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Description

Technical Field

[0001] The present invention relates to a pressed product to be used, for example, for the housing of a portable electronic device, particularly to a pressed product having a sharp corner portion.

Background Art

[0002] Metal such as aluminum or its alloy is used as the material for the housing of a portable electronic device or the like, such as a cellular phone and a note-book-type personal computer. Generally, in comparison with resin, metal has a higher strength and is more resistant to an impact.

[0003] As the foregoing material for the housing, magnesium alloys have been used which are formed by adding various elements to magnesium. Although a magnesium alloy has excellent specific strength and specific rigidity, it has poor plastic workability at ordinary temperatures because it has a hexagonal crystalline structure (hexagonal close-packed structure). Consequently, the housing and the like are mainly formed by using a cast product produced by a die-casting process or a thixomold process. In recent years, engineers have been studying the performing of press working on a magnesium alloy (Patent Literatures 1 and 2).

Summary of Invention

Technical Problem

[0004] A typical shape of the housing is a box type provided with a rectangular top plate and four side walls formed from the edges of the top plate. For the box-type shaped body, the market desires to obtain a housing having sharpness both at the corner portion connecting the top plate and the side wall and at the corner portion connecting two side walls. It is likely that a housing having sharp corner portions can be formed when the injection molding of resin or casting is used. Nevertheless, a resinous product and a cast product generally have a lower strength than that of a pressed product of metal.

[0005] When the box-type shaped body falls and collides with the ground or the like, the impact at the time of the collision is applied to the above-described corner portions in many cases. As a result, in a resinous product and a cast product both having low strength, the corner portion is deformed (broken) or otherwise damaged, so that it is difficult for the corner portion to maintain the sharp condition.

JP 9 001253A discloses a socket for a hose union formed by press working to have a sharp corner at the outer peripheral face of the end cap of the socket.

Solution to Problem

[0006] Examples of the present invention offer a shaped body having a sharp corner portion and having high strength. More specifically, the present invention offers a pressed product produced by press-forming a blank metal plate as set out in claim 1.

[0007] According to the above structure, by performing the press forming on a metal plate, the hardness of the corner portion is increased by the work hardening owing to the plastic working. Consequently, even when an impact is applied to the corner portion and the like, deformation is less likely to occur, so that the sharp corner portion can be maintained for a long time. Moreover, because the pressed product of the present invention is formed by the press forming of a metal plate, in addition to the strength of the material itself, the strength can be increased by the plastic working, so that the entire pressed product has high strength. Furthermore, because the pressed product of the present invention has the foregoing sharp corner portion, it can give an impression of stylishness with a refined design. As a result, it is expected that the pressed product has excellent appearance as a commodity and therefore has an enhanced commercial value.

[0008] The above-described pressed product of the present invention having a sharp corner portion can be produced, for example, by performing the below-described multistage press working on a blank plate made of metal. More specifically, the production method is to produce a pressed product having a corner portion by performing press working on a metal plate and has the steps described below.

A step of preparing a blank plate: this step prepares a blank plate made of metal.

A first pressing step: this step produces a pressed material that has at least one corner portion connecting two surfaces in the peripheral surface under the condition that the blank plate is heated at a temperature of 200°C or more and 300°C or less. In particular, the first press working is performed so that at least one corner portion can have an inside corner radius "r" that is practically 0 mm by using a punch having a shoulder portion with a corner radius Rp that is practically 0 mm.

A second pressing step: this step produces a pressed product that has at least one corner portion having an outside corner radius R that is equal to or smaller than the thickness "t" of the metal plate by performing the second press working under the condition that the foregoing pressed material is heated at a temperature of 200°C or more and 300°C or less. In particular, the second press working is performed so that the above-described corner portion, which has an inside corner radius "r" that is practically 0 mm, can have an outside corner radius R that is equal to or smaller than the foregoing thickness "t" by using a step-shaped punch for pressing both the end face of the pressed material and the corner portion, which has been formed on the inside surface in the first pressing step and which has "r" that is practically 0 mm.

[0009] A sharp corner portion having an outside corner radius R that is equal to or smaller than the thickness "t" of the metal plate can become easily formed when the blank plate to be pressed has the thinnest possible thickness. Nevertheless, when the blank plate itself is excessively thin, the strength of the pressed product is decreased, so that it cannot satisfy the strength and rigidity required for the housing of a portable electronic device. On the other hand, to increase through the work hardening the hardness of the corner portion of a pressed product, the corner portion being likely to suffer from an impact at the time of the falling, it can be conceived to form the corner portion at a high working ratio. However, when the bending or deep drawing is performed at a high working ratio, the corner portion-formed place in the blank plate is partially elongated reducing its thickness. This thickness decrease leads to the reduction in strength.

[0010] In consideration of the foregoing phenomenon, the above-described production method carries out the press forming at a high working ratio by dividing the process into multiple stages as described above, not by a process of one stage. Consequently, the corner portion is prevented from becoming extremely thin, so that the reduction in strength resulting from the thickness reduction can be suppressed. As a result, the above-described production method can not only produce a pressed product having a sharp corner portion but also maintain the sharp corner portion for a long period.

[0011] In addition, the above-described production method performs the press working under a heated condition. Consequently, even a metal that has poor plastic workability and therefore develops springback, cracking, or the like in the cold working, such as magnesium alloy having an elongation of 20% or so at the most at ordinary temperatures, can increase the elongation of the object to be worked (the blank plate and pressed material) to 100% or more at the time of the pressing. Furthermore, because the object to be worked has a sufficient elongation, a pressed product that has a corner portion having an extremely small outside corner radius R can be produced with high precision.

Advantageous Effects of Invention

[0012] The pressed product of the present invention has a sharp corner portion and high strength.
According to the above-described production method, a corner portion formed on the peripheral surface, that is, the corner portion forming the appearance, is sharp. In addition, a corner portion formed on the inside surface is also sharp. Consequently, the pressed product has an ample internal space. As a result, when the pressed product obtained by the foregoing production method is used for a housing, various components can be adequately housed in the housing.

Brief Description of Drawings

[0013] Figure 1 is a schematic cross-sectional view for explaining the procedure of the press working in the process of producing a pressed product having a sharp corner. The (A) portion of Fig. 1 shows a state in which a blank plate is placed in a die. The (B) portion of Fig. 1 shows a state in which a pressed material is formed by the first press working. The (C) portion of Fig. 1 shows a state in which a punch is performing pressing in the second press working. The (C') portion of Fig. 1 is a partially enlarged view of the corner portion shown in the (C) portion. The (D) portion of Fig. 1 shows a state in which a pressed product having a sharp corner portion is formed by the second press working. The (E) portion of Fig. 1 shows an obtained pressed product.

Description of Embodiments

[0014] An explanation is given below to the embodiments of the present invention. In the explanation of the drawings, the same component bears the same sign to eliminate duplicated explanations. The ratio of the dimensions in the drawing does not necessarily coincide with that of the explanation.

Pressed product

Composition

[0015] The pressed product of the present invention may be formed by using various metals having excellent press formability at a temperature range of 200°C or more and 300°C or less. In particular, it is desirable to use magnesium or its alloy as the material for forming, for example, the housing of a portable electronic device required to have light

weight, because magnesium and its alloy are lightweight, have high strength, and have excellent impact resistance.

[0016] It is possible to use magnesium alloys having various compositions formed by adding various elements to Mg (the remainder: Mg and impurities). The types of magnesium alloy include Mg-Al-based alloy, Mg-Zn-based alloy, Mg-RE (rare-earth element)-based alloy, and Y-added alloy. In particular, Mg-Al-based alloy, which contains A1, has high corrosion resistance. The types of Mg-Al-based alloy include, as specified in the Standards of American Society for Testing and Materials (ASTM), AZ-family alloy (Mg-Al-Zn-based alloy, Zn: 0.2 to 1.5 mass %), AM-family alloy (Mg-Al-Mn-based alloy, Mn: 0.15 to 0.5 mass %), AS-family alloy (Mg-Al-Si-based alloy, Si: 0.6 to 1.4 mass %), and Mg-Al-RE (rare-earth element)-based alloy. It is desirable that the Al content be 1.0 to at most 11 mass %. In particular, an Mg-Al-based alloy containing 8.3 to 9.5 mass % Al and 0.5 to 1.5 mass % Zn, represented by AZ91 alloy, has excellent corrosion resistance and mechanical properties such as strength and resistance to plastic deformation in comparison with other Mg-Al-based alloys such as AZ31 alloy. The types of Mg-Zn-based alloy, containing Zn, include, as specified in the ASTM Standards, ZK-family alloy (Mg-Zn-Zr-based alloy, Zn: 3.5 to 6.2 mass %, Zn: 0.45 mass % or more).

Shape

[0017] The pressed product of the present invention is formed by performing press working, such as bending and deep drawing, on a metal plate. In the pressed product, the peripheral surface has at least one corner portion that connects two surfaces in the peripheral surface. A typical shape of the pressed product has a top-plate portion (an undersurface portion) and a side-wall portion formed from the edge of the top-plate portion. More specifically, the types of the shape include a box-shaped body having a top-plate portion with the shape of a rectangular plate and only one pair of opposed side-wall portions, a box-shaped body having two pairs of opposed side-wall portions, and a lidded hollow cylindrical body having a top-plate portion with the shape of a circular plate and a hollow cylindrical side-wall portion. The top-plate portion and the side-wall portion each have an outside surface and an inside surface that are practically parallel to each other. In the pressed product of the present invention, the corner portion connecting two outside surfaces is sharp.

[0018] The above-described top-plate portion and side-wall portion are each typically formed with a flat surface; their shape and size are not particularly limited. They may have a unitarily formed or bonded boss or the like. They may have a through hole penetrating from the outside surface to the inside surface or a groove recessed in the thickness direction. They may have a stepped shape. They may have a portion having a locally different thickness, the portion being formed by plastic working or cutting. The portion other than the corner portion has a nearly uniform thickness, except the above-described portions having a boss, a recessed portion, and a different thickness. Hence, the thickness "t" of the metal plate forming the pressed product is defined as the average thickness of the entire portion excluding the foregoing boss and the like and the corner portion. More specifically, five or more measuring spots are chosen from the portion other than the above-described portions such as the boss to obtain the average value. When the top-plate portion is formed of a flat surface, the foregoing thickness "t" may be the average thickness of the entire top-plate portion. The thickness "t" mostly depends on the thickness of the blank plate. In the case where the plate is not subjected to the press working, the thickness "t" is practically the same as that of the blank plate.

[0019] When the above-described metal plate has a thickness "t" of 0.4 mm or more and 2.0 mm or less, a pressed product having excellent strength is obtained. When the thickness is less than 0.4 mm, because the blank plate is thin, it is easy to form a pressed product having a smaller outside corner radius R. As a result, a pressed product having very excellent appearance, such as stylishness, is obtained. When the metal plate has a thickness "t" of 2.0 mm or less; particularly 1.5 mm or less, yet particularly 0.6 mm or less, it is expected that the pressed product of the present invention can be suitably used, for example, for the housing of a portable electronic device.

[0020] The most noticeable feature of the pressed product of the present invention is that in the peripheral surface, at least one corner portion connecting two surfaces in the peripheral surface has an outside corner radius R that is equal to or smaller than "t." The conventional pressed product made of a metal plate has had an outside corner radius larger than the thickness of the metal plate; conventionally, no pressed product has satisfied the condition that R is equal to or smaller than "t." In contrast, the pressed product of the present invention has at least one corner portion satisfying the condition that R is equal to or smaller than "t." When all corner portions existing in the pressed product of the present invention satisfy the condition that R is equal to or smaller than "t," it is expected that the stylishness can be further enhanced.

[0021] In particular, when the outside corner radius R satisfies the condition that R is equal to or smaller than (2/3) x t, the corner portion can easily have a hardness higher than that of the portion other than the corner portion, such as the top-plate portion, so that the corner portion can have improved impact resistance. When the condition that R is equal to or smaller than (1/2) $\times$ t is satisfied, the impact resistance of the corner portion and the stylishness can be further improved. More specifically, it is desirable that the outside corner radius R be 0.1 to 0.3 mm. When the outside corner radius R is 0.1 mm or more, the possibility of being cut or damaged by a sharp corner portion can be reduced. When R is 0.3 mm or less, the corner portion can have excellent impact resistance while obtaining good appearance. The

decreasing of the outside corner radius R can be achieved, for example, by increasing the pressing pressure in the second pressing step.

[0022] In the pressed product obtained by the above-described production method, at the corner portion that satisfies the condition that R is equal to or smaller than "t," the inside corner radius "r" becomes practically 0 mm. In other words, in the inside surface, the two surfaces positioned at the inside of the above-described corner portion are practically perpendicular to each other. Such a pressed product has an ampler internal space than the pressed product having an inside corner radius "r" that is larger than zero and therefore can be suitably used for a housing to be used to house various components.

Production method

Preparation of the blank plate

[0023] When magnesium alloy is used to form the blank plate, it is desirable to use a rolled sheet produced by rolling a plurality of times a cast sheet produced by a continuous casting process such as the twin-roll process, particularly the casting process stated in WO/2006/003899. Because the continuous casting process enables the rapid solidification, the creation of oxides and segregation can be decreased, so that a cast sheet having excellent rolling workability can be obtained. When a cast sheet is subjected to heat treatment such as the solution treatment (heating temperature: 380°C to 420°C, heating time: 60 to 600 minutes) or the aging treatment, the composition can be homogenized. In particular, in the case of a magnesium alloy having a high Al content, it is desirable to perform the solution treatment for a long time. The size of the cast sheet is not particularly limited. Nevertheless, if the sheet is excessively thick, segregation tends to be created. Hence, it is desirable that the thickness be 10 mm or less, particularly 5 mm or less.

[0024] When a plurality of rolling operations are performed on the above-described cast sheet, the desired sheet thickness can be obtained and the average crystal grain size can be decreased. In addition, for a magnesium alloy having a high Al content, such as AZ91 alloy, defects such as coarse impurities in crystal and coarse precipitated impurities can be eliminated, so that the press workability can be increased. The rolling operation may be performed by combining with a well-known condition, for example, in the case of magnesium alloy, the controlled rolling disclosed in Patent Literature 2 or the like. When during the course of the rolling operation, an intermediate heat treatment (heating temperature: 250°C to 350°C, heating time: 20 to 60 minutes) is conducted to remove or decrease the strain, residual stress, aggregated texture, and so on all introduced into the object to be worked through the working before the intermediate heat treatment, the subsequent rolling operation can be performed more smoothly by preventing accidental cracking, strain, and deformation. The obtained rolled sheet may undergo a heat treatment at 300°C or more to remove the work strain resulting from the rolling operation and to achieve complete recrystallization. Alternatively, the obtained rolled sheet may acquire strain through the use of a roller leveler or the like under a heated condition to be recrystallized during the press working.

Press working

[0025] It is desirable that the press working in multiple stages be performed in a temperature range of 200°C to 300°C in every stage in order to increase the plastic workability of the object to be worked (the blank plate and pressed material).

[0026] In the first press working, the use of a punch having a shoulder portion with a corner radius Rp nearly equal to zero (desirably, the corner radius Rp is 0.3 mm or less) forms a pressed material having a sharp corner portion (practically right-angled) at the inside, that is, a pressed material having an inside surface in which a corner portion is formed by two surfaces perpendicular to each other. In the second press working, the end face of the pressed material and the foregoing inside corner portion are pressed with a step-shaped punch. Thus, constituting materials of the blank plate are forcefully gathered at the corner portion of the die, and the forcefully gathered constituting materials are deformed in such a way that a sharp corner portion is formed at the outside of the pressed material. At the time of the press working, a suitable die is used, such as a movable die or a recessed die.

[0027] After the press forming, heat treatment may be conducted in order to remove the strain and residual stress introduced by the press working and to improve the mechanical property. An example of the heat treatment condition is as follows: heating temperature: 100°C to 450°C, heating time: 5 minutes to 40 hours or so. When the pressed product obtained by the press working is provided with a covering layer aiming at corrosion proofing, protection, and ornamentation, the corrosion resistance, commercial value, and so on can be further increased.

Test example 1

[0028] A plurality of pressed products each made of magnesium alloy and having corner portions were produced to examine the outside corner radius R of the corner portions and the hardness of the pressed products.

[0029] A plurality of cast sheets (thickness: 4 mm) were prepared that were made of magnesium alloy having a composition equivalent to that of AZ91 alloy (Mg, 9.0 mass % Al, and 1.0 mass % Zn) and that were produced by the twin-roll continuous casting process. The obtained cast sheets were subjected to a plurality of rolling operations until the thickness was reduced to 0.6 mm under the following rolling conditions: roller temperature: 150°C to 250°C, sheet temperature: 200°C to 400°C, and rolling reduction per pass: 10% to 50%. The obtained sheet materials were subjected to blanking to prepare blank plates for the press forming.

[0030] The prepared blank plates underwent two stages of press working. Figure 1 is a schematic cross-sectional view for explaining the procedure of the press working. Figure 1 shows the blank plate by emphasizing it.

[0031] The first press working produces a pressed material P (a box-shaped body having outside dimensions of 45 $\times$ 95 $\times$ 6 mm) having a flat top-plate portion 10 as shown in the (B) and (C) portions of Fig. 1 and two pairs of flat side-wall portions 11 formed from the top-plate portion 10. More specifically, as shown in the (A) portion of Fig. 1, a blank plate B having a thickness "t" of 0.6 mm is placed on a plate 51 and a die plate 52, and on the blank plate B, a punch 53 and a holding plate 54 are placed. Then, under the condition that the blank plate B is sandwiched between the plate 51 and the punch 53, the punch 53 is moved downward in Fig. 1 to form the pressed material. The punch 53 has a shoulder portion whose corner radius Rp is practically 0 mm, and the two surfaces forming the shoulder portion are perpendicular to each other. In the pressed material P produced by this press working, the corner portion 12, which connects the outside surface 10o of the top-plate portion 10 and the outside surface 11o of the side-wall portion 11, has an outside corner radius Ro that is larger than the thickness to of the top-plate portion 10. In addition, the inside surface 10i of the top-plate portion 10 and the inside surface 11i of the side-wall portion 11 are perpendicular to each other. In other words, the inside corner radius r_0 of the corner portion 12 is practically 0 mm. In the above description, the plate 51, the die plate 52, the punch 53, the holding plate 54, and the below-described stepped punch 55 and die 56 all can be heated with a heating means, which is unshown. In the-first press working, the heating temperature was 200°C or more.

[0032] The second press working uses, for example, as shown in the (C) and (D) portions of Fig. 1, a protrusion-type stepped punch 55 and a die 56 having a recessed portion to press an end face 11e of the side-wall portion 11 of the pressed material P. This pressing operation produces a pressed product F that has a sharp corner portion whose outside corner radius R is equal to or smaller than the thickness "t" of a metal plate 1. The stepped punch 55 has an end-portion-pressing face 55p and a shoulder portion 55s that, at the inside surface of the pressed material P, is brought into contact with an inside corner portion 12i, which is nearly right-angled, to press the inside corner portion 12i. In the recessed portion of the die 56, a bottom face 56b and a side face 56s are perpendicular to each other, so that the corner portion is right-angled.

[0033] As shown in the (C) and (C') portions of Fig. 1, under the condition that the pressed material P is placed in the die 56, which has a recessed portion fitting to the outer contour of the box-shaped pressed material P, the inside of the pressed material P is pressed with the stepped punch 55. At this moment, first, the end-portion-pressing face 55p of the stepped punch 55 presses the end face 11e of the side-wall portion 11. Then, when the stepped punch 55 continues the downward pressing, a main pressing face 55m of the stepped punch 55 is brought into contact with the inside surface 10i of the top-plate portion 10 to press it. When the inside corner portion 12i of the pressed material P is pressed with the shoulder portion 55s of the stepped punch 55, constituting materials both in a part of the side-wall portion 11 and in a part of the top-plate portion 10 are forcefully gathered at the corner portion of the recessed portion of the die 56. As a result, a sharp corner portion is formed in the pressed material P in accordance with the corner portion of the recessed portion. In the above description, in order to facilitate uniform pressing of the end face 11e of the side-wall portion 11, part of the side-wall portion of the pressed material obtained by the first press working is worked by the side cutting, so that the pressed material has a side-wall portion with a uniform height of 5.5 mm. Under this condition, the second press working was carried out. In the second press working, the magnitude of the outside corner radius R was varied by varying the pressure at the time of the pressing.

[0034] Through the above-described process, as shown in the (E) portion of Fig. 1, a pressed product F can be obtained in which a corner portion 22 that connects an outside surface 20o of a top-plate portion 20 and an outside surface 21o of a side-wall portion 21 has an outside corner radius R that is equal to or smaller than the thickness "t" of the top-plate portion 20. When the thickness of the top-plate portion 20 and the side-wall portion 21 was measured using a pointed micrometer, the thickness was 0.6 mm, which is nearly equal to the thickness of the blank plate B.

[0035] The obtained pressed product was subjected to the measurements of the outside corner radius R, the hardness of the corner portion, and the hardness of the top-plate portion. The results are shown in Table I.

[0036] The outside corner radius R (mm) was measured by the following method. First, a pressed product was cut in a direction perpendicular to the ridge line between the outside surface of the top-plate portion and the outside surface of the side-wall portion. The cut surface was buff-polished (using diamond abrasive grain No. 200) and then observed under an optical microscope (400 power). The observed image was used to measure the radius. Similarly, the inside corner radius "r" (mm) of the corner portion was measured. The result showed that the radius was practically 0 mm and the inside surface of the top-plate portion and the inside surface of the side-wall portion were practically perpendicular to each other.

[0037] The hardness Hv of the corner portion was measured by the following method. First, a pressed product was cut in a direction perpendicular to the ridge line between the outside surface of the top-plate portion and the outside surface of the side-wall portion. The obtained cut piece was used to produce an embedded specimen. The cut surface was mirror-polished. Three measuring spots were chosen from the center portion of the plate in the thickness direction in the cut surface of the pressed product. The hardness of the individual measuring spots was measured using a micro-Vickers hardness tester. The average value of the three measurements is shown in Table 1.

[0038] The hardness Hv of the top-plate portion was measured by the following method. First, a part of the top-plate portion was cut from the pressed product. The obtained cut piece was used to produce an embedded specimen. The cut surface was mirror-polished. Three measuring spots were chosen from the center portion of the plate in the thickness direction in the cut surface of the top-plate portion. The hardness of the individual measuring spots was measured using a micro-Vickers hardness tester. The average value of the three measurements is shown in Table I. Alternatively, the hardness Hv may also be measured by producing an embedded specimen including both the corner portion and top-plate portion.

[0039]

[Table I]

Thickness of metal plate (mm)	0.6				
Sample No.	1-1	1-2	1-3	1-4	1-5
Outside corner radius R (mm)	0.6	0.5	0.4	0.3	0.2
Relation between R and t	R is equal to t	R is larger than (2/3)t	R is equal to (2/3)t	R is equal to (1/2)t	R is smaller than (1/2)t
Hardness of corner portion (Hv)	85	86	90	95	97
Hardness of top-plate portion (Hv)	85	86	85	85	86

[0040] As can be seen from Table I, the performing of the multistage hot press working described above can produce with high precision pressed products whose outside corner radius R satisfies the condition that R is equal to or smaller than the thickness "t." In particular, when the above-described press working is performed on a metal plate, the corner portion and the top-plate portion have a comparable hardness. Consequently, because these pressed products have corner portions with high strength, it is expected that they are less likely to be deformed when they undergo an impact such as one due to the falling.

[0041] Table I also shows that when the outside corner radius R satisfies the condition that R is equal to or smaller than (2/3) $\times$ t, the hardness of the corner portion is increased. The reason for this is attributable to the work hardening resulting from the multistage press working. Furthermore, when the outside corner radius R satisfies the condition that R is equal to or smaller than (1/2) $\times$ t, the hardness of the corner portion is significantly increased. It can be expected that these pressed products have corner portions that are excellent in impact resistance and that can accordingly maintain the sharp condition for a long time.

[0042] In Test example 1 described above, an explanation is given to the case where the corner portion connecting the top-plate portion and the side-wall portion has an outside corner radius R satisfying the condition that R is equal to or smaller than "t" in a box-type shaped body having two pairs of side-wall portions. Similarly, a pressed product can also be produced in which a corner portion connecting the side-wall portions has an outside corner radius R satisfying the condition that R is equal to or smaller than "t." A pressed product having only one pair of side-wall portions can also be produced. Furthermore, in Test example 1 described above, an explanation is given by referring to the unitarily formed stepped punch. Nevertheless, a stepped punch formed by combining divided pieces may also be used. For example, a stepped punch may also be used that is provided with a divided piece for pressing mainly the top-plate portion and another divided piece for pressing the end face of the side-wall portion and part of the top-plate portion.

Test example 2

[0043] Blank plates having various thicknesses were prepared to produce pressed products made of magnesium alloy. The produced pressed products were subjected to examination of strength and appearance.

[0044] Cast sheets (thickness: 4 mm) of the same type as prepared in Test example 1 were prepared. The prepared cast sheets had a composition equivalent to that of AZ91 alloy and were subjected to a rolling operation by varying the number of times of rolling to produce rolled sheets having various thicknesses (thicknesses: 0.3 to 0.8 mm). As with Test example 1, the obtained rolled sheets were subjected to blanking to prepare blank plates. As with Test example 1, the individual blank plates underwent two stages of hot press working (the heating temperature at the time of pressing was selected as appropriate from the range of 200°C to 250°C). Thus, pressed products were produced each of which had a flat top-plate portion and two pairs of flat side-wall portions formed from the top-plate portion.

[0045] The obtained individual pressed products were subjected to the measurement of the outside corner radius R (mm) of the corner portion by the same method as used in Test example 1. The results are shown in Table II.

[0046] In addition, the strength of the pressed product was measured as described below. The pressed product was placed such that the top-plate portion of the pressed product pointed upward on the side-wall portion used as a supporting member. Under this condition, a cemented-carbide ball having a diameter of 38 mm is pressed into the center of the top-plate portion at a load of 1 kgf (9.8 N) to deform the pressed product permanently. The amount of deformation (the dimensional difference between the most protruding portion and the most recessed portion in the peripheral surface of the top-plate portion) is measured with a contact profilometer. The amount of deformation is evaluated as the strength of the pressed product. When the amount of deformation is 1 mm or more, the pressed product is considered to have an insufficient strength and evaluated as "poor." When the amount of deformation is less than 1 mm, the pressed product is considered to have a sufficient strength and evaluated as "good." When the amount of deformation is less than 0.3 mm, the pressed product is considered to have an excellent strength and evaluated as "excellent." The results are shown in Table II.

[0047] The appearance is evaluated through a panel test conducted by 10 panelist chosen randomly. When five or less panelists judged that the pressed product has a sharp and distinctive outside corner portion, stylishness, and excellent designability, the pressed product is evaluated as "poor." When six to eight panelists judged as described above, the pressed product is evaluated as "good." When nine or more panelists judged as described above, the pressed product is evaluated as "excellent." The results are shown in Table II.

[0048]

[Table II]

Sample No.	Thickness oftop-plate portion, t (mm)	Outside corner radius R (mm)	Relation between R and t	Amount of deformation (mm)	Evaluation of strength	Evaluation of appearance	Total evaluation
2-1	0.3	0.2	R is equal to (2/3)t	1.30	Poor	Excellent	Poor
2-2	0.4	0.2	R is equal to (1/2)t	0.55	Good	Excellent	Good
2-3	0.5	0.2	R is equal to or smaller than (1/2)t	0.35	Good	excellent	Good
2-4	0.6	0.2	R is equal to or smaller than (1/2)t	0.25	Excellent	Excellent	Excellent
2-5	0.6	0.3	R is equal to (1/2)t	0.25	Excellent	Excellent	Excellent
2-6	0.6	0.4	R is equal to (2/3)t	0.25	Excellent	Good	Good
2-7	0.6	0.5	R is larger than (2/3)t	0.25	Excellent	Poor	Poor

(continued)

Sample No.	Thickness oftop-plate portion, t (mm)	Outside corner radius R (mm)	Relation between R and t	Amount of deformation (mm)	Evaluation of strength	Evaluation of appearance	Total evaluation
2-8	0.8	0.2	R is equal to or smaller than (1/2)t	0.18	Excellent	Excellent	Excellent
Note: Between the evaluation of strength and the evaluation of appearance, whichever is worse in the evaluation is used as the total evaluation.							

[0049] As can be seen from Table II, as the thickness "t" of the top-plate portion increases, the strength is increased. In addition, when the outside corner radius R is equal to or smaller than (1/2) × t, the strength is high and the appearance is excellent.

[0050] The above-described embodiments may be changed as appropriate without deviating from the gist of the present invention and not limited to the above-described constitutions. For example, the material of the metal plate may be changed from magnesium alloy to aluminum, its alloy, and other various metals.

Industrial Applicability

[0051] The pressed product of the present invention can be suitably used for various electronic devices, particularly for the housing of a portable electronic device or the like.

Reference Signs List

[0052]

1: metal plate
10: top-plate portion; 10o: outside surface of the top-plate portion; 10i: inside surface of the top-plate portion
11: side-wall portion; 11o: outside surface of the side-wall portion; 11i: inside surface of the side-wall portion; 11e: end face of the side-wall portion
12: corner portion; 12i: inside corner portion
20: top-plate portion; 20o: outside surface of the top-plate portion; 21: side-wall portion;
21o: outside surface of the side-wall portion; 22: corner portion
51: plate; 52: die plate; 53: punch; 54: holding plate; 55: stepped punch; 55m: main pressing face; 55p: end-portion-pressing face; 55s: shoulder portion; 56: die; 56b: bottom face; 56s: side face
B: blank plate; P: pressed material; F: pressed product

Citation List

Patent Literature

[0053]

PTL 1: the published Japanese patent application *Tokukai* 2002-239644
PTL 2: the published Japanese patent application *Tokukai* 2007-098470

Claims

1. A pressed product, being produced by press-forming a blank metal plate;
wherein the pressed product has a top-plate portion (10) and a side-wall portion (11) and has an external surface that has a corner portion (12) connecting two parts of the external surface;
the corner portion (12) having an outside corner radius R satisfying the condition that R is equal to or smaller than (2/3) x t, where "t" is the thickness of the blank metal plate;

characterized in that
the pressed product is a housing for a portable electronic device and is formed of a material comprising from 8.3 mass % to 9.5 mass % A1, from 0.5 mass % to 1.5 mass % Zn, and the remainder Mg and impurities;
the outside corner radius R is from 0.2 mm to 0.4 mm;
the thickness "t" is from 0.4 mm to 0.8;
the corner portion has a hardness of 90 Hv or more; and
said top-plate portion (10) and said side-wall portion (11) have thickness t.

2. The pressed product as defined by claim 1,
wherein:

(a) the outside corner radius R satisfies the condition that R is equal to or smaller than (1/2) $\times$ t;
(b) the thickness "t" is from 0.4 mm to 0.6 mm; and
(c) the corner portion has a hardness of 95 Hv or more.

3. The pressed product as defined by claim 1 or 2, wherein the corner portion has a hardness higher than that of the portion other than the corner portion.

4. The pressed product as defined by any one of claims 1 to 3, wherein the pressed product has an inside corner radius "r" that is practically 0 mm.

Patentansprüche

1. Pressprodukt, das durch Formpressen einer blanken Metallplatte hergestellt ist;
wobei das Pressprodukt einen Kopfplattenabschnitt (10) und einen Seitenwandabschnitt (11) und eine Außenfläche mit einem Eckabschnitt (12), der zwei Teile der Außenfläche verbindet, aufweist; und
der Eckabschnitt (12) einen Außeneckradius R aufweist, der die Beziehung, dass R gleich oder kleiner ist als (2/3) x t, erfüllt, wobei "t" die Dicke der blanken Metallplatte ist;
dadurch gekennzeichnet, dass
das Pressprodukt ein Gehäuse für eine tragbare elektronische Einrichtung ist und aus einem Material mit von 8.3 Massen-% bis 9.5 Massen-% Al, von 0.5 Massen-% bis 1.5 Massen-% Zn, und dem Rest Mg und Verunreinigungen gebildet ist; und
der Außeneckradius R von 0.2 mm bis 0.4 mm beträgt;
die Dicke " t" von 0.4 mm bis 0.8 beträgt;
der Eckabschnitt eine Härte von 90 Hv oder mehr aufweist; und
der Kopfplattenabschnitt (10) und der Seitenwandabschnitt (11) Dicke t aufweisen.

2. Pressprodukt nach Anspruch 1, bei dem:

(a) der Außeneckradius R die Beziehung, dass R gleich oder kleiner ist als (1/2) x t, erfüllt;
(b) die Dicke " t" von 0.4 mm bis 0.6 mm beträgt; und
(c) der Eckabschnitt eine Härte von 95 Hv oder mehr aufweist.

3. Pressprodukt nach Anspruch 1 oder 2, bei dem der Eckabschnitt eine Härte aufweist, die größer ist als diejenige des anderen Abschnitts als des Eckabschnitts.

4. Pressprodukt nach einem der Ansprüche 1-3, bei dem das Pressprodukt einen Inneneckradius "r" aufweist, der praktisch 0 mm beträgt.

Revendications

1. Produit pressé qui est produit en formant à la presse une plaque métallique d'ébauche ;
dans lequel le produit pressé a une partie de plaque supérieure (10) et une partie de paroi latérale (11) et a une surface externe qui a une partie de coin (12) raccordant deux parties de la surface externe ;
la partie de coin (12) ayant un rayon de coin externe R satisfaisant la condition que R est égal ou inférieur à (2/3) x t, où « t » est l'épaisseur de la plaque métallique d'ébauche ;

caractérisé en ce que :

le produit pressé est un boîtier pour un dispositif électronique portable et est formé à partir d'un matériau comprenant de 8,3% en poids à 9,5% en poids de Al, de 0,5% en poids à 1,5% en poids de Zn et le reste composé de Mg et d'impuretés ;
le rayon de coin externe R est de l'ordre de 0,2 mm à 0,4 mm ;
l'épaisseur « t » est de l'ordre de 0,4 mm à 0,8 ;
la partie de coin a une dureté de 90 Hv ou supérieure ; et
ladite partie de plaque supérieure (10) et ladite partie de paroi latérale (11) ont une épaisseur t.

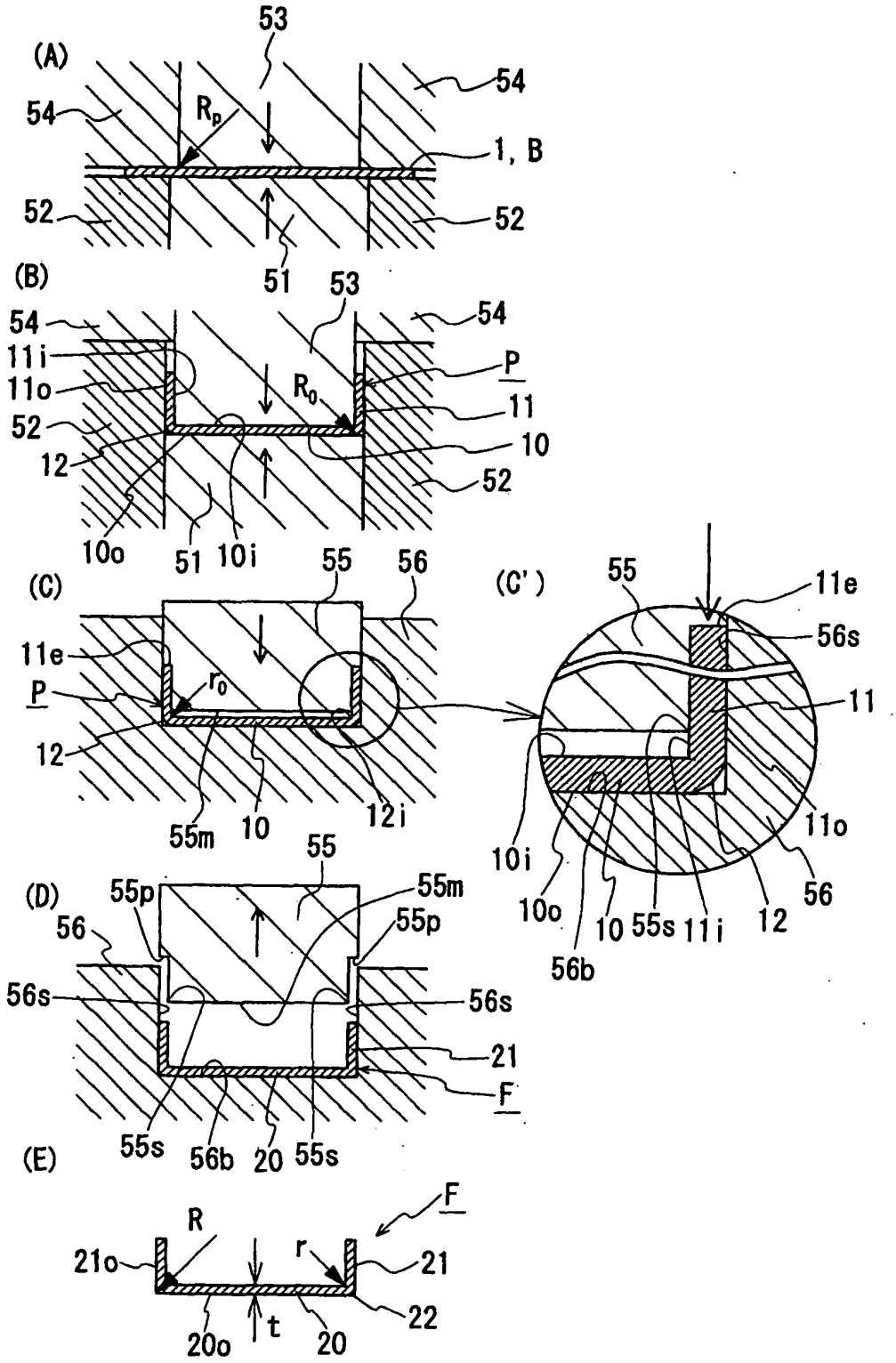
2. Produit pressé selon la revendication 1, dans lequel :

(a) le rayon de coin externe R satisfait la condition que R est égal ou inférieur à (1/2) x t ;
(b) l'épaisseur « t » est de l'ordre de 0,4 mm à 0,6 mm ; et
(c) la partie de coin a une dureté de 95 Hv ou supérieure.

3. Produit pressé selon la revendication 1 ou 2, dans lequel la partie de coin a une dureté supérieure à celle de la partie différente de la partie de coin.

4. Produit pressé selon l'une quelconque des revendications 1 à 3, dans lequel le produit pressé a un rayon de coin interne « r » qui est pratiquement de 0 mm.

FIG. 1


(A)
53
54
54
R_p
1, B
52
52
51
(B)
53
54
54
11i
11o
P
R_0
11
52
10
12
52
10o
51
10i
(C)
55
56
11e
P
r_0
12
55m
10
12i
(C')
55
11e
56s
11
11o
10i
10o
10
55s
11i
12
56
56b
(D)
55
55p
55m
55p
56
56s
56s
21
F
55s
56b
20
55s
(E)
F
R
21o
r
21
22
20o
t
20

REFERENCES CITED IN THE DESCRIPTION

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- JP 2002239644 A **[0053]**
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