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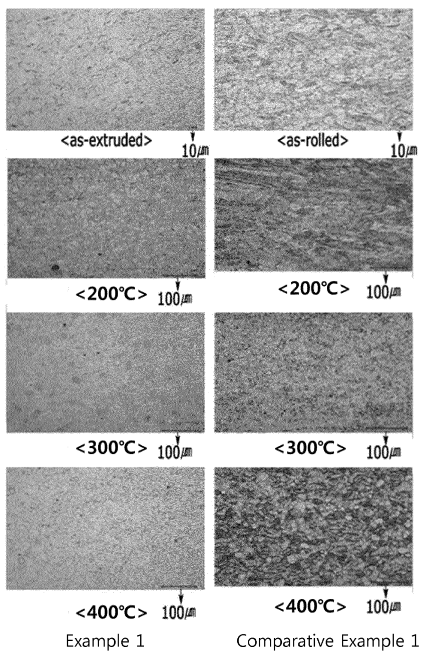
(54) ## MAGNESIUM ALLOY MATERIAL AND MANUFACTURING METHOD THEREFOR

(57) The present invention relates to a magnesium alloy material and a method for manufacturing the same.

An embodiment of the present invention provides a magnesium alloy material comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%, wherein the magnesium alloy material has a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

FIG. 2



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Description

TECHNICAL FIELD

[0001] An embodiment of the present invention relates to a magnesium alloy material and a method for manufacturing the same.

TECHNICAL BACKGRAOUND

[0002] Recently, as the LED industry evolved, the development of high power LED lighting of the tens or even hundreds of watts-class is becoming more active.

[0003] As a result, the size and the weight of the heat sinking component for dissipating heat generated by the LED become large, and it is important to solve such a problem.

[0004] Since the weight of the heat sinking component is about 80% of the total weight of the LED lighting, the light efficiency of the heat sinking component may be effectively increased by reducing the weight of the heat sinking component.

[0005] Therefore, it is necessary to reduce the weight of heat sinking component.

[0006] Magnesium has been the subject of lightweight metals in this regard. The density of magnesium is 1.74 g/cm^3, and magnesium is classified as the lightest metal among the structural metals including aluminum and steel.

[0007] In addition, the thermal conductivity of pure magnesium is 155 W/mK, which is considerably excellent considering the specific gravity. However, the thermal conductivity of the commonly used magnesium alloy is 80 W/mK, which is lower than that of pure magnesium.

[0008] This may be due to the alloy component and the manufacturing process added to improve the mechanical strength.

[0009] Thermal conductivity is interrupted due to the degree of solubility of the added alloy component, intermetallic compounds, or dislocations such as, internal substances or defects.

[0010] Korean Patent Registration No. 1516378 discloses a method for manufacturing a magnesium alloy sheet having a high thermal conductivity.

[0011] However, the above patent discloses a magnesium alloy having an excellent thermal conductivity, but, since the magnesium alloy thin sheet is disclosed, additional molding is required for use as a heat sink.

[0012] In addition, since the thermal conductivity of the magnesium alloy thin sheet is about 120 W/mK, which is insufficient compared to pure magnesium (155 W/mK), there is still a shortcoming to replace the existing materials in the heat sink market.

[0013] Thus, in an embodiment of the present invention, the microstructure of the magnesium alloy material may be controlled by removing unnecessary alloying elements and controlling the manufacturing process differently from the prior art.

[0014] This makes it possible to provide a magnesium alloy material having a higher thermal conductivity.

CONTENTS OF THE INVENTION

PROBLEM TO SOLVE

[0015] The present invention is intended to provide a magnesium alloy material and a method for manufacturing the same.

SUMMARY OF THE INVENTION

[0016] The magnesium alloy material which is an embodiment of the present invention may provide a magnesium alloy material comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%, wherein the magnesium alloy material has a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

[0017] An average diameter of the grains of the magnesium alloy material may be 10 μm to 20 μm.

[0018] A thermal conductivity of the magnesium alloy material may be 135 W/mK or more.

[0019] The method for manufacturing a magnesium alloy material which is another embodiment of the present invention may comprise the steps of continuously casting a molten alloy to prepare a billet; subjecting the billet to homogenizing heat treatment; preheating the homogenizing heat-treated billet; hot extruding the preheated billet to manufacture an extruded material; and subjecting the manufactured extruded material to heat treatment.

[0020] The step of subjecting the manufactured extruded material to heat treatment may be a heat treatment at a temperature in the range of 200°C to 400°C.

[0021] More specifically, it may be heat treatment for 0.5 to 2 hours.

[0022] The step of hot extruding the preheated billet to manufacture an extruded material may be hot extrusion by a direct extrusion method.

[0023] The step of hot extruding the preheated billet to manufacture an extruded material may be hot extrusion at a temperature in the range of 350 °C to 550 °C.

[0024] More specifically, it may be a hot extrusion at a rate of 10 to 30 mpm.

[0025] The step of preheating the homogenizing heat-treated billet may be a preheating in indirect heating type heating furnace.

[0026] More specifically, it may be a preheating to a temperature in the range of 350°C to 550°C.

[0027] The step of subjecting the billet to homogenizing heat treatment may be a homogenizing heat treatment at a temperature in the range of 400 °C to 500 °C.

[0028] More specifically, it may be a homogenizing heat treatment for 10 hours to 16 hours.

[0029] In the step of continuously casting a molten alloy to prepare a billet, the molten may comprise 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%.

[0030] Further, the step of continuously casting a molten alloy to prepare a billet may be a continuous casting at a temperature in the range of 650 °C to 750 °C.

[0031] Further, the step of continuously casting a molten alloy to prepare a billet may be a continuous casting at a rate of 50 to 150 mm/min.

[0032] The magnesium alloy material may have a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

[0033] An average diameter of the grains of the magnesium alloy material may be 10 μm to 20 μm.

[0034] A thermal conductivity of the magnesium alloy material may be 135 W/mK or more.

EFFECTS OF THE INVENTION

[0035] According to an embodiment of the present invention, a high heat sinking magnesium alloy material having excellent thermal conductivity and a method for manufacturing the same may be provided.

DESCRIPTION OF THE DRAWINGS

[0036]

FIG. 1 shows a schematic diagram of a direct extruder used in a method for manufacturing a magnesium alloy material according to an embodiment of the present invention.

FIG. 2 shows the microstructure by the heat treatment temperature after extrusion of Example and the microstructure by the heat treatment temperature after rolling of Comparative Example 1 with an optical microscope.

FIG. 3 shows the surface characteristics of the extruded material according to whether or not the Ca component is added through Example of the present invention and Comparative Example 5.

DETAILED DESCRIPTION OF THE INVENTION

[0037] The advantages and features of the present invention and the manner of achieving them will become apparent with reference to the embodiments described in detail below with the accompanying drawings.

[0038] However, it is to be understood that the present invention is not limited to the disclosed embodiments, but may be embodied in many different forms, and these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to a person skilled in the art, and the present invention is only defined by the scope of the claims.

[0039] Same reference numerals refer to same elements throughout the specification.

[0040] Thus, in some embodiments, well-known techniques are not specifically described to avoid an ambiguous interpretation of the present invention.

[0041] Unless defined otherwise, all terms (including technical and scientific terms) used herein may be used in a sense commonly understood by a person skilled in the art.

[0042] Further, through the specification, unless explicitly described to the contrary, the word "comprise" and variations such as "comprises" or "comprising" will be understood to imply the inclusion of stated elements but not the exclusion of any other elements.

[0043] Also, singular forms comprise plural forms unless noted otherwise.

[0044] The magnesium alloy material which is an embodiment of the present invention may provide a magnesium alloy material comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%.

[0045] At this time, the magnesium alloy material may have a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

[0046] More specifically, the microstructure of the magnesium alloy material may be a complete recrystallized structure in which there is almost no deformed structure and no secondary phase.

[0047] More specifically, the magnesium alloy material may obtain a magnesium alloy material of the complete recrystallized structure as described above by a method for manufacturing a magnesium alloy material described below.

[0048] An average diameter of the grains of the magnesium alloy material may be 10 μm to 20 μm.

[0049] The average diameter of the grains of the magnesium alloy material may be controlled as described above by the step of subjecting to heat treatment in the method for manufacturing the magnesium alloy material described below.

[0050] When the average diameter of the grains of the magnesium alloy material is in the above range, the thermal conductivity may be improved somewhat.

[0051] In this specification, the diameter of a grain refers to the diameter of a grain present in a measurement unit.

[0052] In case of non-spherical, the diameter of a grain means the diameter of the sphere calculated by approximating the non-spherical material to a spherical shape.

[0053] In the following, the reasons for limiting the components and the composition range of the alloy in the present invention will be described.

[0054] Manganese (Mn) may be comprised in an amount of 0.8 to 1.8 wt%.

[0055] More specifically, when the manganese is less than 0.8 wt%, the strength of the magnesium alloy material may be lowered too much.

[0056] On the other hand, if it exceeds 1.8 wt%, a large amount of secondary phase may be generated, so that the thermal conductivity may be decreased.

[0057] Calcium (Ca) may be comprised in an amount of 0.2 wt% or less (excluding 0%).

[0058] More specifically, when calcium is added in a small amount, it acts to increase the ignition temperature of the alloy itself and suppress ignition.

[0059] It also serves to prevent surface cracking during the hot extrusion process.

[0060] However, when it is comprised in an amount exceeding 0.2 wt%, a secondary phase such as Mg_2Ca may be formed.

[0061] Further, in terms of the thermal conductivity, it is advantageous that the addition amount of the alloying elements is minimized.

[0062] Therefore, when the maximum addition amount is in the above range, a magnesium alloy material having excellent thermal conductivity may be produced without forming a secondary phase.

[0063] Accordingly, the thermal conductivity of the magnesium alloy material may be 135 W/mK or more.

[0064] More specifically, it may be 135 W/mK to 145 W/mK.

[0065] The method for manufacturing a magnesium alloy material which is another embodiment of the present invention may comprise the steps of continuously casting a molten alloy to prepare a billet; subjecting the billet to homogenizing heat treatment; preheating the homogenizing heat-treated billet; hot extruding the preheated billet to manufacture an extruded material; and subjecting the manufactured extruded material to heat treatment.

[0066] First, a step of continuously casting a molten alloy to prepare a billet; may be carried out.

[0067] In the step of continuously casting a molten alloy to prepare a billet, the molten alloy may comprise 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%.

[0068] The reasons for limiting the components and the composition of the molten alloy are the same as the reason for limiting the components and the composition of the magnesium alloy material, and therefore will be omitted.

[0069] More specifically, the step of continuously casting a molten alloy to prepare a billet; may be a continuous casting at a temperature in the range of 650 °C to 750 °C.

[0070] The rate of the continuous casting may be 50 mm/min to 150 mm/min.

[0071] In addition, continuous casting may be performed by using a billet cutting apparatus that is interlocked with a casting rate, and defects inside and outside the billet may be minimized by using an electromagnetic field method (EMC/EMS).

[0072] Thereafter, the step of subjecting the billet to homogenizing heat treatment; may be carried out.

[0073] More specifically, the billet may be subjected to a homogenizing heat treatment at a temperature in the range of 400 °C to 500 °C.

[0074] More specifically, the billet may be subjected to a homogenizing heat treatment for 10 hours to 16 hours.

[0075] When the billet is subjected to a homogenizing heat treatment at too low a temperature or for too short a time, homogenization treatment of the heterogeneous microstructure that occurs during casting may not be performed properly.

[0076] As a result, during the subsequent extrusion process, the extrusion pressure may be increased.

[0077] On the other hand, when the billet is subjected to homogenizing heat treatment at too high a temperature or for too long a time, localized melting may occur in some concentrated layers and segregation rod. This may cause defects in the billet.

[0078] Thereafter, the step of preheating the homogenizing heat-treated billet; may be carried out. The homogenizing heat-treated billet may be preheated in indirect heating type heating furnace.

[0079] More specifically, when the homogenizing heat-treated billet is preheated in a direct heating type heating furnace, the surface may be locally overheated by a direct flame.

[0080] As a result, the surface may be melted and there is a risk of fire. Therefore, the billet may be preheated in the indirect heating type heating furnace.

[0081] More specifically, the indirect heating type heating furnace may be, for example, an induction heater type using a high frequency or low frequency induced current.

[0082] However, the present invention is not limited thereto, and it is possible to use them all without a direct flame, such as a torch.

More specifically, the homogenizing heat-treated billet may be preheated to a temperature in the range of 350°C to 550°C.

[0083] Even more specifically, when the homogenizing heat-treated billet is preheated to less than 350 °C, the stress to plastic deform the billet in the step of hot extruding described below increases and the extruder is subjected to a heavy load due to the high extrusion pressure.

[0084] Due to this, the extrusion rate may not be fast so that the productivity is decreased.

[0085] More specifically, when the homogenizing heat-treated billet is preheated to more than 550 °C, the extrusion rate at the time of extrusion in the step of hot extruding described below is rapidly controlled, so that the surface of the billet, due to the heat generated by friction with the extrusion die and plastic deformation, may exceed the solidus temperature of the material.

[0086] As a result, it may be locally melted on the surface of the billet and defects may occur.

[0087] In addition, abnormal coarse grains may appear due to overheating, which may cause surface defects.

[0088] By preheating the homogenizing heat-treated billet for the above time, it is possible to easily extrude it without surface defects and without giving a large load to the extruder in the step of hot extruding described below.

[0089] Thereafter, the step of hot extruding the preheated billet to manufacture an extruded material; may be carried out.

[0090] More specifically, it is possible to quickly hot extrude before the heat of the billet, which is preheated by the above-mentioned step of preheating the homogenizing heat-treated billet, cools.

[0091] More specifically, the preheated billet may be hot extruded by a direct extrusion method.

[0092] More specifically, it may be hot extruded using a direct extruder. This is as disclosed in FIG. 1.

[0093] FIG. 1 shows a schematic diagram of a direct extruder used in a method for manufacturing a magnesium alloy material according to an embodiment of the present invention.

[0094] More specifically, the billet 11 loaded in the container 31 may be manufactured to the extruded material 12 through the die 21 by applying pressure to the ram 41 of the direct extruder.

[0095] Therefore, the extruded material 12 may be manufactured by using a direct extrusion method which proceeds in the same direction as the advancing direction of the ram 41.

[0096] At this time, in order to minimize thermal deformation, the die 21 which is designed to be able to control the temperature by season or the extrusion situation may be used.

[0097] In addition, it may include a multi-stage mold, a support stand, and the like. The preheated billet may be hot extruded at a temperature in the range of 350 °C to 550 °C. More specifically, the preheated billet is hot extruded at the above-mentioned temperature range, so that the extruded material may be easily manufactured without surface defects and without giving a large load to the extruder.

[0098] The preheated billet may be hot extruded at a rate of 10 to 30 mpm. More specifically, if the hot extrusion rate is too slow, productivity may be significantly reduced.

[0099] On the other hand, if the extrusion rate is too fast, the extrusion pressure becomes excessively high, so that the extruder may be overloaded. Also, at some high temperature and high rate sections, surface cracking may occur due to localized melting.

[0100] Thereafter, the step of subjecting the manufactured extruded material to heat treatment; may be comprised.

[0101] More specifically, in the step of subjecting the manufactured extruded material to heat treatment; the extruded material may be subjected to heat treatment at a temperature in the range of 200°C to 400°C.

[0102] More specifically, the extruded material may be subjected to heat treatment for 0.5 to 2 hours.

[0103] By subjecting the extruded material to heat treatment at the above temperature range and for the above time, the deformed structure and the residual stress generated in the above-described step of hot extruding may be alleviated.

[0104] This makes it possible to obtain a magnesium alloy material having a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material, therefore, the thermal conductivity of the magnesium alloy material may be 135 W/mK or more.

[0105] Hereinafter, it will be described in detail with example. However, the following example is for exemplary purposes only, and the scope of the present invention is not limited thereto.

Example

[0106] A molten alloy comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt% was continuously casted to prepare a billet.
[0107] Thereafter, the billet was subjected to homogenizing heat treatment at 400 °C for 16 hours.
[0108] Thereafter, the homogenizing heat-treated billet was preheated at 430 °C for 4 hours.
[0109] Thereafter, the preheated billet was hot extruded using a direct hot extruder.
[0110] At this time, the extruded material was produced by hot extrusion at 430 °C at a rate of 15 mpm.
[0111] Thereafter, the extruded material was subjected to heat treatment at 300 °C for 1 hour to obtain a final magnesium alloy material.

Comparative Example 1

[0112] A magnesium alloy comprising 0.5 to 2.0 wt% of Mn, 0.1 wt% or less (excluding 0 wt%) of Al, 8 to 15 ppm of Be, and the balance of Mg, for a total of 100 wt% was strip casted to prepare a sheet;
[0113] Thereafter, the sheet was subjected to homogenizing heat treatment under the same conditions as in Example of the present invention.
[0114] Thereafter, the homogenizing heat-treated sheet was warm-rolled at a temperature of 150 to 300 °C.

Comparative Example 2

[0115] A commercially available AZ31 magnesium alloy was prepared.

Comparative Example 3

[0116] A commercially available AZ61 magnesium alloy was prepared.

Comparative Example 4

[0117] A commercially available STS304 stainless steel was prepared.

Comparative Example 5

[0118] A molten alloy comprising 0.8 to 1.8 wt% of Mn, and the balance of Mg and inevitable impurities, for a total of 100 wt% was continuously casted to prepare a billet.
[0119] Compared with the above Example, a molten alloy having the same composition and composition, except that the Ca component was not included, was continuously casted to prepare a billet.
[0120] Thereafter, the steps of subjecting the billet to homogenizing heat treatment; preheating the homogenizing heat-treated billet; hot extruding the preheated billet to manufacture an extruded material; and subjecting the manufactured extruded material to heat treatment were carried out under the same conditions as those of the above Example to manufacture a magnesium alloy material.

Experimental Example: Comparison of Thermal Conductivity

[0121] Then, the thermal conductivities of the prepared Example and Comparative Examples 1 to 4 were compared.
[0122] At this time, the thermal conductivity was measured at 25 °C using a thermal constant measuring apparatus after processing the specimen in the form of a circular disk having a diameter of 10 to 13 mm and a thickness of 2.0 to 3.0 mm.
[0123] The results are as shown in Table 1 below.

[Table 1]

No.	Thermal Conductivity (W/mK, 25°C)
Example	138.51
Comparative 1	119.98
Comparative 2	86.92

(continued)

No.	Thermal Conductivity (W/mK, 25°C)
Comparative 3	65.63
Comparative 4	18.75

[0124] As shown in Table 1, the thermal conductivities of Example of the present invention and Comparative Examples 1 to 4, which are commercially available alloys, are shown in comparison.

[0125] As a result, it may be confirmed that Example of the present invention is significantly excellent in thermal conductivity as compared with Comparative Examples 1 to 4.

[0126] More specifically, in the case of Comparative Example 1, a magnesium alloy sheet material was manufactured by warm-rolling after strip casting a molten alloy comprising all of Mn, Al, Be, and Ca.

[0127] As shown in Table 1, it may be seen that Example of the present invention is excellent in thermal conductivity as compared with Comparative Example 1, which may be explained through the microstructure of the above Example and Comparative Example 1.

[0128] The microstructure of the above Example and Comparative Example 1 are shown in FIG. 2 of the present invention.

[0129] FIG. 2 shows the microstructure by the heat treatment temperature after extrusion of Example and the microstructure by the heat treatment temperature after rolling of Comparative Example 1 with an optical microscope.

[0130] More specifically, FIG. 2 shows the microstructure of Example manufactured by extrusion and Comparative Example 1 manufactured by strip casting method while changing the temperature in the heat treatment condition according to an embodiment of the present invention.

[0131] At this time, the heat treatment time was 1 hour at each temperature.

[0132] As shown in FIG. 2, in the case of Comparative Example 1, many deformed structures such as shear band and twin defect caused by plastic working are observed.

[0133] In addition, in the case of Comparative Example 1, it is seen that residual stress due to cumulative rolling is also accumulated.

[0134] On the other hand, in the case of present Example, some recrystallized structure, such as annealed, may be identified in the microstructure of the extruded material by the step of hot extruding (As-extruded in Example).

[0135] However, although some twin structures and secondary phases (black particles) are also identified, it is possible to visually confirm that the fraction of the deformed structure is much smaller than that of Comparative Example 1.

[0136] Thus, in the case of Comparative Example 1 manufactured by strip casting and warm-rolling, it may be confirmed that a large amount of the deformed structure remains even after the subsequent heat treatment is carried out at the same temperature and time as in Example after the rolling.

[0137] On the other hand, in the case of Example of the present invention, before the heat treatment, since the fraction of the internal stress, the deformed structure, and the secondary phase accumulated in the manufactured extruded material (As-extruded in the example) was remarkably smaller than that of the total microstructure, as a result of the subsequent heat treatment, it was confirmed that recovery and recrystallization occurred smoothly.

[0138] As a result, the recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure was confirmed. In addition, in Example of the present invention, it may be seen that the diameter of the grains is relatively large.

[0139] That is, as compared with the microstructure of Comparative Example 1, it may be seen that the microstructure of Example of the present invention has significantly fewer factors impeding thermal conductivity.

[0140] Accordingly, as shown in Table 1, the thermal conductivity of Comparative Example 1 is 120 W/mK, while the thermal conductivity of the Example of the present invention is 20 W/mK higher than that of Comparative Example 1.

[0141] It may be seen that it is an excellent value compared to that the thermal conductivity of pure magnesium metal is about 155 W/mK and the thermal conductivity of commercially available magnesium alloy is about 80 W/mK.

[0142] This feature is achieved by reducing unnecessary alloying elements in the present invention and controlling the process conditions in the step of manufacturing the magnesium alloy material to obtain a microstructure in which recrystallization is completed in which almost no residual stress, secondary phase, deformed structure and the like.

[0143] More specifically, it is a result of formation of recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure.

[0144] In addition, FIG. 3 shows the surface characteristics of the extruded material according to whether or not the Ca component is added through Example of the present invention and Comparative Example 5.

[0145] As shown in FIG. 3, in the case of Example of the present invention in which the Ca component is comprised, since the ignition temperature of the alloy is increased as comprising a small amount of the Ca component, it may be confirmed that surface cracking is suppressed during hot extrusion.

[0146] As a result, it may be confirmed that the surface shape is excellent.

[0147] On the other hand, in the case of Comparative Example 5 which does not comprise a small amount of Ca, since the ignition temperature is low, it may be confirmed that the surface shape of the magnesium alloy is inferior due to surface cracking during hot extrusion.

[0148] For this reason, it may be seen that adding Ca in a small amount is important from the viewpoint of productivity.

[0149] Although the embodiments of the present invention have been described with reference to the accompanying drawings, it will be understood by a person skilled in the art may understand that it may be carried out in different and concrete forms without changing the technical idea or fundamental feature of the present invention.

[0150] Therefore, it is to be understood that the above-mentioned examples or embodiments are illustrative in all aspects and not limitative.

[0151] The scope of the present invention is defined by the appended claims rather than the detailed description, and all changes or modifications derived from the meaning and scope of the claims and their equivalents should be interpreted as being included in the scope of the present invention.

Explanation of symbols

[0152]

1: Direct extrusion extruder
11: Billet
12: Extruded material
21: Die (Extrusion mold)
22: Die Holder (Extrusion mold supporter)
31: Container
41: Ram (Parts moved by hydraulic pressure)

Claims

1. A magnesium alloy material containing 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%,
wherein the magnesium alloy material has a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

2. The magnesium alloy material according to claim 1,
wherein an average diameter of the grains of the magnesium alloy material is 10 μm to 20 μm.

3. The magnesium alloy material according to claim 2,
wherein a thermal conductivity of the magnesium alloy material is 135 W/mK or more.

4. A method for manufacturing a magnesium alloy material comprising the steps of continuously casting a molten alloy comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%, to prepare a billet;
subjecting the billet to homogenizing heat treatment;
preheating the homogenizing heat-treated billet;
hot extruding the preheated billet to manufacture an extruded material; and
subjecting the manufactured extruded material to heat treatment.

5. The method for manufacturing a magnesium alloy material according to claim 4,
wherein the step of subjecting the manufactured extruded material to heat treatment is a heat treatment at a temperature in the range of 200 °C to 400 °C.

6. The method for manufacturing a magnesium alloy material according to claim 5,
wherein the step of subjecting the manufactured extruded material to heat treatment, is a heat treatment for 0.5 to 2 hours.

7. The method for manufacturing a magnesium alloy material according to claim 4,
wherein the step of hot extruding the preheated billet to manufacture an extruded material is a hot extrusion by a

direct extrusion method.

8. The method for manufacturing a magnesium alloy material according to claim 7, wherein the step of hot extruding the preheated billet to manufacture an extruded material is a hot extrusion at a temperature in the range of 350 °C to 550 °C.

9. The method for manufacturing a magnesium alloy material according to claim 8, wherein the step of hot extruding the preheated billet to manufacture an extruded material is a hot extrusion at a rate of 10 to 30 mpm.

10. The method for manufacturing a magnesium alloy material according to claim 4, wherein the step of preheating the homogenizing heat-treated billet is a preheating in indirect heating type heating furnace.

11. The method for manufacturing a magnesium alloy material according to claim 10, wherein the step of preheating the homogenizing heat-treated billet is a preheating to a temperature in the range of 350 °C to 550 °C.

12. The method for manufacturing a magnesium alloy material according to claim 4, wherein the step of subjecting the billet to homogenizing heat treatment is a homogenizing heat treatment at a temperature in the range of 400 °C to 500 °C.

13. The method for manufacturing a magnesium alloy material according to claim 12, wherein the step of subjecting the billet to homogenizing heat treatment is a homogenizing heat treatment for 10 hours to 16 hours.

14. The method for manufacturing a magnesium alloy material according to claim 4, wherein the step of continuously casting a molten alloy comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%, to prepare a billet is a continuous casting at a temperature in the range of 650 °C to 750 °C.

15. The method for manufacturing a magnesium alloy material according to claim 14, wherein the step of continuously casting a molten alloy comprising 0.8 to 1.8 wt% of Mn, 0.2 wt% or less (excluding 0 wt%) of Ca and the balance of Mg and inevitable impurities, for a total of 100 wt%, to prepare a billet is a continuous casting at a rate of 50 to 150 mm/min.

16. The method for manufacturing a magnesium alloy material according to any one according to claims 4 to 15, wherein the magnesium alloy material has a recrystallized structure of 99 vol% or more for 100 vol% of the total microstructure of the magnesium alloy material.

17. The method for manufacturing a magnesium alloy material according to any one according to claims 4 to 15, wherein an average diameter of the grains of the magnesium alloy material is 10 μm to 20 μm.

18. The method for manufacturing a magnesium alloy material according to any one of claims 4 to 15, wherein a thermal conductivity of the magnesium alloy material is 135 W/mK or more.

FIG. 1

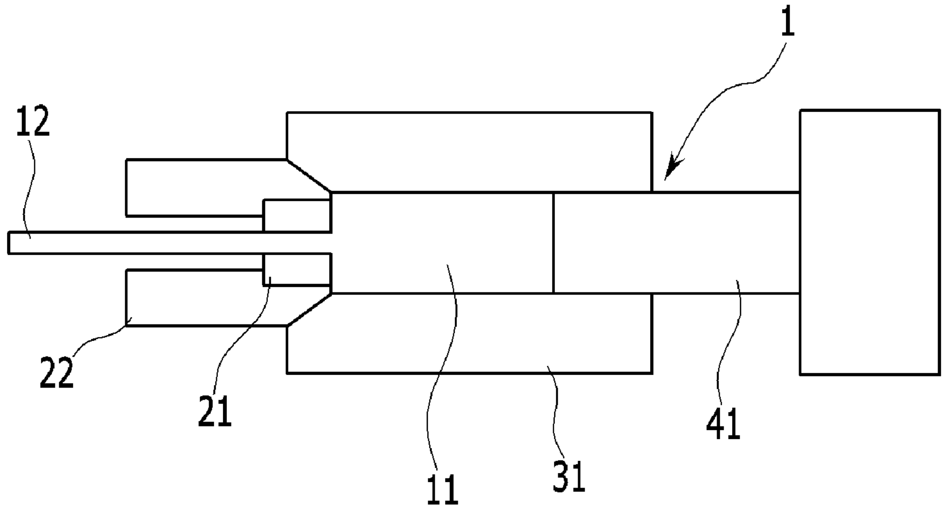
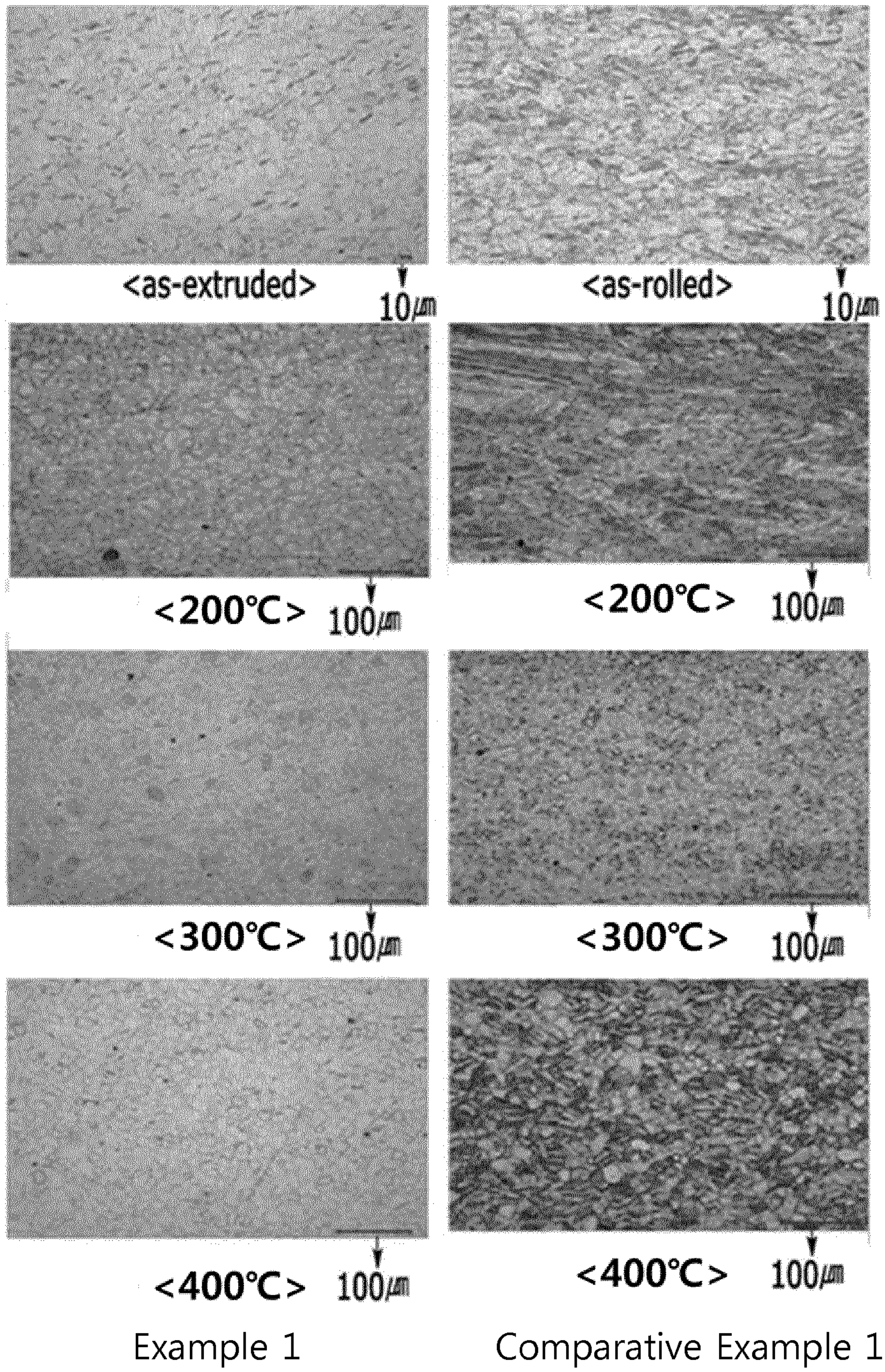


FIG. 2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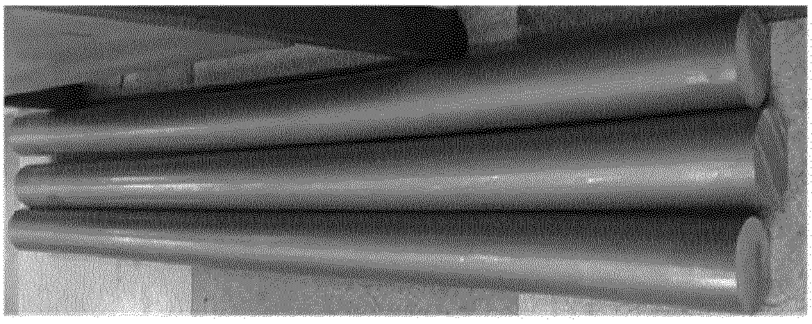
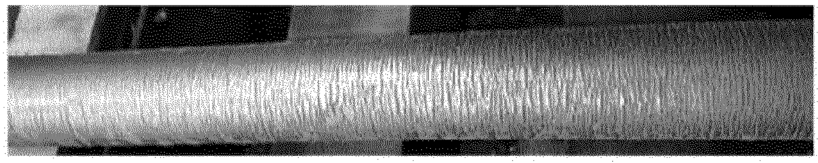
Example 1
Comparative Example 1

FIG. 3



Example 5



Comparative Example 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2017/006270

A. CLASSIFICATION OF SUBJECT MATTER

C22C 23/00(2006.01)i, C22C 1/02(2006.01)i, C22F 1/06(2006.01)i, B22D 11/00(2006.01)i, B22D 11/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22C 23/00; C22C 23/06; C22F 1/06; C22C 23/04; C22C 1/02; B22D 11/00; B22D 11/16

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: magnesium, manganese, calcium, casting, homogenization, billet, hot, extrusion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 4395820 B2 (NAKABOHTEC CORROSION PROTECTING CO., LTD.) 13 January 2010 See paragraphs [0009], [0010] and claim 1.	4-15
A		1-3,16-18
Y	KR 10-2003-0048412 A (SHIN, Kwang-Seon) 19 June 2003 See pages 4, 5 and claims 11, 14-16.	4-15
A	US 2013-0199677 A1 (VENKATESAN et al.) 08 August 2013 See paragraphs [0049]-[0053] and claims 11, 14-22.	1-18
A	CN 101392343 A (SHANGHAI JIAO TONG UNIVERSITY) 25 March 2009 See page 4, lines 6-27 and claim 1.	1-18
A	KR 10-2015-0144593 A (KOREA INSTITUTE OF INDUSTRIAL TECHNOLOGY) 28 December 2015 See paragraphs [0034]-[0037] and claims 8, 9.	1-18

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

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 SEPTEMBER 2017 (19.09.2017)	**20 SEPTEMBER 2017 (20.09.2017)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2017/006270

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 4395820 B2	13/01/2010	JP 2001-355033 A	25/12/2001
KR 10-2003-0048412 A	19/06/2003	CA 2423459 A1	04/04/2002
		CA 2423459 C	15/09/2009
		EP 1339888 A1	03/09/2003
		EP 1339888 B1	13/04/2011
		IL 154897 B	24/12/2009
		JP 2004-510057 A	02/04/2004
		JP 3891933 B2	14/03/2007
		WO 02-27053 A1	04/04/2002
US 2013-0199677 A1	08/08/2013	AU 2011-257953 A1	06/12/2012
		AU 2011-257953 B2	08/05/2014
		CN 103038379 A	10/04/2013
		CN 106399783 A	15/02/2017
		EP 2576851 A1	10/04/2013
		JP 2013-533375 A	22/08/2013
		JP 2016-138336 A	04/08/2016
		KR 10-2013-0075749 A	05/07/2013
		WO 2011-146970 A1	01/12/2011
CN 101392343 A	25/03/2009	NONE	
KR 10-2015-0144593 A	28/12/2015	KR 10-1585089 B1	22/01/2016

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1516378 **[0010]**