is produced by press-forming but also when another press-formed part configured such that the tensile strength varies at different portions is produced.

## SUMMARY OF THE INVENTION

**[0007]** The invention is made in the light of the above-described circumstances, and it is an object of the invention to make it possible, when a steel sheet is heated to different temperatures at various portions as described in JP 2009-95869 A, to heat the steel sheet to different temperatures at various portions at the same time, through a single heating treatment. It is another object of the invention to easily form a prescribed press-formed part while further improving various performances of the press-formed part, for example, reducing the weight of the press-formed part and facilitating forming of the press-formed part by varying the tensile strength of the press-formed part in three or more levels.

### 1. Means for Achieving the Object

**[0008]** To achieve the above object, the first aspect of the invention relates to a steel sheet heating device that heats a flat steel sheet, characterized by comprising: (a) a hot plate having a flat heating surface brought into close contact with the steel sheet; and (b) a plurality of heating equipment able to heat a plurality of heating regions, formed by dividing the heating surface of the hot plate into a plurality of sections, to different heating temperatures at the same time, (c) wherein the steel sheet is heated to different temperatures at various portions based on the heating temperatures of the plurality of heating regions of the heating surface, at the same time through a single heating treatment.

**[0009]** The second aspect of the invention relates to the steel sheet heating device according to the first aspect of the invention, characterized in that: (a) the hot plate is made of a single plate member; (b) the heating equipment include (b-1) multiple heaters disposed in the plate member at predetermined intervals so as to be positioned within a single plane parallel to the heating surface, and (b-2) multiple temperature control circuits disposed so as to correspond to the multiple heaters and able to control heating temperatures of the heaters independently of each other; and (b-3) the number of the plurality of heating regions that differ in heating temperature and ranges of the plurality of heating regions are able to set to any given number and any given ranges, respectively.

**[0010]** The third aspect of the invention relates to the steel sheet heating device according to the second aspect of the invention, characterized in that the heating temperature of the heater disposed near a boundary between the plurality of heating regions is made higher or lower than the heating temperature of the other heaters in the same heating region to alleviate an influence of the heating temperature of the contiguous heating region.

**[0011]** The fourth aspect of the invention relates to the steel sheet heating device according to the first aspect of the invention, characterized in that the hot plate includes a plurality of plate members that are aligned so as to correspond to the plurality of heating regions and that differ in heating temperature.

**[0012]** The fifth aspect of the invention relates to the steel sheet heating device according to the fourth aspect of the invention, characterized in that a heat insulator is disposed at a boundary between the plurality of plate members.

**[0013]** The sixth aspect of the invention relates to the steel sheet heating device according to any one of the first to the fifth aspects of the invention, characterized in that: there are provided a pair of the hot plates each of which has the flat heating surface brought into close contact with the steel sheet, the plurality of heating regions formed by dividing the heating surface into the plurality of sections being heated by the plurality of heating equipment; and the steel sheet is sandwiched between the hot plates and heated from both sides.

**[0014]** The seventh aspect of the invention relates to the steel sheet heating device according to any one of the first to the sixth aspect of the invention, characterized in that: (a) the steel sheet is a steel sheet for hot-pressing; and (b) at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3** by heating at least part of the plurality of heating regions to a temperature equal to or higher than the transformation point Ac**3**.

**[0015]** Note that, hot-pressing signifies subjecting a steel sheet, which has been heated to a temperature equal to or higher than the transformation point Ac**3**, to press-forming, and subsequently, rapidly cooling the steel sheet retained in a die, so that martensitic transformation is caused to quench-harden the steel sheet. The steel sheet for hot-pressing signifies a steel sheet for quenching that is subjected for the above-described press-forming. The transformation point Ac**3** is a temperature to which the steel sheet needs to be heated in order to cause the martensitic transformation through cooling during the press-forming so that the steel sheet is quench-hardened. The transformation point Ac**3** is the temperature for transforming the structure of the steel sheet for hot-pressing into austenite structure. The transformation point Ac**3** varies depending on, for example, the carbon content.

**[0016]** The eighth aspect of the invention relates to a method for producing a prescribed press-formed part, in which tensile strength varies at different portions, by subjecting a steel sheet for hot-pressing to press-forming, characterized by comprising: (a) a heating process in which the steel sheet for hot-pressing is heated to different temperatures at various portions at the same time through a single heating treatment such that at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3**; and (b) a press-forming process in which the steel sheet for hot-pressing, which has been heated to the different temperatures at the various portions though the heating process, is subjected to press-forming to be formed into a prescribed shape, and, at the same time, the steel sheet for hot-pressing is rapidly cooled to be quench-hardened based on the temperatures to which the steel sheet for hot-pressing has been heated so that the tensile strength varies at different portions.

**[0017]** The ninth aspect of the invention relates to a press-formed part in which tensile strength is varied at different portions by quench-hardening, the press-formed part being formed by heating a single steel sheet for hot-pressing to different temperatures at various portions such that at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3**, and subsequently forming the steel sheet for hot-pressing into a prescribed shape through press-forming, and, at the same time, rapidly cooling the steel sheet for hot-pressing so that the part which has been heated to the temperature equal to or higher than the transformation point Ac**3** is quench-hardened, characterized in that the steel sheet for hot-pressing is divided into three or more portions and the three or more portions are heated to different temperatures, two or more portions out of the three or more portions are heated to different temperatures that are equal to or higher than the transformation point Ac**3**, and the press-forming is subsequently performed, whereby three or more portions, which differ in tensile strength in three or more levels due to differences between the temperatures to which each of the three or more portions is heated, are formed in the press-formed part.

2. Effect of the Invention

**[0018]** According to the steel sheet heating device in the first aspect of the invention, since the hot plate has the flat heating surface and brought into close contact with the steel sheet, the heating surface is divided into the plurality of heating regions and the plurality of heating regions are heated to different heating temperatures by the plurality of the heating equipment, it is possible to heat the steel sheet to different temperatures at various portions, based on the heating temperatures of the plurality of heating regions of the heating surface, at the same time through a single heating treatment with the use of the hot plates. Thus, when the steel sheet is heated to different temperatures at various portions in order to quench-harden part of the steel sheet, as in the case where the reinforcement member for a center pillar mentioned above is formed, it is possible to perform the heating treatment easily and within a short time. In addition, it is possible to easily control the temperature because the steel sheet is heated at once. As a result, it is possible to achieve a target temperature distribution with high accuracy. Further, it is possible to easily vary the heating temperature in three or more levels, and it is possible to vary the tensile strength of the press-formed part at various portions in three or more levels based on the differences between the heating temperatures. Therefore, it is possible to easily obtain the press-formed part while improving various performances of the press-formed part, for example, reducing the weight of the press-formed part while ensuring the required strength at each portion, and facilitating forming of the overall press-formed part.

**[0019]** According to the second aspect of the invention, the hot plate is made of a single plate member, the multiple heaters are provided at predetermined intervals in the hot plate, and the temperatures of the multiple heaters are controlled independently of each other by the temperature control circuits. Therefore, it is possible to set the number of the plurality of heating regions that differ in heating temperature and the ranges of the plurality of heating regions to any given number and any given ranges. Accordingly, it is possible to employ multiple types of the steel sheets that differ in the number of the heating regions, ranges of the heating regions and the heating temperatures. As a result, it is possible to achieve high versatility and reduce the facility costs relatively.

**[0020]** According to the third aspect of the invention, the heating temperature of the heater positioned near the boundary between the plurality of heating regions is made higher or lower than the heating temperature of the other heaters in the same heating region in order to alleviate the influence of the heating temperature of the consecutive heating region. Therefore, the heating temperature sharply changes at the boundaries. Accordingly, it is possible to heat the plurality of heating regions to predetermined heating temperatures respectively with high accuracy. Thus, for example, when part of the steel sheet is quench-hardened through hot press-forming, it is possible to control, for example, the ranges of quench-hardening, the degree of hardening to be achieved, and the tensile strength with high accuracy.

**[0021]** According to the fourth aspect of the invention, the hot plate has the plurality of plate members that are aligned so as to correspond to the plurality of heating regions and that differ in the heating temperature. Therefore, it is possible to heat, through a single heating treatment, the steel sheet at the same time to different temperatures at various portions. Further, according to the fifth aspect of the invention, since the heat insulator is disposed at the boundary between the plurality of plate members, the heating temperature is changed sharply at the boundary, and the plurality of heating regions are heated to predetermined heating temperatures respectively with high accuracy. Thus, when a portion of the steel sheet is quench-hardened through hot press-forming, it is possible to control the range of quench-hardening and the degree of hardening to be achieved with high accuracy.

**[0022]** According to the sixth aspect of the invention, since the steel sheet is sandwiched between a pair of hot plates and then heated, it is possible to perform the heating treatment within a short time, and to achieve a target temperature distribution with higher accuracy.

**[0023]** According to the seventh aspect of the invention, the steel sheet for hot-pressing is heated to different temperatures at various portions. At least part of the steel sheet is heated to a temperature equal to or higher than the transformation point Ac**3**, and the steel sheet that has been heated is subjected to press-forming, and at the same time, rapidly cooled. Thus, the part of the steel sheet is quench-hardened based on the temperatures to which the steel sheet is heated. As a result, the press-formed part in which the tensile strength varies at different portions is obtained. In this case, because the steel sheet for hot-pressing is heated at once, it is possible to easily control the temperatures of the various portions of the steel sheet for hot-pressing, and to achieve a target temperature distribution with high accuracy. As a result, it is possible to improve the degree of tensile strength and the accuracy of strength distribution of the press-formed part obtained through press-forming subsequently performed.

**[0024]** The eighth aspect of the invention relates to a method for producing a prescribed press-formed part, in which the tensile strength varies at different portions, by subjecting the steel sheet for hot-pressing to press-forming. In the heating process, the heating treatment is performed using, for example, the heating device according to the seventh aspect of the invention. Thus, the steel sheet for hot-pressing is heated to different temperatures at various portions at the same time such that at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than the transformation point Ac**3**. Subsequently, press-forming is performed in the press-forming process so that the steel sheet is formed into a prescribed shape, and, at the same time, the steel sheet is rapidly cooled to be quench-hardened based on the temperatures to which the steel sheet has been heated. As a result, the press-formed part in which the tensile strength varies at different portions is obtained. In this case, in the heating process, the steel sheet for hot-pressing is heated to different temperatures at various portions at the same time in a single heating treatment. Accordingly, it is possible to easily perform the heating treatment within a short time. In addition, because the steel sheet for hot-pressing is heated at once, it is possible to easily control the temperatures of the various portions of the steel sheet for hot-pressing and to achieve the target temperature distribution with high accuracy. As a result, it is possible to improve the degree of tensile strength and the accuracy of strength distribution of the press-formed part obtained through press-forming subsequently performed.

**[0025]** According to the ninth aspect of the invention, three or more portions of which the tensile strength varies in three levels or more are formed in the press-formed part in the following manner. The single steel sheet for hot-pressing is divided into the three or more portions, the three or more portions are heated to different temperatures respectively by the heating device, the heating process or the like, and two or more portions of the three or more portions are heated to different temperatures that are equal to or higher than the transformation point Ac**3**. Then, the steel sheet is subjected to press-forming in this state. Due to the differences among the temperatures to which the three or more portions are heated, the tensile strength varies in three levels or more. Because the tensile strength in the press-formed part varies in three levels or more as described above, for example, it is possible to improve various performances of the press-formed part, such as to reduce the weight of the press-formed part while improving impact energy absorption performance by optimizing the strength distribution in the press-formed part, and to facilitate forming of the overall press-formed part.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0026]** Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

**[0027]** FIGS. **1**A to **1**C are views illustrating a heating process in which a steel sheet for hot-pressing is heated to different temperatures at various portions by a heating device according to a first embodiment of the invention;

**[0028]** FIGS. **2**A and **2**B are views schematically illustrating the structure of the heating device in FIGS. **1**A and **1**B, wherein FIG. **2**A is a plan view illustrating a lower hot plate, and FIG. **2**B is a sectional view taken along the line IIB-IIB in FIG. **2**A;

**[0029]** FIGS. **3**A and **3**B are views illustrating a plurality of heating regions, which are heated to different heating temperatures, formed in the heating device shown in FIGS. **2**A and **2**B in a manner different from that in FIGS. **2**A and **2**B;

**[0030]** FIG. **4** is a graph illustrating an example of the result of a study on the relationship between the temperature to which a blank is heated and the Vickers hardness Hv after the blank is quench-hardened through press-forming;

**[0031]** FIGS. **5**A and **5**B are views illustrating an example of the relationship between temperatures to which various portions of the blank are heated and the tensile strengths of the various portions after press-forming, when a reinforcement member for a vehicle center pillar is produced by a production method according to the invention; and

**[0032]** FIGS. **6**A and **6**B are views illustrating a heating device according to a second embodiment of the invention, in which a hot plate is formed of a plurality of plate members.

## DETAILED DESCRIPTION OF EMBODIMENTS

**[0033]** Prescribed press-formed parts in which the tensile strength varies at different portions are used as, for example, vehicle reinforcement members such as a reinforcement member for a center pillar and a bumper reinforcement member, other press-formed parts for a vehicle such as a door beam and a rocker, and other press-formed parts such as a reinforcement member used for a purpose other than a vehicle. In any of the above-mentioned press-formed parts, the tensile strength is varied at different portions by heating a steel sheet for hot-pressing to different temperatures at various portions, forming the steel sheet for hot-pressing into a predetermined shape through press-forming and, at the same time, rapidly cooling the steel sheet for hot-pressing so that part of the steel sheet is quench-hardened according to the heating temperatures. The heating device according to any one of the first aspect of the invention to the seventh aspect of the invention is used preferably in the heating process for producing the press-formed part. Further, the heating device may be adapted to other uses in which a flat steel sheet is heated to different temperatures at various portions.

**[0034]** The steel sheet that is heated by the heating device according to the first aspect of the invention need not be a steel sheet for hot-pressing. As a plurality of heating equipment able to heat a plurality of heating regions to different temperatures at the same time, for example, sheathed heaters are preferably used. Alternatively, near-infrared heaters such as halogen heaters or other heaters may be employed. Various methods for heating the heating surface to different temperatures at various portions may be employed. If the temperatures of the heaters themselves are adjustable, the temperatures of the heaters may be adjusted. Alternatively, the temperature of the heating surface may be varied by changing the number of heaters (per unit area) or changing the distance between the heating surface and the heaters.

**[0035]** According to the second aspect of the invention, the multiple heaters are disposed in the hot plate at predetermined intervals respectively so as to be positioned within a single plane that is parallel to the heating surface. For example, disc-shaped or dice-shaped heaters are disposed in a grid, or long heaters are disposed parallel to each other at predetermined intervals. According to the second aspect of the invention, the temperatures of the individual heaters are controlled independently of each other, and it is possible to set the number of a plurality of heating regions that differ in heating temperature and the ranges of the heating regions to any possible given number and any possible given ranges based on the arrangement of the heaters. For example, when the heaters are disposed in a grid, the shapes of the heating regions may be set to any given shapes.

**[0036]** According to the third aspect of the invention, for example, when the heating temperature of the contiguous heating region is high, the temperature of the heater near the boundary with the contiguous region is made lower than the target heating temperature, and when the heating temperature of the contiguous region is low, the temperature of the heater near the boundary with the contiguous region is made higher than the target heating temperature. Thus, the temperature changes sharply at the boundary. As a result, it is possible to adjust the heating temperatures of the heating regions to respective target heating temperatures with high accuracy.

**[0037]** According to the fourth aspect of the invention, the hot plate is formed of a plurality of plate members that differ in heating temperature. In this case as well, it is preferable to set the heating temperatures to any given temperatures by controlling the temperatures of the heaters disposed in respective plate members. Alternatively, the heating temperature may be varied by changing the number of heaters (per unit area) or changing the distance between the heating surface and the heaters based on the heating temperatures of the plate members respectively. According to the fifth aspect of the invention, the heat insulator is disposed at the boundary between the plurality of plate members. However, when the fourth aspect of the invention is implemented, simply a gap may be formed between the plurality of plate members, or the plurality of plate members may be brought into close contact with each other. When the plate members are brought into close contact with each other, it is preferable to correct the temperature of the heater positioned near the boundary as in the third invention, if possible.

**[0038]** According to the sixth aspect of the invention, the steel sheet is sandwiched between the hot plates and heated from both sides. However, when the other inventions are implemented, the steel sheet may be heated from only one side, for example, by placing the steel sheet on a single hot plate.

**[0039]** According to any one of the seventh aspect of the invention to the ninth aspect of the invention, at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than the transformation point Ac**3**. However, even if the steel sheet is heated to a temperature is equal to or higher than the transformation point Ac**3**, the quench-hardness or the tensile strength varies depending on the temperature. Accordingly, the overall steel sheet for hot-pressing may be heated to temperatures equal to or higher than the transformation point Ac**3** that are different at various portions.

**[0040]** When the press-formed part according to the ninth aspect of the invention is produced, three or more portions may be heated to different temperatures at the same time by the heating device according to any one of the first to seventh aspects of the invention or by the method according to the eighth aspect of the invention. Alternatively, the three or more portion may be heated to different temperatures in multiple processes as described in, for example, JP 2009-95869 A.

**[0041]** Hereafter, embodiments of the invention will be described in detail with reference to the accompanying drawings.

**[0042]** FIGS. **1**A to **1**C are views illustrating a heating process in which a flat blank **16** cut into a predetermined shape is heated to different temperatures at various portions by a heating device **10** according to a first embodiment of the invention. FIG. **1**A is a view illustrating the state before the blank **16** is heated. FIG. **1**B is a view illustrating the state where the blank **16** is being heated. FIG. **1**C is a view illustrating the blank **16** after heated. The heating device **10** includes a lower hot plate **12** and an upper hot plate **14** that are disposed substantially horizontally. The blank **16** is sandwiched between the lower hot plate **12** and the upper hot plate **14**, for example, by placing the blank **16** on the lower hot plate **12** and then moving the upper hot plate **14** down using an elevating device (not shown). Then, the blank **16** sandwiched between these hot plates **12** and **14** is heated. A top surface **12*f***

of the lower hot plate **12** and a bottom surface **14***f* of the upper hot plate **14** correspond to flat heating surfaces that are brought into close contact with the respective surfaces of the blank **16**. The lower hot plate **12** and the upper hot plate **14** are formed in substantially the same manner except that they are configured so as to be symmetric in the up-down direction.

**[0043]** FIGS. **2**A and **2**B are views illustrating the lower hot plate **12** and a control system. FIG. **2**A is a plan view. FIG. **2**B is a view illustrating a cross section taken along the line IIB-IIB in FIG. **2**A. The lower hot plate **12** is made of a single flat plate member. In the lower hot plate **12**, multiple linear and long sheathed heaters **18***a* to **18***m* (referred simply as "sheathed heaters **18**" in FIG. **1**) are disposed parallel to each other, side by side, and at predetermined intervals so as to be positioned within a single plane that is parallel to the top surface **12***f*. In the lower hot plate **12**, multiple linear holes are formed at a predetermined depth from the top surface **12***f* and at predetermined intervals so as to be parallel to the top surface **12***f* and parallel to each other. The sheathed heaters **18***a* to **18***m* are disposed in the holes. Temperature control circuits **32***a* to **32***m* each having, for example, a temperature sensor are connected to the multiple sheathed heaters **18***a* to **18***m*, respectively. The temperature control circuits **32***a* to **32***m* are individually controlled by a control unit **30**. Thus, the temperatures of the sheathed heaters **18***a* to **18***m* are controlled independently of each other.

**[0044]** In the lower hot plate **12** described above, the lower hot plate **12** may be divided into a plurality of heating regions **20**, and the temperatures (heating temperatures) of the regions **20** of the top surface **12***f* may be adjusted to any given different temperatures at the same time respectively. The number of the heating regions **20** and the ranges of the heating regions **20** may be set to any given number and any given ranges, respectively. FIGS. **1**A and **1**B and FIGS. **2**A and **2**B illustrate a case where the lower hot plate **12** is divided into three heating regions, that is, a heating region **20***a* that includes three sheathed heaters **18***a* to **18***c*, a heating region **20***b* that includes seven sheathed heaters **18***d* to **18***j*, and a heating region **20***c* that includes three sheathed heaters **18***k* to **18***m*. FIGS. **3**A and **3**B illustrate another manner of dividing the lower hot plate **12**. FIG. **3**A illustrates a case where the lower hot plate **12** is divided into three heating regions, that is, a heating region **20***a* that includes two sheathed heaters **18***a* and **18***b*, a heating region **20***b* that includes six sheathed heaters **18***c* to **18***h*, and a heating region **20***c* that includes five sheath heaters **18***i* to **18***m*. FIG. **3**B illustrates a case where the lower hot plate **12** is divided into four heating regions, that is, a heating region **20***a* that includes two sheathed heaters **18***a* and **18***b*, a heating region **20***b* that includes three sheathed heaters **18***c* to **18***e*, a heating region **20***c* that includes three sheathed heaters **18***f* to **18***h*, and a heating region **20***d* that includes five sheathed heaters **18***i* to **18***m*. Note that, various other manners of dividing the lower hot plate **12** into a plurality of heating regions may be employed.

**[0045]** The upper hot plate **14** as well as the lower hot plate **12** may be divided into a plurality of heating regions **20**, and the temperatures (heating temperatures) of the regions **20** of the bottom surface **14***f* may be adjusted to different desired temperatures at the same time respectively. As shown in FIG. **1**A, each of the hot plates **12** and **14** is divided into the heating regions **20***a* to **20***c*, and the temperature control is executed such that the heating temperatures of the heating regions **20***a*, **20***b* and **20***c* of the upper hot plate **14** are substantially equal to the heating temperatures of the heating regions **20***a*, **20***b* and **20***c* of the lower hot plate **12**, respectively. In this state, as shown in FIG. **1**B, the hot plates **12** and **14** are brought into close contact with both sides of the blank **16** such that the blank **16** is sandwiched between the hot plates **12** and **14** in the up-down direction. Thus, as shown in FIG. **1**C, the blank **16** is divided into three portions **16***a* to **16***c* that correspond to the heating regions **20***a* to **20***c*, respectively, and the portions **16***a* to **16***c* of the blank **16** are heated to different temperatures at the same time respectively.

**[0046]** The sheathed heaters **18***c*, **18***d*, **18***j* and **18***k* (see FIG. **2**) are positioned near the boundaries between the plurality of heating regions **20***a* to **20***c*. The heating temperature of each of the sheathed heaters **18***c*, **18***d*, **18***j* and **18***k* is made higher or lower than the heating temperature of the other heaters in the same heating region in order to alleviate the influence of the heating temperature of the contiguous heating region. More specifically, when the heating region **20***b* located at the center has the highest heating temperature, the temperatures of the sheathed heaters **18***c* and **18***k*, which are positioned at the edge portion of the heating regions **20***a* and **20***c* respectively next to the heating region **20***b*, are reduced based on, for example, target temperature differences. Further, the temperatures of the sheathed heaters **18***d* and **18***j* that are positioned at respective ends of the heating region **20***b* are increased based on, for example, the target temperature differences. Thus, the heating temperature sharply changes at the boundaries, and the plurality of heating regions **20***a* to **20***c* are heated to the respective target heating temperatures with high accuracy. Thus, the portions **16***a* to **16***c* of the blank **16** are able to be heated to the respective target temperatures with high accuracy.

**[0047]** The blank **16** is made of a steel sheet for hot-pressing that can be quench-hardened due to martensitic transformation caused by rapid cooling from a temperature equal to or higher than the transformation point Ac**3**. At least part of the plurality of heating regions **20***a* to **20***c* of each of the hot plates **12** and **14** is heated to the transformation point Ac**3** or higher, and at least part of the three portions **16***a* to **16***c* of the blank **16** is also heated to the transformation point Ac**3** or higher. Therefore, when the blank **16** is subjected to press-forming in the subsequent press-forming process to be formed into a predetermined shape and, at the same time, rapidly cooled, a portion of the blank member **16** is quench-hardened based on the temperatures to which the portions **16***a* to **16***c* of the blank **16** are heated. As a result, a press-formed part in which the tensile strength varies at different portions is obtained. FIG. **4** illustrates an example of the result obtained by checking, according to "Vickers hardness test method" defined in Japanese Industrial Standards JIS-Z2244, the Vickers hardness Hv after quench-hardening through press-forming, while variously changing the temperature to which the blank **16** is heated. The transformation point Ac**3** in this case is approximately 730° C. If the blank **16** is heated until the temperature thereof exceeds the transformation point Ac**3**, the Vickers hardness Hv increases due to quench-hardening. Even after the temperature of the blank **16** exceeds the transformation point Ac**3**, the Vickers hardness Hv varies depending on the temperature to which the blank **16** is heated. If the blank **16** is heated to approximately 800° C., the Vickers hardness Hv becomes approximately 300. If the blank **16** is heated to approximately 850 to 900° C., the Vickers hardness Hv exceeds 400.

**[0048]** FIGS. **5**A and **5**B are views illustrating an example of a press-formed part that is produced through the heating process and the press-forming process according to the first embodiment. FIGS. **5**A and **5**B illustrate a case where a reinforcement member **62** for a vehicle center pillar is produced as a press-formed part. FIG. **5**A illustrates the case where a blank **60**, which is made of a steel sheet for hot-pressing and has a predetermined shape, is divided into four portions **60***a* to **60***d* and the four portions **60***a* to **60***d* are heated, at the same time, to different temperatures by the heating device **10** shown in FIGS. **1**A and **1**B to FIGS. **3**A and **3**B. In this example, the T-shaped upper portion **60***a* and the T-shaped lower portion **60***d* are heated with the target temperature set at 700° C., the pillar upper portion **60***b* is heated with the target temperature set at 900° C., and the pillar lower portion **60***c* is heated with the target temperature set at 830° C. FIG. **5**B illustrates the reinforcement member **62** formed in a predetermined shape by subjecting the blank **60**, heated as taught in FIG. **5**A, to press-forming. Because the blank **60** is quench-hardened through press-forming, the pillar upper portion **62***b* is given a tensile strength of approximately 1500 MPa and a Vickers hardness Hv of approximately 450, and the pillar lower portion **62***c* is given a tensile strength of approximately 980 MPa and a Vickers hardness Hv of approximately 300. Each of the remaining T-shaped upper portion **62***a* and the T-shaped lower portion **62***d* has a tensile strength of approximately 590 MPa and a Vickers hardness Hv of approximately 180, which are the original tensile strength and Vickers hardness Hv of the material.

**[0049]** By increasing the tensile strength of the pillar portions **62***b* and **62***c* through quench-hardening as described above, it is possible to reduce the thickness of the reinforcement member **62** to achieve weight reduction, while appropriately ensuring predetermined impact energy absorption performance in the event of, for example, a side-impact collision. Especially, because the tensile strength of the pillar upper portion **62***b* is made higher than the tensile strength of the pillar lower portion **62***c*, it is possible to achieve the predetermined impact energy absorption performance while appropriately protecting, for example, the head of an occupant. The T-shaped upper and lower portions **62***a* and **62***d* that have complicated shapes are portions that are not quench-hardened. However, the portions **60***a* and **60***d* to be formed into these portions **62***a* and **62***d* are heated to a temperature equal to or higher than the softening temperature of the blank **60**, and therefore the required pressing pressure is reduced. As a result, the overall blank **60** is easily pressed into shapes through a single heating treatment.

**[0050]** The heating device **10** according to the first embodiment has the hot plates **12** and **14** that have the flat heating surfaces (top surface **12***f*, bottom surface **141**) that are brought into close contact with the blank **16** or **60**. Each heating surface is divided into the plurality of heating regions **20** and the plurality of heating regions **20** are heated to different heating temperatures by the multiple sheathed heaters **18***a* to **18***m*. With the use of the hot plates **12** and **14** of the heating device **10**, it is possible to heat the blank **16** or **60** to different temperatures at various portions, based on the heating temperatures of the plurality of heating regions **20** of the heating surface, at the same time through a single heating treatment. Thus, when the blank **60** is heated to different temperatures at various portions in order to quench-harden part of the blank **60**, as in the case where the reinforcement member **62** for a center pillar shown in FIG. **5** is formed, it is possible to perform the heating treatment easily and within a short time. In addition, it is possible to easily control the temperature because the blank **60** is heated at once. As a result, it is possible to achieve a target temperature distribution with high accuracy.

**[0051]** In the first embodiment, each of the hot plates **12** and **14** is made of a single plate member. In addition, in each of the hot plates **12** and **14**, the multiple sheathed heaters **18***a* to **18***m* are provided at predetermined intervals, and the temperatures of the sheathed heaters **18***a* to **18***m* are controlled independently of each other by the temperature control circuits **32***a* to **32***m*. Therefore, it is possible to set the number of the plurality of heating regions **20** that differ in heating temperature and the ranges of the plurality of heating regions **20** to any given number and any given ranges. Accordingly, it is possible to employ multiple types of blanks **16** and **60** that differ in the number of the heating regions **20**, ranges of the heating regions **20** and the heating temperatures. As a result, it is possible to achieve high versatility and reduce the facility costs.

**[0052]** In the first embodiment, the heating temperature of each of the sheathed heaters positioned near the boundaries between the plurality of heating regions **20**, that is, the sheathed heaters **18***c*, **18***d*, **18***j* and **18***k* in the example in FIG. **2**, is made higher or lower than the heating temperature of the other sheathed heaters in the same heating region in order to alleviate the influence of the heating temperatures of the consecutive heating regions. Therefore, the heating temperature sharply changes at the boundaries. Accordingly, it is possible to heat the plurality of heating regions **20** to predetermined heating temperatures with high accuracy respectively. Thus, for example, when part of the blank **16** or **60** is quench-hardened through hot press-forming, it is possible to control, for example, the ranges of quench-hardening, the degree of hardness to be achieved, and the tensile strength with high accuracy.

**[0053]** In the first embodiment, the blank **16** or **60** is sandwiched between a pair of hot plates **12** and **14** and then heated. Accordingly, it is possible to perform the heating treatment within a short time, and to achieve a target temperature distribution with higher accuracy.

**[0054]** According to the first embodiment, a prescribed press-formed part in which the tensile strength varies at different portions is produced by subjecting the blank **16** or **60**, made of a steel sheet for hot-pressing, to press-forming. First, in the heating process, the heating treatment is performed using the heating device **10** shown in FIGS. **1**A and **1**B, FIGS. **2**A and **2**B, and FIGS. **3**A and **3**B. As a result, the blank **16** is heated to different temperatures at various portions at the same time such that the temperature of at least part of the blank **16** becomes equal to or higher than the transformation point Ac**3**. Subsequently, press-forming is performed in the press-forming process. Thus, the blank **16** is formed in a predetermined shape and, at the same time, quench-hardened through rapid cooling based on the temperatures to which the blank **16** is heated. As a result, it is possible to obtain a press-formed part in which the tensile strength varies at different portions, such as the reinforcement member **62** for a center pillar shown in FIG. **5**. In this case, in the heating process, the blank **16** or **60** is heated to different temperatures at various portions, at the same time, through a single heating treatment by the heating device **10**. Therefore, it is possible to perform the heating treatment easily and within a short time. In addition, because the blank **16** or **60** is heated at once, it is easy to control the temperatures of each of the portions **16***a* to **16***c* of the blank **16** or each of the portions **60***a* to **60***d* of the blank **60**, and to achieve the target temperature distribution with high accuracy. Further, it is possible to increase the degree of tensile strength and the accuracy of the strength distribution of the press-formed part such as the reinforcement member **62** obtained through subsequently performed press-forming.

**[0055]** The four portions **62***a* to **62***d* of which the tensile strength varies in three levels are formed in the reinforcement member **62** in the following manner. The blank **60** made of a single steel sheet for hot-pressing is divided into the four portions **60***a* to **60***d*, the four portions **60***a* to **60***d* are heated to different temperatures respectively by the heating device **10**, and the two portions **60***b* and **60***c* of the four portions **60***a* to **60***d* are heated to different temperatures that are equal to or higher than the transformation point Ac**3**. Then, the blank **60** is subjected to press-forming in this state. Due to the differences among the temperatures to which the portions **60***a* to **60***d* are heated, the tensile strength varies in three levels. Because the tensile strength varies in three levels as described above, it is possible to reduce the weight of the reinforcement member **62** while appropriately ensuring predetermined impact energy absorption performance in the event of, for example, a side-impact collision using the pillar portions **62***b* and **62***c* that are given a high tensile strength through quench-hardening. In addition, it is possible to facilitate forming of the T-shaped upper and lower portions **62***a* and **62***d* having complicated shapes, by heating the portions **60***a* and **60***d* of the blank **60** to temperatures lower than the transformation point Ac**3** and equal to or higher than the softening temperature of the blank **60**. As a result, it is possible to easily obtain the reinforcement member **62** while improving the performance of the reinforcement member **62** through a single heating treatment of the blank **60**.

**[0056]** Next, a second embodiment of the invention will be described. Note that, in the second embodiment, portions that are substantially the same as those in the first embodiment will be denoted by the same reference numerals as those in the first embodiment, and the detailed description thereof will be omitted.

**[0057]** A hot plate **40** shown in FIG. **6**A has a plurality of plate members **42**, **44** and **46** that are aligned so as to correspond to the plurality of heating regions and that differ in heating temperature. Heat insulators **48** are disposed at the boundaries (gaps) between the plate members **42**, **44** and **46** respectively, and the plate members **42**, **44** and **46** are attached onto a common single base **50**. In this state, the hot plate **40** is used. FIG. **6**B illustrates the three types of plate members **42**, **44** and **46** that differ in heating temperature when they are not assembled together. These plate members **42**, **44** and **46** are equal in size but different in the number of sheathed heaters **52** embedded therein. Thus, the heating temperatures of the plate members **42**, **44** and **46** differ from each other. That is, the sheathed heaters **52** are configured so as to generate the same amount of heat respectively. Therefore, in the plate member having a larger number of sheathed heaters **52**, the heating temperature of the heating surface is higher. Therefore, among the plate members **42**, **44** and **46**, the plate member **42** has the lowest heating temperature and the plate member **46** has the highest heating temperature. In the second embodiment as well as in the first embodiment, a pair of hot plates **40** is prepared, and the blank **16** is sandwiched between the pair of the hot plates **40** and then heated.

**[0058]** The hot plate **40** in the second embodiment has the plurality of plate members **42**, **44** and **46** that are aligned so as to correspond to the plurality of heating regions and that differ in the heating temperature. Therefore, it is possible to heat, through a single heating treatment, the blank **16**, **60** or the like at the same time to different temperatures at various portions based on the heating temperatures of heating surfaces **42***f*, **44***f*, and **46***f*. Accordingly, as in the first embodiment, it is possible to perform the heating treatment easily and within a short time, and easily control the temperature because the different portions of the blank **16**, **60** are heated at once. In addition, because the heat insulators **48** are disposed at the boundaries (gaps) between the plurality of plate members **42**, **44** and **46** respectively, the heating temperature is changed sharply at the boundaries, and the plurality of heating regions are heated to predetermined heating temperatures respectively with high accuracy. Thus, when a part such as the reinforcement member **62** shown in FIG. **5** is formed by quench-hardening through hot press-forming from the blank **16** or **60**, it is possible to control the range of quench-hardening, the degree of hardening to be achieved and the like with high accuracy.

**[0059]** The multiple sheathed heaters **52** in the second embodiment may be configured such that the temperatures of the sheathed heaters **52** may be adjusted independently of each other, as in the first embodiment. In addition, the heating temperatures of the heating surfaces **42***f*, **44***f* and **46***f* of the plate members **42**, **44** and **46** may be set to any given temperatures respectively.

**[0060]** While the embodiments of the invention have been described in detail with reference to the accompanying drawings, it is to be understood that the invention is not limited to the embodiments. To the contrary, the invention is intended to cover various modifications and equivalent arrangements that are made based on the knowledge of a person skilled in the art.

What is claimed is:

**1**. A steel sheet heating device that heats a flat steel sheet, comprising:

a hot plate having a flat heating surface brought into close contact with the steel sheet; and

a plurality of heating equipment able to heat a plurality of heating regions, formed by dividing the heating surface of the hot plate into a plurality of sections, to different heating temperatures at the same time, wherein

the steel sheet is heated to different temperatures at various portions based on the heating temperatures of the plurality of heating regions of the heating surface, at the same time through a single heating treatment.

**2**. The steel sheet heating device according to claim **1**, wherein:

the hot plate is made of a single plate member;

the heating equipment include multiple heaters disposed in the plate member at predetermined intervals so as to be positioned within a single plane parallel to the heating surface, and multiple temperature control circuits disposed so as to correspond to the multiple heaters and able to control heating temperatures of the heaters independently of each other; and

the number of the plurality of heating regions that differ in heating temperature and ranges of the plurality of heating regions are able to set to any given number and any given ranges, respectively.

**3**. The steel sheet heating device according to claim **2**, wherein the heating temperature of the heater disposed near a boundary between the plurality of heating regions is made higher or lower than the heating temperature of the other heaters in the same heating region to alleviate an influence of the heating temperature of the contiguous heating region.

**4**. The steel sheet heating device according to claim **1**, wherein the hot plate includes a plurality of plate members that are aligned so as to correspond to the plurality of heating regions and that differ in heating temperature.

**5**. The steel sheet heating device according to claim **4**, wherein a heat insulator is disposed at a boundary between the plurality of plate members.

**6**. The steel sheet heating device according to claim **1**, wherein:

there are provided a pair of the hot plates each of which has the flat heating surface brought into close contact with the steel sheet, the plurality of heating regions formed by dividing the heating surface into the plurality of sections being heated by the plurality of heating equipment; and

the steel sheet is sandwiched between the hot plates and heated from both sides.

**7**. The steel sheet heating device according to claim **1**, wherein:

the steel sheet is a steel sheet for hot-pressing; and

at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3** by heating at least part of the plurality of heating regions to a temperature equal to or higher than the transformation point Ac**3**.

**8**. A method for producing a prescribed press-formed part, in which tensile strength varies at different portions, by subjecting a steel sheet for hot-pressing to press-forming, comprising:

a heating process in which the steel sheet for hot-pressing is heated to different temperatures at various portions at the same time through a single heating treatment such that at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3**; and

a press-forming process in which the steel sheet for hot-pressing, which has been heated to the different temperatures at the various portions though the heating process, is subjected to press-forming to be formed into a prescribed shape, and the steel sheet for hot-pressing is rapidly cooled to be quench-hardened based on the temperatures to which the steel sheet for hot-pressing has been heated so that the tensile strength varies at different portions.

**9**. A press-formed part in which tensile strength is varied at different portions by quench-hardening, the press-formed part being formed by heating a single steel sheet for hot-pressing to different temperatures at various portions such that at least part of the steel sheet for hot-pressing is heated to a temperature equal to or higher than a transformation point Ac**3**, and subsequently forming the steel sheet for hot-pressing into a prescribed shape through press-forming, and rapidly cooling the steel sheet for hot-pressing so that the part which has been heated to the temperature equal to or higher than the transformation point Ac**3** is quench-hardened,

the steel sheet for hot-pressing being divided into three or more portions and the three or more portions being heated to different temperatures, two or more portions out of the three or more portions being heated to different temperatures that are equal to or higher than the transformation point Ac**3**, and the press-forming being subsequently performed, whereby three or more portions, which differ in tensile strength in three or more levels due to differences between the temperatures to which each of the three or more portions is heated, being formed in the press-formed part.

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