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(54) **ALUMINUM ALLOY FOR DIE CASTING**

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(71) Applicants: **Hyundai Motor Company**, Seoul (KR); **Kia Motors Corporation**, Seoul (KR); **Industry-Academia Cooperation Group of Sejong University**, Seoul (KR)

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(72) Inventors: **Hoo-Dam Lee**, Anyang (KR); **Chang-Yeol Yoo**, Suwon (KR); **Jong-Kook Lee**, Suwon (KR); **Ki Buem Kim**, Seoul (KR); **Yeon Beom Jeong**, Seoul (KR)

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CPC **C22C 21/08** (2013.01); **C22C 1/026** (2013.01)

(57) **ABSTRACT**

Disclosed is an aluminum alloy for a die casting. The aluminum alloy includes aluminum (Al) as a base material and magnesium (Mg) in an amount of about 6.8 to 10 wt % thereby exhibiting sufficient aesthetic appearance without performing additional process and improving strength thereof.

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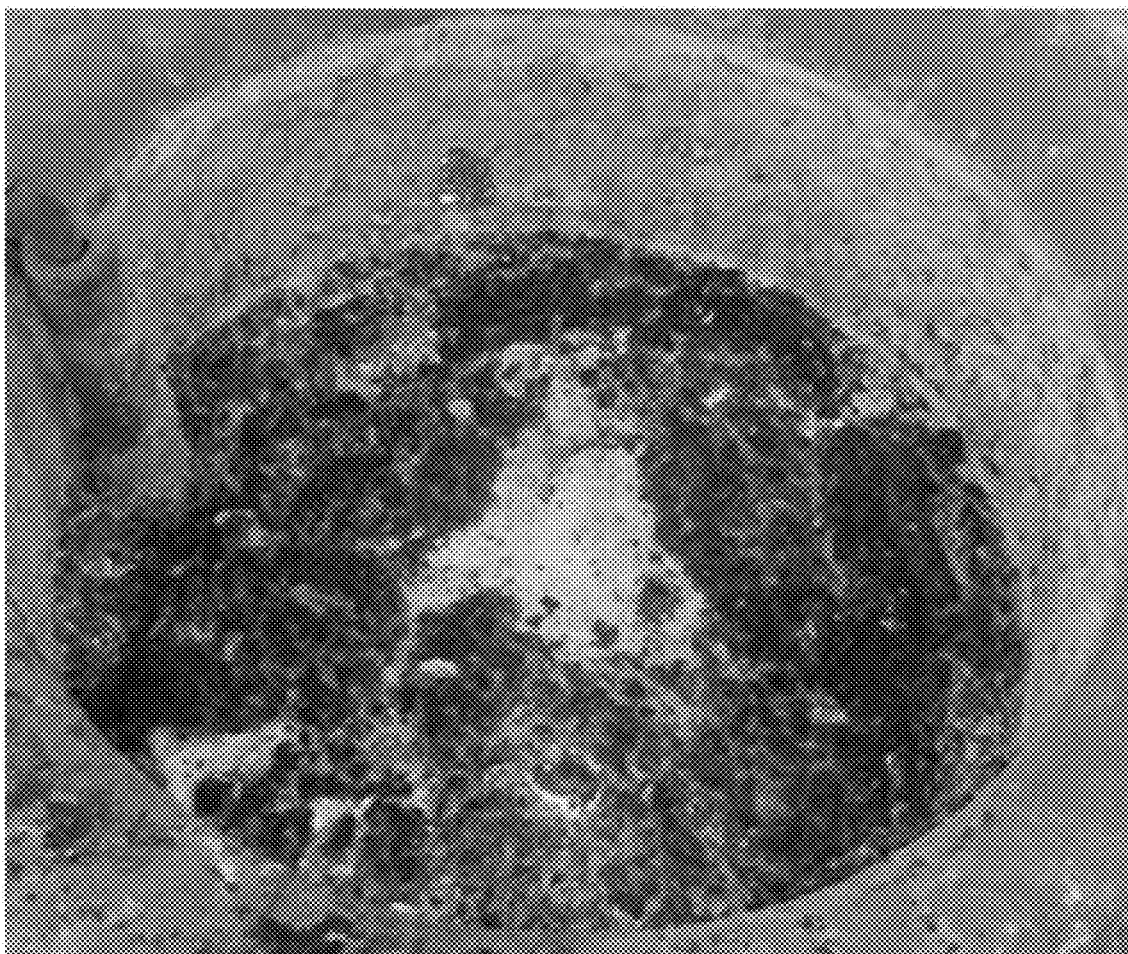


FIG. 1A

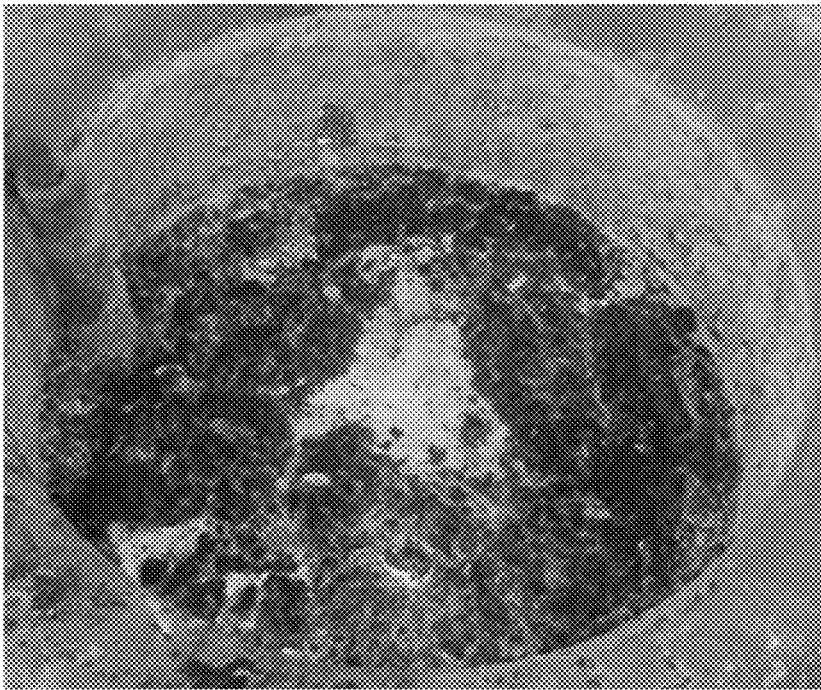


FIG. 1B

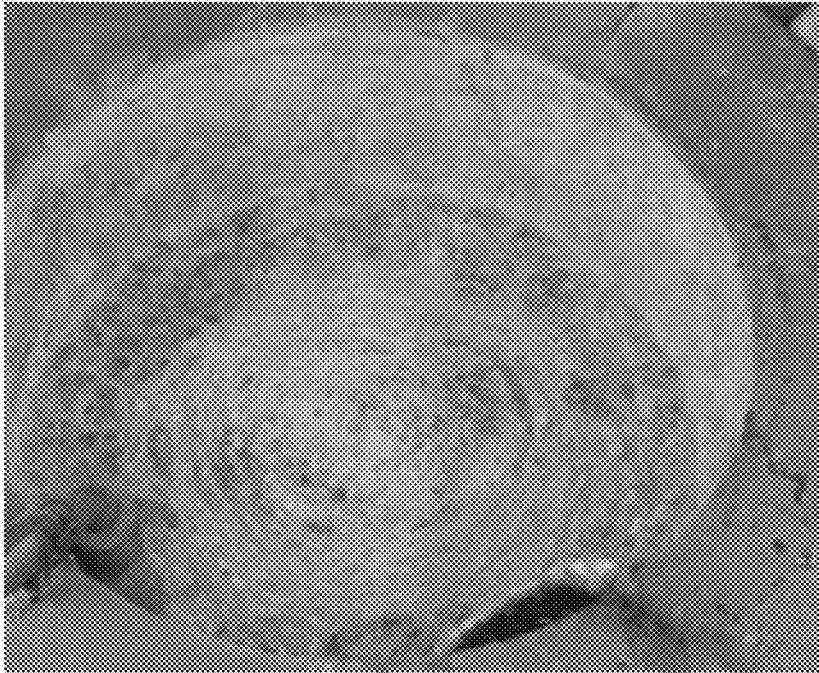


FIG. 2

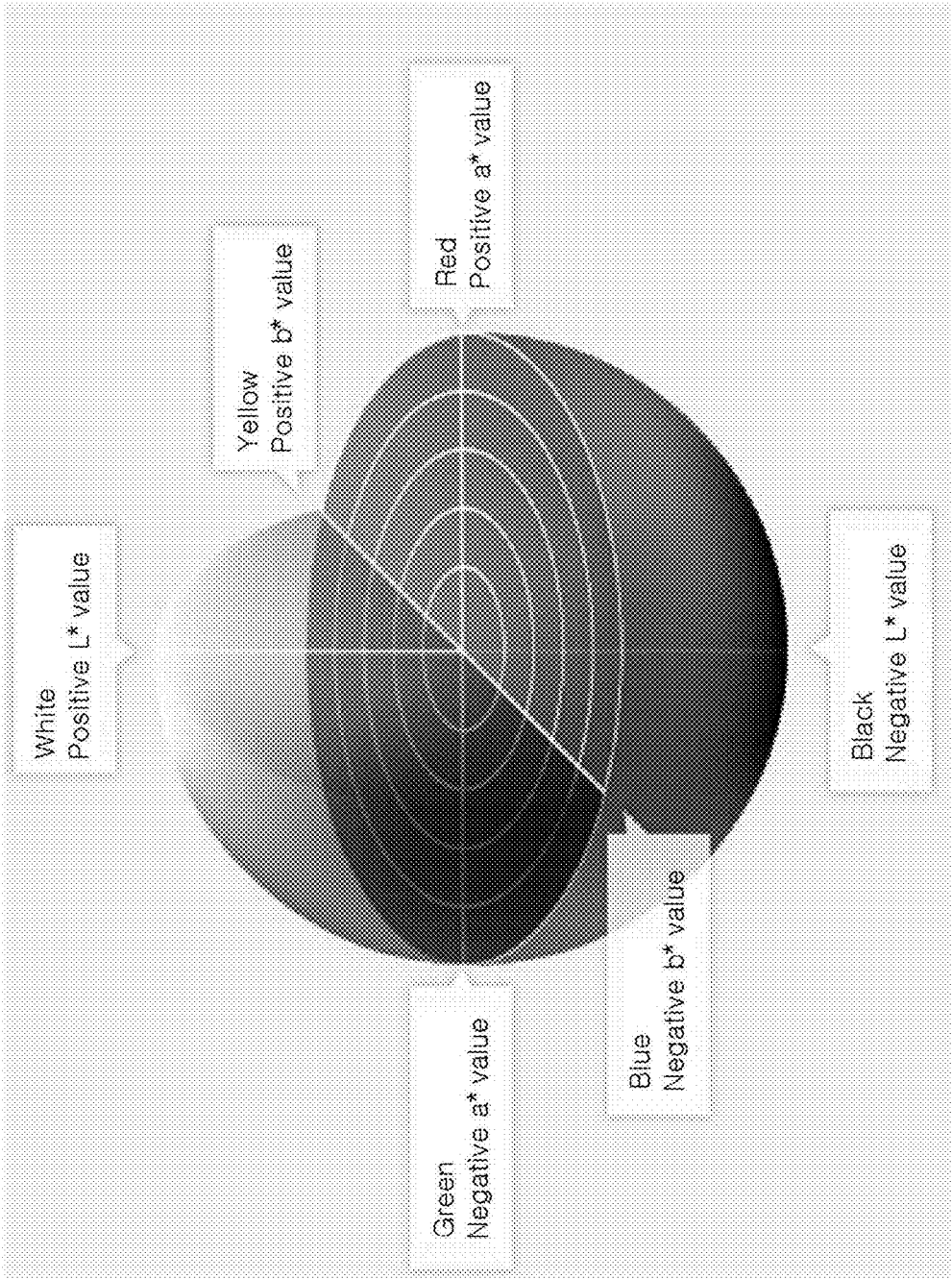


FIG. 3

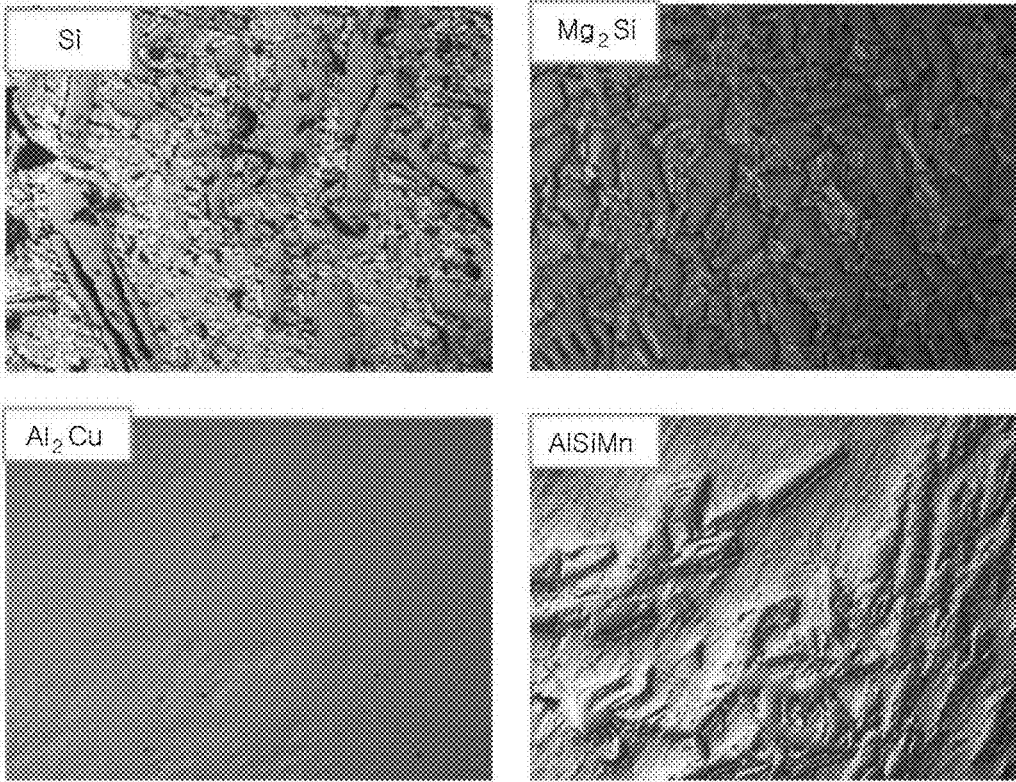


FIG. 4

2017.01.09.13.00.11
TCAL: AL, CU, FE, MG, SI
N=1, P=1, Q1.325E5, WWS0=0.11, WICU=3E-2, WIFE=1E-2

COMPARATIVE EXAMPLE 2

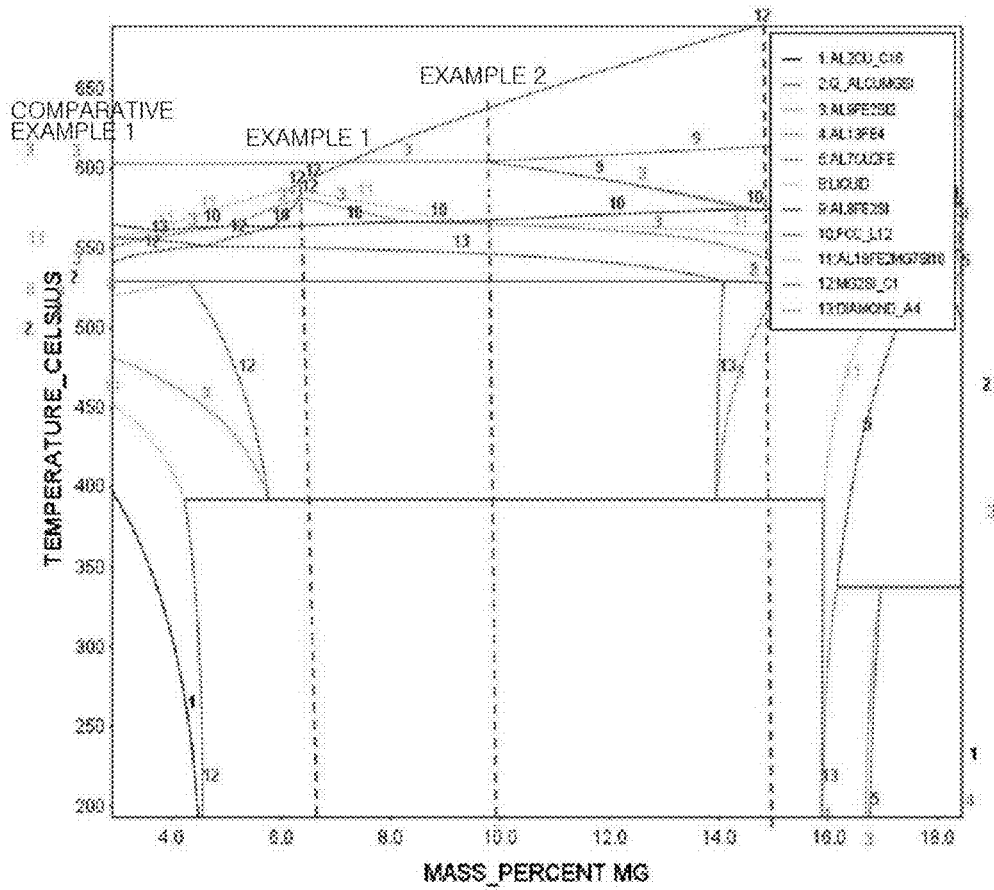


FIG. 5

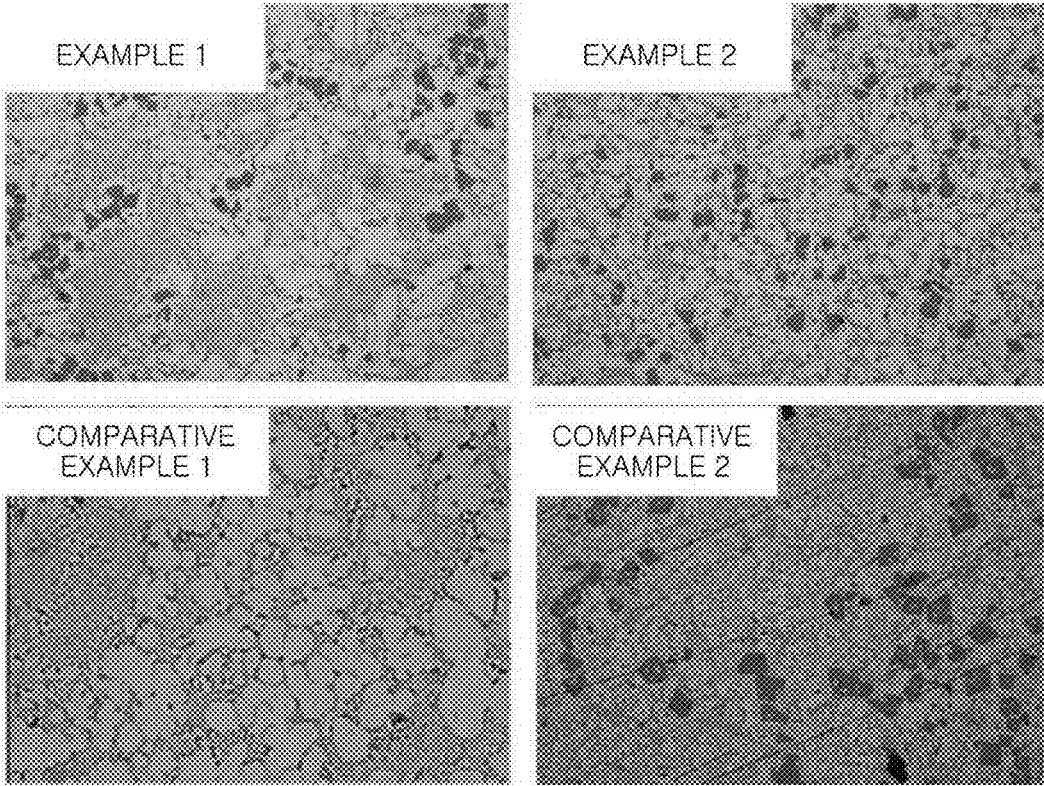
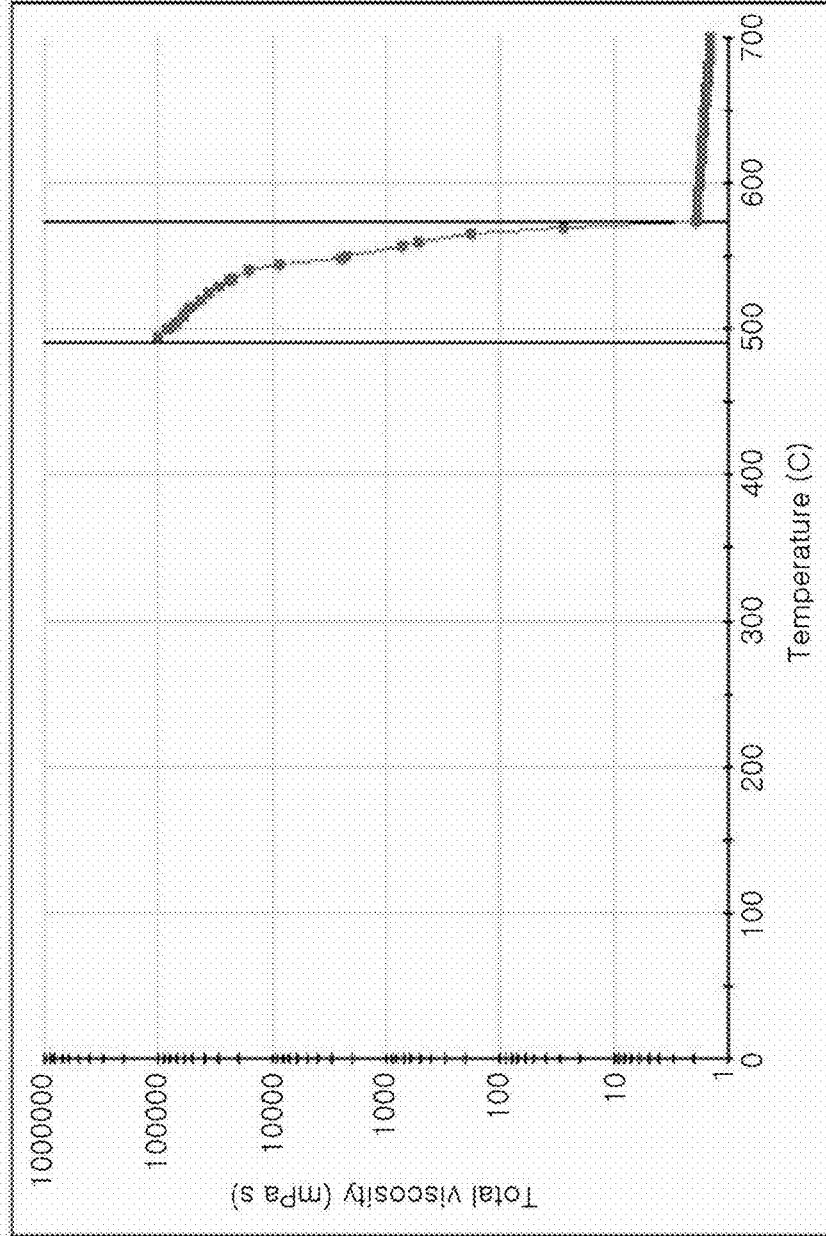


FIG.6A

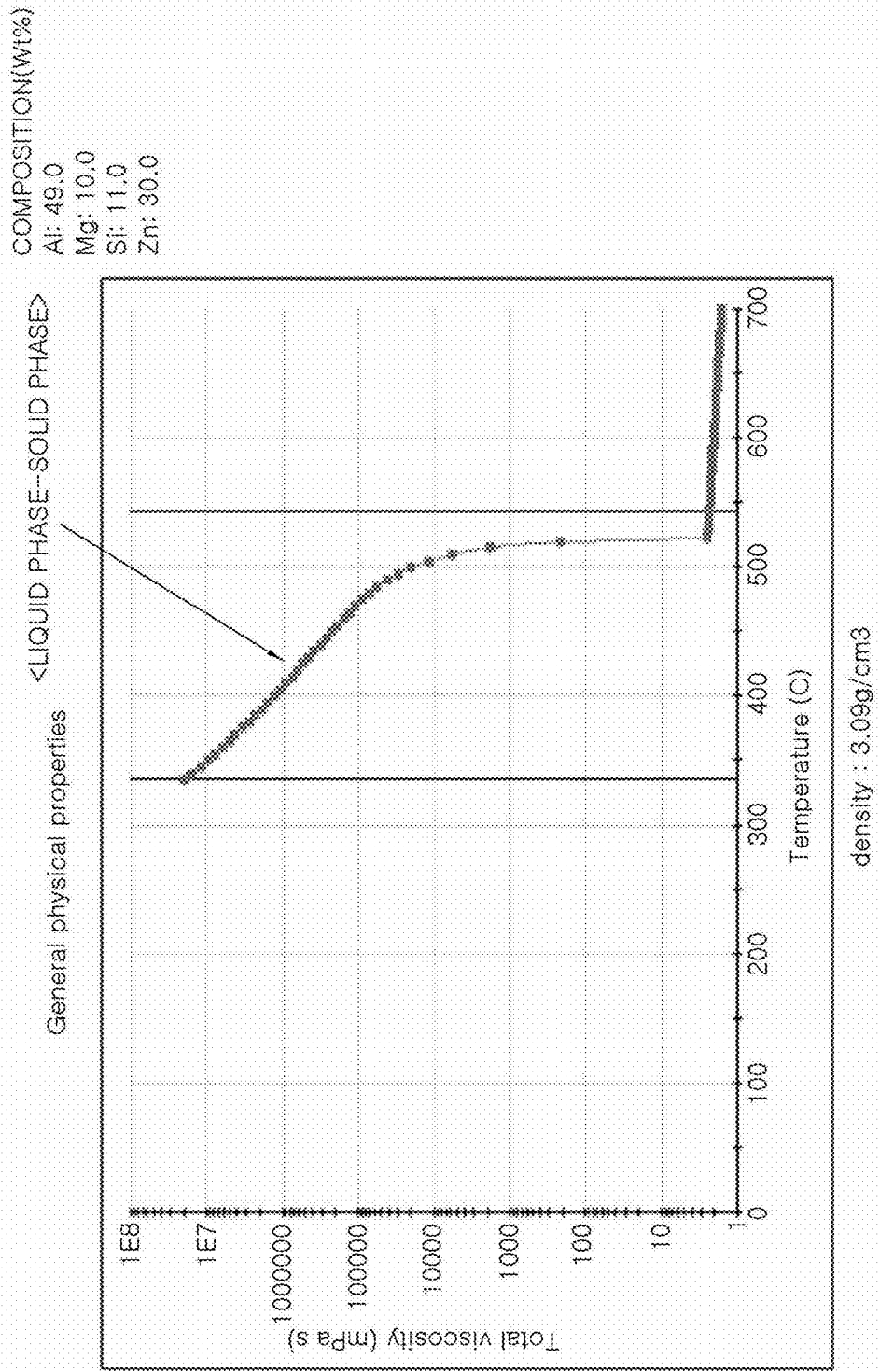
Al: 75.0
Cu: 2.0
Fe: 1.0
Mg: 10.0
Si: 11.0
Zn: 1.0

General physical properties



density : 2.61g/cm³

FIG.6B



ALUMINUM ALLOY FOR DIE CASTING

CROSS-REFERENCE(S) TO RELATED APPLICATIONS

[0001] This application claims priority to Korean Patent Application No. 10-2017-0170600, filed on Dec. 12, 2017, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to an aluminum alloy for a die casting, which may be used in a vehicle.

BACKGROUND

[0003] A conventional aluminum alloy has been developed to improve strength. In addition, when the aluminum alloy can be used as visible vehicle parts, a light emission of metal may be reduced and patterns on a surface of the alloy may be formed for improving an aesthetic functionality or appearance. Alternatively, a surface treatment such as an anodizing or the like has been performed on the alloy.

[0004] In the related art, the aluminum alloy, which has been developed with focus on strength only, has a limitation on aesthetic features such as appearance and requires additional process for enhancing aesthetic feeling.

[0005] The contents described in Description of Related Art are to help the understanding of the background of the present invention, and may include what is not previously known to those skilled in the art to which the present invention pertains.

SUMMARY OF THE INVENTION

[0006] In preferred aspects, provided is an aluminum alloy for a die casting, which can may provide sufficient aesthetic appearance even without performing additional process and can also improve strength.

[0007] In an aspect, provided is an aluminum alloy for a die casting that may include magnesium (Mg) in an amount of about 6.8 to 10 wt % based on the total weight of the aluminum alloy, and aluminum as a base material.

[0008] The term “aluminum as a base material” as used herein refers to an aluminum component having its content greater than about 85 wt %, greater than about 90 wt %, greater than about 91 wt %, greater than about 92 wt %, greater than about 93 wt %, or greater than about 94 wt % based on the total weight of the aluminum alloy.

[0009] Preferably, the aluminum alloy may include Mg₂Si in an amount of about 10 wt % or greater and about 16 wt % or less based on the total weight of the aluminum alloy.

[0010] Preferably, the aluminum alloy may have a color space value of about 3 or greater than a color space value of an ADC12 alloy. The color space may be calculated by values of L*, a* and b* defined by a Lab color coordinate. L* is a value of lightness, a* is a value representing green and red components of light, and b* is a value representing blue and yellow component of light. For example, the lightness value, “L*” represents black at L*=0 and white at L*=100. A value of the term “a*” as used herein represents green-red components, for example, a* is negative for green and positive for red. A value of the term “b*” as used herein represents blue-yellow component, for example, b* is negative for blue and positive for yellow.

[0011] The term “ADC12 alloy” as used herein refers to an aluminum alloy for die casting, which includes aluminum as

a main component and other components, for example, silicon (Si) in an amount of about 9.6 to 12.0 wt %, copper (Cu) in an amount of about 1.5 to 3.5 wt %, magnesium (Mg) in an amount up to about 0.3 wt %, zinc (Zn) in an amount up to about 1.0 wt %, manganese (Mn) in an amount up to about 0.5 wt %, iron (Fe) in an amount up to about 0.9 wt %, nickel (Ni) in an amount up to about 0.5 wt %, and tin (Sn) in an amount up to about 0.2 wt %, based on the total weight of the ADC12 alloy composition.

[0012] Preferably, a value of b* may be less than about 2.

[0013] In an aspect of the present invention, provided is a method of manufacturing an aluminum alloy as described herein. The method may include admixing a magnesium alloy including Al in an amount of about 9 wt % or greater based on the total weight of the magnesium alloy to an aluminum-silicon-copper-based alloy. Preferably, the magnesium alloy may be added to the aluminum-silicon-copper-based alloy in a molten state.

[0014] The term “magnesium alloy” as used herein refers to an alloy including Mg in an amount greater than about 85 wt %, greater than about 90 wt %, greater than about 91 wt %, greater than about 92 wt %, greater than about 93 wt %, greater than about 94 wt %, greater than about 95 wt %, greater than about 96 wt %, greater than about 97 wt %, greater than about 98 wt %, or greater than about 99 wt %, based on the total weight of the magnesium alloy. Preferred magnesium alloy may include an aluminum component in an amount of about 9 wt % or greater based on the total weight of the magnesium alloy. Exemplary magnesium alloy may include AZ31, AZ61, AZ80, Elektron 675, ZK60, M1A, HK31, HM21, ZE41, ZC71, ZM21, AM40, AM50, AM60, K1A, M1, ZK10, ZK20, ZK30, or ZK40.

[0015] Further provided is a vehicle part that may include the aluminum alloy as described herein. Also provided is a vehicle that may include the vehicle part include the aluminum alloy as described herein.

[0016] Other aspects of the invention are disclosed infra.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1A is a photograph showing a surface oxide of a molten metal after adding pure Mg, and FIG. 1B is a photograph showing a surface oxide of a molten metal after adding AZ91.

[0018] FIG. 2 shows a color coordinate diagram.

[0019] FIG. 3 a photograph showing a result of observation of a color according to strengthening phase added to Al.

[0020] FIG. 4 is a view showing states of an aluminum alloy according to the present invention and a comparative example.

[0021] FIG. 5 is a photograph showing surface conditions of the aluminum alloy according to the present invention and a comparative example.

[0022] FIGS. 6A and 6B respectively show changes in viscosity and a solidifying point according to an increase of a Zn content in an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0023] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be

further understood that the terms “comprise”, “include”, “have”, etc. when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements and/or components but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or combinations thereof.

[0024] Further, unless specifically stated or obvious from context, as used herein, the term “about” is understood as within a range of normal tolerance in the art, for example within 2 standard deviations of the mean. “About” can be understood as within 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, 0.1%, 0.05%, or 0.01% of the stated value. Unless otherwise clear from the context, all numerical values provided herein are modified by the term “about.”

[0025] It is understood that the term “vehicle” or “vehicular” or other similar term as used herein is inclusive of motor vehicles in general such as passenger automobiles including sports utility vehicles (SUV), buses, trucks, various commercial vehicles, watercraft including a variety of boats and ships, aircraft, and the like, and includes hybrid vehicles, electric vehicles, plug-in hybrid electric vehicles, hydrogen-powered vehicles and other alternative fuel vehicles (e.g. fuels derived from resources other than petroleum). As referred to herein, a hybrid vehicle is a vehicle that has two or more sources of power, for example both gasoline-powered and electric-powered vehicles.

[0026] Unless otherwise defined, all terms including technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0027] In order to fully understand the present invention, operational advantages of the present invention, objects achieved by embodiments of the present invention, reference should be made to the accompanying drawings and contents illustrated in the accompanying drawings which illustrate the preferred embodiments of the present invention.

[0028] In describing the exemplary embodiments of the present invention, well-known techniques or repetitive descriptions that may unnecessarily obscure the gist of the present invention will be reduced or omitted.

[0029] The present invention relates to an aluminum alloy for a die casting, which may be used by replacing a conventional ADC12 alloy for die casting product.

[0030] Composition of an exemplary aluminum alloy of the present invention is as shown in Table 1.

[0031] According to an exemplary embodiment, the aluminum alloy of the present invention may include a conventional magnesium alloy such as AZ91 alloy and a conventional aluminum alloy such as ADC12. For example, the aluminum alloy may be produced by adding the magnesium alloy (e.g., AZ91 alloy) to the conventional aluminum alloy (e.g., ADC12) that may be molten.

When pure magnesium (Mg) is added without using protective gas to control composition of the alloy, surface oxidation may be generated on the alloy, so that it is difficult to control a yield. However, when a magnesium alloy such as AZ91 containing aluminum of 9 wt % or greater based on the total weight of the magnesium alloy composition is added into and dissolved in an aluminum melt or a molten aluminum alloy, AZ91 may be well melted in the aluminum melt without generating surface oxidation.

[0032] FIG. 1A shows a surface oxide of a molten metal after adding pure Mg to a molten aluminum alloy, and FIG. 1B shows a surface oxide of an exemplary molten metal after adding AZ91 according to an exemplary embodiment of the present invention.

[0033] In addition, a composition ratio may be adjusted by utilizing existing mass products, which may be applied to a conventional process.

[0034] In the related art, the alloy has been manufactured so as to decrease a process temperature when a new composition of alloy is manufactured by using a master alloy. In preferred aspect of the present invention, instead of decreasing the process temperature, a magnesium alloy such as AZ91 may be proportionally added to easily create magnesium silicide (Mg₂Si) in the conventional aluminum alloy, e.g., ADC12 alloy. Because the AZ91 alloy has excellent oxidation stability compared to an elemental Mg component, protective gas used when the elemental Mg component is added during aluminum casting may not be required.

[0035] In other words, the aluminum alloy in an exemplary embodiment of the present invention may be manufactured by controlling a fraction of MgSi-based phase generated by the content of Mg and silicon (Si). Therefore, an exemplary aluminum alloy may have a color which differs from that of the conventional alloy and may realize a high-quality appearance of the aluminum alloy may be obtained by using the conventional ADC12 alloy and AZ91 alloy.

[0036] The ratios of ADC12 and AZ91 are shown in Table 2.

TABLE 1

Composition	Composition range (wt %)						
	Al	Si	Cu	Mg	Fe	Zn	Remainder
Present invention	Bal.	10~12	1.5~2.5	6.8~10	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1
ADC12	Bal.	10~12	1.5~2.5	0.45~0.65	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1

TABLE 2

Composition	Alloy Content (wt %)		Composition range (wt %)						
	ADC12	AZ91	Al	Si	Cu	Mg	Fe	Zn	Remainder
Example 1	93	7	Bal.	10~12	1.5~2.5	6.8	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1
Example 2	89	11	Bal.	10~12	1.5~2.5	10	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1
Comparative Example 1	100	—	Bal.	10~12	1.5~2.5	0.45~0.65	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1
Comparative Example 1	85	17	Bal.	10~12	1.5~2.5	15	Equal to or less than 1	Equal to or less than 1	Equal to or less than 1

[0037] In addition, the content of magnesium silicide (Mg₂Si) created in the alloy is as shown in Table 3.

TABLE 3

	Content of Mg ₂ Si (wt %)
Example 1	10.72
Example 2	15.77
Comparative Example 1	0.7~1.0
Comparative Example 2	23.66

[0038] As shown in the Table 3, Mg₂Si may be generated in an amount of about 10 wt % or greater and about 16 wt % or less based on the total weight of the aluminum alloy.

[0039] The content of Mg₂Si may be at least about 10 wt % to control the color, and when the Mg₂Si content is greater than about 16 wt %, physical properties may deteriorate.

[0040] The comparison results of the physical properties of the Examples of the present invention and the Comparative Examples having the above described compositions are as shown in below Table 4.

TABLE 4

		Yield	Tensile	Elongation	Density	Remark
		strength	strength			
		(MPa)	(MPa)	(%)		
Comparative Example 1	ADC12	170	310	3.3~3.8	2.74	
Example 1	Adding Mg of 6.8 wt %	230	260	0.6~0.7	2.67	—
Example 2	Adding Mg of 10 wt %	235	250	0.57~0.63	2.63	—
Comparative Example 2	Adding Mg of 15 wt %	—	—	—	2.56	Specimen could not be made

[0041] As shown in the Table 4, the yield strength of the alloy of the present invention was improved by about 30% as compared to the ADC12 alloy and that the density was also decreased by about 2.5 to 4% than that of the conventional alloy, so that a weight of the alloy may be substantially reduced.

[0042] Furthermore, the reflectance of the alloy for each wavelength was measured as shown in Table 5, and the color differences were compared as shown in Table 6. FIG. 2 shows a color coordinate.

[0043] Conditions of color measuring equipment are as follows.

[0044] Reference color space: Reference wavelength (CIE 1976 L*a*b*) for converting measured wavelength into a color space

[0045] Reference observer angle: A setting of constant observer angle (10 Degree) since the wavelength value of light is changed depending on viewing angle to the color,

[0046] Light source: Generation of reflection and color difference (D65) depending on a value of incident wavelength

[0047] Aperture size: Minimization of error for surface roughness influence (6 mm) when the metal is measured.

[0048] Surface roughness: Uniformization of surface roughness through 0.5 micron polishing (a generation of change in L, a and b values depending on illumination)

TABLE 5

Composition	Reflectance (%) depending on wavelength (nm)						
	~400 nm	450 nm	500 nm	550 nm	600 nm	650 nm	700 nm
Comparative Example 1	39.17	40.22	41.6	42.61	43.1	44	44.07
Example 1	38.14	37.31	38.2	39.14	39.21	39.19	39.08
Example 2	35.56	36.42	37.32	38	38.26	38.85	38.85

TABLE 6

Composition	L*	a*	b*	Color difference
Comparative Example 1	71.1654	0.1045	2.5478	—
Example 1	68.1766	-0.0089	1.9831	3.0437
Example 2	67.9267	-0.0113	1.8265	3.3206

[0049] As comparing a color measurement to the conventional ADC12 alloy, the alloy of the present invention may have a color difference of 3 or greater, which may be distinguished by naked eyes. This color difference may be most influenced by an illuminance value which is the L* value, and the b* value has a value of 2 or less, so that the color of alloy may be shifted to a blue-based color. As a result, the alloy manufacture may show blue light component compared to a conventional alloy.

[0050] As described above, the color or appearance of the aluminum alloy of the present invention may be controlled by utilizing the Mg₂Si-based phase, and may allow the alloy to show the color that may not be obtained by controlling Si content in the related art.

[0051] As shown in FIG. 3, difference in color may depend on strengthened phase added in Al.

[0052] The phase created by adding Mg and Si may be the most important phase for changing aluminum into a blue-based colored alloy.

[0053] In the related art, Si and Mg have been rarely used together in the conventional Al alloy, and in Al—Mg—Si alloy system, for example, the 6000-series alloy, Mg₂Si has been utilized to improve the strength. However, because its content is not greater than about 3 wt %, the color difference may not be significant.

[0054] In the conventional aluminum alloy, a small amount of Mg₂Si has been used only for obtaining the precipitation hardening effect, so that the amount thereof is minimized.

[0055] In addition, as a result of numerical calculation of the range by which the color of the alloy are changed, which can be visually confirmed, an exemplary alloy may have a Mg content of about 6.8 wt % to 10 wt %, or alternatively, a Mg₂Si content of about 10 wt % to 16 wt %, based on the total weight of the alloy composition. Also, when Mg greater than about 10 wt % is added, or alternatively, the Mg₂Si content is greater than about 16 wt %, as shown in the Comparative Example 2, a specimen may not be made because internal fluidity is sharply reduced to such an extent that an evaluation of physical properties may not be possible.

[0056] Further, the influence caused by an addition of Mg was examined through the state diagram of FIG. 4 which was calculated except for the elements which are not influenced by an addition of Mg,

[0057] Moreover, Mg₂Si was created as shown in FIG. 5 when the content of Mg was 6.8 wt % or greater, and when Mg₂Si was created to have the content of 10 wt % or greater, the color difference was changed as compared with the conventional ADC12 alloy.

[0058] As the content of Mg₂Si is increased, the L and b values are decreased to change the color of the alloy into the blue-based color, and alloy, and the color difference of 3 or greater for visual change may be obtained when the Mg₂Si content is about 10 wt % or greater.

[0059] In addition, FIG. 6A shows a change in viscosity and a solidifying point of an exemplary alloy of the present invention, and FIG. 6B shows a change in viscosity and a solidifying point of the conventional alloy having a substantial Zn content.

[0060] Zn in the present invention may be remained as an impurity as the conventional aluminum alloy, such as ADC12 alloy, and may be a residue contained in AZ91 that is added to facilitate a casting process.

[0061] The conventional Al—Zn—Mg—Si alloy in the related art is a plating alloy prepared for controlling a low melting point and containing zinc (Zn) in a specific gravity of 1 to 1.5 relative to Al.

[0062] As a result, the above aluminum alloy in the present invention has an increased specific gravity of at least of about 3 g/cm³ because of high Zn content, which may not be used for a high-pressure casting due to a high viscosity.

[0063] A wide liquid phase-solid phase region in FIG. 6B means that the cast product is not solidified and is maintained in a slurry state. Accordingly, the cast product may not be manufactured because a temperature range in which the alloy is solidified in a high-pressure casting process may be wide.

[0064] According to the present invention, the color of the aluminum alloy for a die casting may be controlled by the phase created by adding magnesium and silicon, and thus the aesthetic appearance of the alloy may be increased as compared with a conventional alloy.

[0065] In addition, the specific gravity of the alloy may be decreased and the alloy may have substantially increased physical properties such as a yield strength compared to the existing material.

[0066] Although the above-described present invention has been described with reference to the illustrated drawings, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the scope of the present invention. Accordingly, such modifications or changes should be considered as being fallen with the claims of the present invention, and the scope of the present invention should be construed on the basis of the appended claims.

What is claimed is:

1. An aluminum alloy for a die casting, comprising:
magnesium (Mg) in an amount of about 6.8 to 10 wt %
based on the total weight of the aluminum alloy, and
aluminum (Al) as a base material.
2. The aluminum alloy of claim 1, wherein the aluminum
alloy comprises Mg_2Si in an amount of about 10 wt % or
greater and about 16 wt % or less based on the total weight
of the aluminum alloy.
3. The aluminum alloy of claim 1, wherein the aluminum
alloy has a color space value of about 3 or greater than a
color space value of a ADC alloy,
wherein the color space value is calculated by values of
 L^* , a^* and b^* as defined by a Lab color coordinate, and
wherein L^* is a value of lightness, a^* is a value repre-
senting green and red components of light, and b^* is a
value representing blue and yellow component of light.
4. The aluminum alloy for a die casting of claim 3,
wherein a value of b^* is less than about 2.
5. The aluminum alloy for a die casting of claim 1,
wherein the aluminum alloy comprises,
Si in an amount of about 10 wt % or greater and about 12
wt % or less, and
- Cu in an amount of about 1.5 wt % or greater and about
2.5 wt % or less based on the total weight of the
aluminum alloy.
6. The aluminum alloy for a die casting of claim 5,
wherein the aluminum alloy comprises,
Fe in an amount of about 0 wt % greater and about 1 wt
% or less,
Zn in an amount of about 0 wt % greater and about 1 wt
% or less, and
unavoidable impurities in an amount about 1 wt % or less
based on the total weight of the aluminum alloy.
7. A method of manufacturing an aluminum alloy of claim
1, comprising:
combining a magnesium alloy including Al in an amount
of about 9 wt % or greater based on the total weight of
the magnesium alloy to an aluminum-silicon-copper-
based alloy.
8. The method of claim 7, wherein the magnesium alloy
is added to the aluminum-silicon-copper-based alloy in a
molten state.
9. A vehicle part comprising an aluminum alloy of claim
1.
10. A vehicle comprising a vehicle part of claim 9.

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