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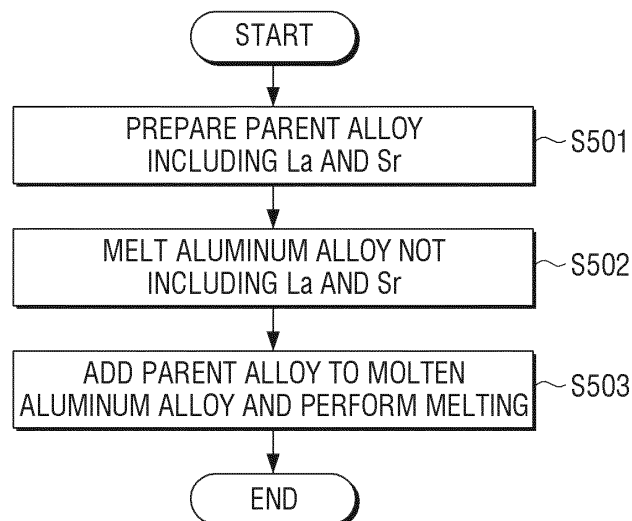
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(54) **ALUMINUM ALLOY FOR DIE CASTING AND METHOD FOR MANUFACTURING THE SAME**

(57) **Aluminum Alloy for Die Casting and Method for Manufacturing the Same** An aluminum alloy for die casting. The aluminum alloy for die casting of the present disclosure includes, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$,

$0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$, $0.05 \leq \text{Ti} \leq 0.15$, $0.01 \leq \text{La} \leq 2$, $0.01 \leq \text{Sr} \leq 2$, a balance of Al, and unavoidable impurities.

FIG. 5



Description

[0001] Apparatuses and methods consistent with the present disclosure relate to an aluminum alloy for die casting, and more particularly, to an aluminum alloy for die casting including, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$, $0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$, $0.05 \leq \text{Ti} \leq 0.15$, $0.01 \leq \text{La} \leq 2$, $0.01 \leq \text{Sr} \leq 2$, a balance of Al, and unavoidable impurities, and having improved mechanical properties and corrosion resistance.

[0002] Generally, since aluminum is light, easily cast, easily alloyed with other metals, easily processed at room temperature and high temperature, and has good thermal and electrical conductivity, it is widely used throughout the industry. Particularly, recently, for improved fuel efficiency, a reduced weight of motor vehicles and electronics, or the like, an aluminum alloy in which aluminum is mixed with other metals is often used. Typically, a method of manufacturing a product with an aluminum alloy is to form a case by press molding, and form a positive electrode oxide film on a surface of the case, and according to this method, a case not being damaged even after prolonged use and having a beautifully colored surface may be obtained, but the design of the case is limited due to the shape which is unmoldable by press processing.

[0003] Accordingly, as a method of manufacturing a product with an aluminum alloy, a die casting method is widely used, and the die casting is precision casting to inject a molten metal into a mold which was precisely machined to a casting shape, thereby obtaining the same casting as the mold. According to this die casting method, the produced product has correct dimensions, and thus, does not need to be ironed, and has excellent mechanical properties, and with high mass productivity due to a mass production possibility and a low production cost, this method is currently most used in various fields such as automotive parts, electrical equipment, optical instruments and measuring instruments.

[0004] As a currently widely used aluminum alloy for die casting, an Al-Si-based alloy such as ALDC 3, ALDC 10 or ALDC 12, and an Al-Mg alloy such as ALDC 5 or ALDC 6, which have good castability have been used. However, these aluminum die casting materials have problems in that pores occur in the inside due to air ingress during die casting, mechanical properties are degraded due to occurrence of the pores, when magnesium is contained in a large amount, a molten metal is deposited on the mold surface to shorten the mold life, and the processing time is increased and a tool is damaged due to chip curling during processing. In addition, since the aluminum die casting materials have poor corrosion resistance, they have limited expansion of coverage. To improve this poor corrosion resistance, a method of forming a protective coated film on the alloy surface using a physical deposition has been suggested, however, this method has problems in that it needs expensive supplementary equipment, and is difficult to be recycled. Other methods have been suggested, such as ion implantation to implant the ions of elements having corrosion resistance in the alloy surface and laser annealing to inject laser into the alloy surface to form a metastable state on the surface layer. However, the former has a limitation in an ion implantation depth and, thus, corrosion resistance is rapidly deteriorated when the ion implantation layer is damaged during use. The latter needs separate machining since the size of the product is changed during a treatment process.

[0005] Therefore, the need for a new aluminum alloy for die casting arises, the aluminum alloy having excellent mechanical properties and corrosion resistance, and not having a deposit on the mold surface in the course of die casting, even in the case of containing a large amount of magnesium.

[0006] To address the above-discussed deficiencies, it is a primary object to provide an alloy for die casting including lanthanum (La) and strontium (Sr) to have improved mechanical properties and corrosion resistance, and a method for manufacturing the same.

[0007] The aluminum alloy for die casting according to an exemplary embodiment of the present disclosure includes, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$, $0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$, $0.05 \leq \text{Ti} \leq 0.15$, $0.01 \leq \text{La} \leq 2$, $0.01 \leq \text{Sr} \leq 2$, a balance of Al, and unavoidable impurities.

[0008] In this case, $0.1 \leq \text{Sr} \leq 1.0$ may be satisfied.

[0009] In this case, $0.01 \leq \text{La} \leq 0.5$ may be satisfied.

Meanwhile, the aluminum alloy for die casting may have a tensile strength of 240 to 270 N/mm², an internal force of 230 to 260 N/mm², and an impact value of 90 to 110 KJ/m².

[0010] Meanwhile, the aluminum alloy for die casting may have a corrosion current of 3.5 to 4.5 μA , a potential of -660 to -645 V, and a corrosion resistance of 4.9 to 5.6 Ω , as measured by a potentiodynamic acceleration test in an environment comprising 5% sodium chloride.

[0011] Meanwhile, an aluminum flange shaft for a washing machine may be manufactured from the alloy for die casting according to an exemplary embodiment of the present disclosure.

[0012] Meanwhile, a method for manufacturing the aluminum alloy for die casting according to an exemplary embodiment of the present disclosure includes: preparing a parent alloy including La and Sr; melting Al, Si, Mg, Fe, Zn, Cu, Mn and Ti in a crucible to include, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$, $0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$ and $0.05 \leq \text{Ti} \leq 0.15$, based on the total weight of the aluminum alloy for die casting; and adding the thus-prepared parent alloy to the crucible to include, by wt%, $0.01 \leq \text{La} \leq 2$ and $0.01 \leq \text{Sr} \leq 2$, based on the total weight of the aluminum alloy for die casting.

[0013] In this case, when the melting is completed, adding flux to the crucible may be further included.

[0014] Meanwhile, the parent alloy may be an Al-La-Sr ternary parent alloy, or an Al-Mg-La-Sr quaternary parent alloy.

[0015] Meanwhile, the melting may be carried out at 600 to 700 °C.

[0016] Before undertaking the DETAILED DESCRIPTION below, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware or software, or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely.

[0017] Moreover, various functions described below can be implemented or supported by one or more computer programs, each of which is formed from computer readable program code and embodied in a computer readable medium. The terms "application" and "program" refer to one or more computer programs, software components, sets of instructions, procedures, functions, objects, classes, instances, related data, or a portion thereof adapted for implementation in a suitable computer readable program code. The phrase "computer readable program code" includes any type of computer code, including source code, object code, and executable code. The phrase "computer readable medium" includes any type of medium capable of being accessed by a computer, such as read only memory (ROM), random access memory (RAM), a hard disk drive, a compact disc (CD), a digital video disc (DVD), or any other type of memory. A "non-transitory" computer readable medium excludes wired, wireless, optical, or other communication links that transport transitory electrical or other signals. A non-transitory computer readable medium includes media where data can be permanently stored and media where data can be stored and later overwritten, such as a rewritable optical disc or an erasable memory device.

[0018] Definitions for certain words and phrases are provided throughout this patent document, those of ordinary skill in the art should understand that in many, if not most instances, such definitions apply to prior, as well as future uses of such defined words and phrases.

[0019] For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numerals represent like parts:

FIGS. 1A, 1B, 2A and 2B are drawings representing the corrosion resistance experiment results of ADC 12 which is the conventional aluminum alloy for die casting and the aluminum alloy for die casting manufactured according to the present disclosure;

FIGS. 3A to 3D are drawings representing the corrosion resistance experiment results of ADC 12 which is the conventional aluminum alloy for die casting and the aluminum alloy for die casting manufactured according to the present disclosure, depending on the content of Sr;

FIGS. 4A to 4C are drawings for comparing and describing the strength of Al 6061 which is the conventional aluminum alloy for die casting and the aluminum alloy for die casting manufactured according to the present disclosure; and FIG. 5 is a flow chart for describing a manufacturing process of the aluminum alloy for die casting according to the present disclosure.

[0020] FIGS. 1A through 5, discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged system or device.

[0021] In addition, unless explicitly described otherwise, 'including' any components will be understood to imply the inclusion of other components but not the exclusion of any other components. Furthermore, various elements and scopes in the drawings were schematically drawn. Accordingly, the technical idea of the present disclosure is not limited by the relative size and spacing depicted in the attached drawings.

[0022] The aluminum alloy for die casting of the present disclosure includes 3 to 10 wt% of silicon (Si), 3 to 10 wt% of magnesium (Mg), 0.01 to 1.3 wt% of iron (Fe), 0.01 to 2 wt% of Zinc (Zn), 0.01 to 1.5 wt% of copper (Cu), 0.01 to 0.5 wt% of manganese (Mn), 0.05 to 0.15 wt% of titanium (Ti), 0.01 to 2 wt% of lanthanum (La), 0.01 to 2 wt% of strontium (Sr), a balance of Al, and unavoidable impurities.

[0023] The unavoidable impurities included in the alloy may be in a trace amount, and incidental impurities which may be present therein may be B, Cr, Sn, Sr, Pb, Ni, Cd, Ag, Zr, Ca, Mo, other transition metal elements, another rare earth elements, or the like, but not limited thereto. The incidental impurities may be varied with the castings, but their presence does not have an influence on the present disclosure, and the total amount of impurities may be less than 0.01 wt%.

[0024] The aluminum alloy for die casting of the present disclosure includes 3 to 10 wt% of magnesium (Mg). The magnesium component improves tensile strength and also is lighter than Si, thereby being advantageous for weight reduction of a product. In the case that the content of magnesium is less than 3 wt%, the effect of increasing tensile strength may not be obtained, and in the case that the content of magnesium is more than 10 wt%, corrosion resistance is deteriorated and stickiness of a molten metal is increased to lower fluidity, leading to deteriorated workability.

[0025] In particular, the aluminum alloy of the present disclosure includes a significantly large amount of magnesium as compared with a conventional Al-Si-based alloy, which is larger than the amount of magnesium in an Al-Mg-based alloy. Such magnesium amount of the present disclosure has a technical significance in that the purpose of higher strength of a product may be achieved, while corrosion resistance and workability are not deteriorated. Due to these characteristics, the alloy of the present disclosure may be applied to the parts of household appliances demanding both strength and high corrosion resistance, and particularly, is advantageous for products which impact is repeatedly applied to and is in contact with water or air. For example, the aluminum alloy according to the present disclosure may be used in the parts such as a flange shaft fixing the drum of a washing machine to be rotated.

[0026] Further, the aluminum alloy for die casting of the present disclosure includes silicon (Si). The Si component improves the fluidity of the aluminum alloy to improve moldability, lowers a coagulation shrinkage rate to reduce a shrinkage amount, and serves to improve hardness. Si can be added in an amount of 3 to 10 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Si component is less than 3 wt%, the addition effect is negligible, whereas in the case that the content of Si component is more than 10 wt%, a thermal expansion coefficient and an elongation may be lowered, and stains may occur on the surface.

[0027] In addition, the aluminum alloy for die casting of the present disclosure includes iron (Fe). The Fe component reduces adhesion in the mold for die casting to have good castability, and serves to deteriorate erosion of the mold. Fe can be added in an amount of 0.01 to 1.3 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Fe component is less than 0.01 wt%, based on the total weight of the whole alloy, it is difficult to release the cast article, whereas in the case that the content of Fe component is more than 1.3 wt%, Al and Si may be bonded to produce vulnerable precipitates, and decrease the corrosion resistance of the aluminum alloy.

[0028] Further, the aluminum alloy for die casting of the present disclosure includes zinc (Zn). The Zn component has an effect of improving strength and castability of an alloy. Zn can be added in an amount of 0.01 to 2 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Zn component is less than 0.01 wt%, based on the total weight of the whole alloy, the improvement of the mechanical properties is negligible, whereas in the case that the content of Zn component is more than 2 wt%, the density of alloy is reduced to cause cracks.

[0029] Further, the aluminum alloy for die casting of the present disclosure includes manganese (Mn). The Mn component serves to precipitate a Mn-Al₆ phase in the alloy to improve the mechanical properties of the alloy by solid solution strengthening and dispersion of fine precipitates. Mn can be added in an amount of 0.01 to 0.5 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Mn component is less than 0.01 wt%, based on the total weight of the whole alloy, the improvement of the mechanical properties is negligible, whereas in the case that the content of Mn component is more than 0.5 wt%, the workability may be deteriorated due to adhesion, which is also caused by Mg.

[0030] Further, the aluminum alloy for die casting of the present disclosure includes copper (Cu). The Cu component has an effect of improving strength and hardness of an alloy. Cu can be added in an amount of 0.01 to 1.5 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Cu component is less than 0.01 wt%, based on the total weight of the whole alloy, the improvement of the mechanical properties is negligible, whereas in the case that the content of Cu component is more than 1.5 wt%, corrosion resistance and an elongation may be deteriorated.

[0031] Further, the aluminum alloy for die casting of the present disclosure includes titanium (Ti). The Ti component may be added to the aluminum alloy to serve to refine crystal grains, and obtain a crack prevention effect, and Ti can be added in an amount of 0.05 to 0.15 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Ti component is less than 0.05 wt%, the effect of crystal grain refining may not be obtained, whereas in the case that the content of Ti component is more than 0.15 wt%, the elongation may be decreased.

[0032] Further, the aluminum alloy for die casting of the present disclosure includes lanthanum (La). The La component is added to the aluminum alloy to have effects of improving the fluidity of the aluminum alloy to improve moldability, improving the deposition properties of the melted alloy on the mold, and improving the corrosion resistance. Specifically, La has an effect of stabilizing a microcrystalline phase in an aluminum matrix by forming an intermetallic compound with an alloy element such as Cu and Fe. Meanwhile, La can be added in an amount of 0.01 to 2 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of

La component is less than 0.01 wt%, the effect is negligible, whereas in the case that the content of La component is more than 2.0 wt%, bubbles occur on an alloy surface. La can be included at 0.01 to 0.5 wt%, based on the total weight of the whole alloy.

[0033] Further, the aluminum alloy for die casting of the present disclosure includes strontium (Sr). The Sr component may have an effect of improving the strength of an alloy by reducing pores produced by air ingress in the course of die casting, and Sr can be added in an amount of 0.01 to 2 wt%, based on the total weight of the whole alloy, in the aluminum alloy for die casting of the present disclosure. In the case that the content of Sr component is less than 0.01 wt%, the improvement of the mechanical properties is negligible, whereas in the case that the content of Sr component is more than 2.0 wt%, the distribution of pores is decreased, but the size of pores is increased. Sr can be included at 0.05 to 1.0 wt%, based on the total weight of the whole alloy. Sr also can be included at 0.1 to 0.5 wt%, based on the total weight of the whole alloy.

[0034] Each component, such as aluminum, silicon, iron, copper and titanium, can have a purity of at least about 99%.

[0035] Though the aluminum alloy for die casting of the present disclosure includes a large amount of Mg (magnesium) as compared with the conventional aluminum alloy of die casting, it has an effect of improving corrosion resistance. Further, the aluminum alloy for die casting of the present disclosure is not deposited on the mold, and thus, is easily worked, may increase the mold life, and reduces pores produced in the course of die casting to improve mechanical properties such as strength, internal force and an impact value. Accordingly, the problems of increased processing time and damaged processing tools due to chip curling during processing the conventional aluminum alloy may be solved.

[0036] Hereinafter, the present disclosure will be described in more detail, by the specific Examples, with reference to the accompanying drawings. However, these Examples are only for illustrating the present disclosure, and the scope of the present disclosure is not limited to these Examples.

Physical property test of aluminum alloy for die casting

[0037] In the present disclosure, an aluminum alloy for die casting having excellent corrosion resistance and mechanical properties was manufactured from silicon, iron, copper, manganese, magnesium, strontium, lanthanum, zinc, titanium and aluminum to have the composition as shown in the following Table 1 (Example). The specific method of manufacturing the aluminum alloy for die casting is described in detail with reference to the following FIG. 5.

[0038] Further, as the Comparative Example of the present disclosure, an ADC 12 alloy having the composition as shown in the following Table 1 (ADC 12 (found)) was manufactured.

[Table 1]

Alloy (wt%)	Si	Fe	Cu	Mn	Mg	Sr	La	Zn	Ti	Al
ADC 12 (average)	9.6-12.0	<1.3	1.5-3.5	<0.5	<0.3	-	-	<1.0	<0.3	balance
ADC 12 (found)	10.7	0.89	1.76	0.19	0.17	-	-	0.7	0.02	balance
Example	6.5	0.8	1.0	0.1	6.0	0.15	0.3	0.8	0.1	balance

Example 1: corrosion resistance evaluation (1)

[0039] The aluminum alloy as the Example according to the present disclosure, manufactured to have the composition as shown in the above Table 1, and ADC 12 as the Comparative Example were dissolved, respectively, maintained at 600 to 700 °C, and then according to the known method, were added to a mold using die casting equipment and subjected to injection and cooling, thereby preparing each specimen. Each specimen after being die cast was immersed in a potassium hydroxide (KOH) solution having a pH of 10 to 11 at 25 °C for 480 hours, and then the surface of each specimen was analyzed using a digital microscope.

[0040] FIGS. 1A and 1B represent analysis of the surface of the specimen formed of ADC 12 which is the conventional aluminum alloy for die casting. Specifically, FIGS. 1A and 1B are magnifications of 50 times and 200 times the surface of the specimen, respectively. Further, FIGS. 2A and 2B represent analysis of the surface of the specimen of the aluminum alloy for die casting manufactured to have the composition as shown in Table 1 according to an exemplary embodiment of the present disclosure. Specifically, FIGS. 2A and 2B are magnifications of 50 times and 200 times the surface of the specimen, respectively.

[0041] Referring to FIGS. 1A and 1B, it may be confirmed that pitting corrosion occurred on the surface of the specimen formed of ADC 12. Here, the pitting corrosion may have a depth of 60 to 100 μm. Further, exfoliation corrosion was also found in the specimen formed of ADC 12.

[0042] However, referring to FIGS. 2A and 2B, it may be confirmed that the pitting corrosion has a small number and

a shallow depth on the surface of the manufactured specimen having the composition according to an exemplary embodiment of the present disclosure.

[0043] That is, according to FIGS. 1A and 1B, it is recognized that the aluminum alloy for die casting according to an exemplary embodiment of the present disclosure including La and Sr has excellent corrosion resistance, despite its higher content of Mg than the conventional aluminum alloy for die casting.

Example 2: corrosion resistance evaluation (2)

[0044] The aluminum alloy as the Example according to the present disclosure, manufactured to have the composition as shown in the above Table 1, and ADC 12 as the Comparative Example were dissolved, respectively, maintained at 600 to 700 °C, and then added to a mold using die casting equipment and subjected to injection and cooling, thereby preparing each specimen. Each specimen after being die cast was cut into an exposure area of 1 cm², and then the corrosion durability of the specimen was evaluated by a potentiodynamic polarization experiment in an environment comprising 5% sodium chloride (NaCl). Here, the potentiodynamic polarization experiment is an experiment using polarity determined by an electrical displacement difference produced in the course of electricity generation, and current, voltage, resistance or the like may be analyzed by the experiment. Referring to the following Table 2, the corrosion current (I_{corr}) of the specimen formed of the aluminum alloy according to an exemplary embodiment of the present disclosure is 4.12 μ A, which means that the specimen has corrosion durability three times more than that of the specimen formed of ADC 12. In addition, the specimen formed of the aluminum alloy according to an exemplary embodiment of the present disclosure represents corrosion resistance (Z_{re}) 1.7 times more than that of the specimen formed of ADC 12, and thus, may be confirmed to have better corrosion durability as compared with that of the conventional aluminum alloy for die casting. Meanwhile, the value representing the corrosion durability in the following Table 2 is only an example, and thus, not limited thereto, and the aluminum alloy according to the present disclosure may have a corrosion current of about 3.5 to 4.5 μ A, a potential of about -660 to -645 V, and a corrosion resistance of about 4.9 to 5.6 Ω , depending on the change in the content of each component.

[Table 2]

Classification	I_{corr} [μ A]	E [mV]	Z_{re} [Ω]
ADC 12	12.68	-608	3.1
Example	4.12	-651	5.3

[0045] FIGS. 3A to 3D are drawings representing the corrosion resistance experiment results of ADC 12 which is the conventional aluminum alloy for die casting and the aluminum alloy for die casting manufactured according to the present disclosure, depending on the content of Sr. Specifically, the Comparative Example illustrated in FIG. 3A was prepared from ADC 12 having the composition as shown in the above Table 1, and the Example according to the present disclosure illustrated in FIGS. 3B to 3D was prepared by changing the content of Sr in the composition as shown in the above Table 1 into 0 wt%, 0.15 wt% and 0.5 wt%, respectively.

[0046] Referring to FIGS. 3A to 3D, it may be confirmed that the pore size is the smallest when the content of Sr is 0.15 wt%. Further, the pore size when the content of Sr was 0 wt% was 5 to 10 μ m as illustrated in FIG. 3B, however, the pore size when the content of Sr was 0.15 wt% was decreased to less than 5 μ m, as illustrated in FIG. 3C. Accordingly, it is recognized that the aluminum alloy for die casting according to an exemplary embodiment of the present disclosure including La and Sr has excellent corrosion resistance, despite its higher content of Mg than the conventional aluminum alloy for die casting.

[0047] Meanwhile, it may be confirmed that when the content of Sr was 0.5 wt%, the pore distribution was the smallest. As illustrated in FIG. 3D, however, the pore size was increased as compared with the pore size when the content of Sr is 0.15 wt%. Thus, the content of Sr can be about 0.15 wt%.

Example 3: physical property evaluation

[0048] The aluminum alloy as the Example according to the present disclosure, manufactured to have the composition as shown in the above Table 1, and ADC 12 as the Comparative Example were dissolved, respectively, maintained at 600 to 700 °C, and then, according to the known method, were added to a mold using die casting equipment and subjected to injection and cooling, thereby preparing each specimen. Each specimen after being die cast was cut into 2.9 mm x 23.7 mm, and tensile strength, yield strength, a deformation amount, internal force, an impact value and the like of the specimen were measured according to ASTM standards, using a universal testing machine. Referring to the following Table 3, it may be confirmed that the specimen formed of the alloy according to an exemplary embodiment of

the present disclosure had tensile strength, 0.2% internal force and an impact value which were all improved as compared with the specimen formed of ADC 12. Meanwhile, since the mechanical property values of the following Table 3 is only an example, and thus, not limited thereto, and the aluminum alloy according to the present disclosure may have a tensile strength of about 240 to 270 N/mm², an internal force of about 230 to 260 N/mm², and an impact value of about 90 to 110 KJ/m².

[Table 3]

Classification	Tensile strength [N/mm ²]	0.2% internal force [N/mm ²]	Impact value [KJ/m ²]
ADC 12	193	188	81
Example	255	247	102

[0049] FIGS. 4A to 4C are drawings for comparing and describing the strength of Al 6061 which is the conventional aluminum alloy and the aluminum alloy manufactured according to the present disclosure. Specifically, each of FIGS. 4A to 4C represents fragments produced when processing the conventional Al 6061, brass and the alloy according to the present disclosure. Herein, Al 6061 and brass may be commercially available alloy products.

[0050] Referring to FIG. 4A, it may be confirmed that Al 6061 does not have high hardness, so that chip curling occurs. Herein, the chip curling refers to curling of the fragments produced from alloy processing without falling off on a tool, and this causes increased processing time and shortened tool life. However, since brass has high strength and hardness, fragments occur in the form of powder when alloy processing, and thus, chip curling does not occur, as illustrated in FIG. 4B.

[0051] Meanwhile, referring to FIG. 4C, the fragments produced when processing the aluminum alloy according to the present disclosure are in the form of powder, similarly to FIG. 4B. As such, the aluminum alloy according to the present disclosure has improved hardness and strength as compared with Al 6061, the conventional aluminum alloy, and has reduced chip curling, and thus, the shortened processing time of the alloy and the prolonged tool life may be expected.

[0052] FIG. 5 is a flow chart for describing a process of manufacturing the aluminum alloy for die casting according to the present disclosure.

[0053] First, a parent alloy including La and Sr is prepared (S501). Specifically, La and Sr are added to Al according to the composition, and melted together at 600 to 700 °C to prepare an Al-La-Sr ternary parent alloy. Herein, Mg is further added to prepare an Al-Mg-La-Sr quaternary parent alloy.

[0054] Next, the components other than La and Sr in the aluminum alloy of the present disclosure may be added to a crucible according to the composition, and melted at 600 to 700 °C (S520). Specifically, Al, Si, Mg, Fe, Zn, Cu, Mn and Ti may be added to the crucible to include, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$, $0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$ and $0.05 \leq \text{Ti} \leq 0.15$, based on the total weight of the aluminum alloy for die casting. Herein, the crucible may be a graphite crucible. Meanwhile, after completing the melting, a process of adding flux to form an oxidation prevention film on the molten metal surface may be further carried out.

[0055] Next, the thus-prepared parent alloy may be added to the molten metal according to the composition, and melted together (S530). Specifically, the parent alloy prepared to include, by wt%, $0.01 \leq \text{La} \leq 2$ and $0.01 \leq \text{Sr} \leq 2$, based on the total weight of the aluminum alloy for die casting may be added to the molten metal. Herein, after adding to the molten metal, the parent alloy may be heated to 600 to 700 °C for 30 to 60 minutes to be completely dissolved.

[0056] Thereafter, the molten alloy may be added to a mold using die casting equipment according to a known method, and subjected to injection and cooling to produce a product.

[0057] As such, the alloy may be manufactured more stably without losing components, by preparing the aluminum alloy using the parent alloy including La and Sr.

[0058] Meanwhile, it is described above that after preparing the parent alloy including La and Sr, the aluminum alloy not including La and Sr is melted, however, the present disclosure is not limited thereto, and after melting the aluminum alloy not including La and Sr, the parent alloy including La and Sr may be prepared, or the two processes may be carried out simultaneously or individually.

[0059] According to the various exemplary embodiments of the present disclosure as described above, the aluminum alloy having excellent fluidity to be easily cast, having a little deposit on the mold surface, and having improved mechanical properties and corrosion resistance may be obtained, by including La and Sr in the aluminum alloy.

[0060] Although the present disclosure has been described with an exemplary embodiment, various changes and modifications may be suggested to one skilled in the art. It is intended that the present disclosure encompass such changes and modifications as fall within the scope of the appended claims.

Claims

1. An aluminum alloy for die casting, comprising, by wt%,

$$3 \leq \text{Si} \leq 10;$$

$$3 \leq \text{Mg} \leq 10;$$

$$0.01 \leq \text{Fe} \leq 1.3;$$

$$0.01 \leq \text{Zn} \leq 2;$$

$$0.01 \leq \text{Cu} \leq 1.5;$$

$$0.01 \leq \text{Mn} \leq 0.5;$$

$$0.05 \leq \text{Ti} \leq 0.15;$$

$$0.01 \leq \text{La} \leq 2;$$

$$0.01 \leq \text{Sr} \leq 2;$$

and a balance of Al.

2. The aluminum alloy for die casting as claimed in claim 1, wherein $0.10 \leq \text{Sr} \leq 1.0$.
3. The aluminum alloy for die casting as claimed in claim 1 or 2, wherein $0.01 \leq \text{La} \leq 0.5$.
4. The aluminum alloy for die casting as claimed in any one of claims 1 to 3, wherein the aluminum alloy has a tensile strength of 240 to 270 N/mm², an internal force of 230 to 260 N/mm², and an impact value of 90 to 110 KJ/m².
5. The aluminum alloy for die casting as claimed in any one of claims 1 to 4, wherein the aluminum alloy has a corrosion current of 3.5 to 4.5 μA , a potential of -660 to -645 V, and a corrosion resistance of 4.9 to 5.6 Ω , as measured by a potentiodynamic acceleration test in an environment comprising 5% sodium chloride.
6. An aluminum flange shaft for a washing machine, manufactured from the aluminum alloy for die casting as claimed in any one of claims 1 to 5.
7. A method of manufacturing an aluminum alloy for die casting, comprising:
- preparing a parent alloy comprising La and Sr;
melting Al, Si, Mg, Fe, Zn, Cu, Mn and Ti in a crucible to comprise, by wt%, $3 \leq \text{Si} \leq 10$, $3 \leq \text{Mg} \leq 10$, $0.01 \leq \text{Fe} \leq 1.3$, $0.01 \leq \text{Zn} \leq 2$, $0.01 \leq \text{Cu} \leq 1.5$, $0.01 \leq \text{Mn} \leq 0.5$ and $0.05 \leq \text{Ti} \leq 0.15$, based on a total weight of the aluminum alloy for die casting; and
adding the prepared parent alloy to the crucible to comprise, by wt%, $0.01 \leq \text{La} \leq 2$ and $0.01 \leq \text{Sr} \leq 2$, based on a total weight of the aluminum alloy for die casting.
8. The method as claimed in claim 7, further comprising:

after completing the melting, adding flux to the crucible.

9. The method as claimed in claim 7 or 8, wherein the parent alloy is an Al-La-Sr ternary parent alloy or an Al-Mg-La-Sr quaternary parent alloy.

10. The method as claimed in any one of claims 7 to 9, wherein the melting is carried out at 600 to 700 °C.

FIG. 1A

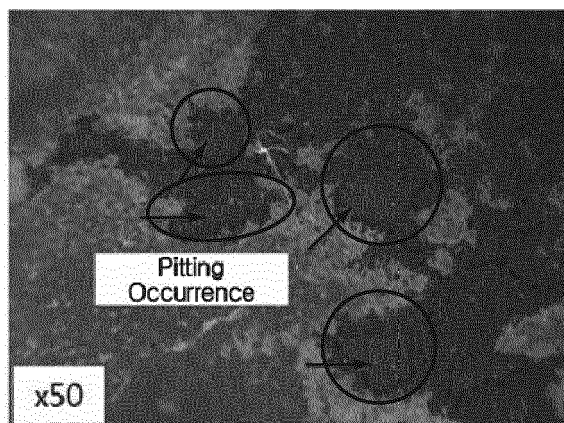


FIG. 1B

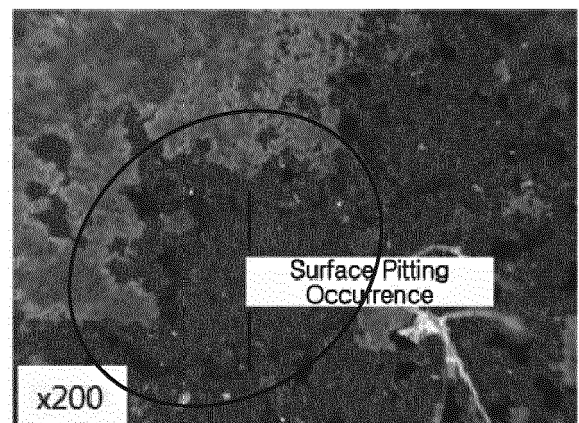


FIG. 2A

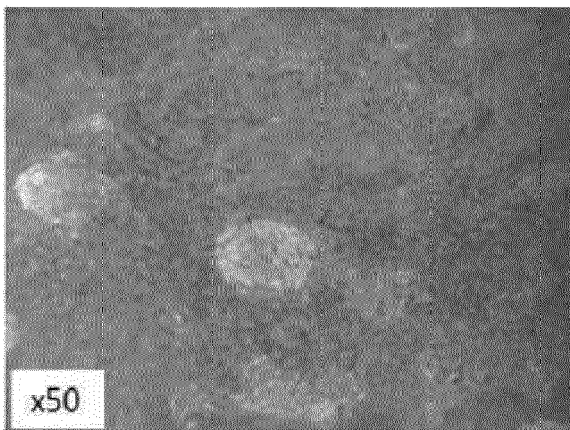


FIG. 2B

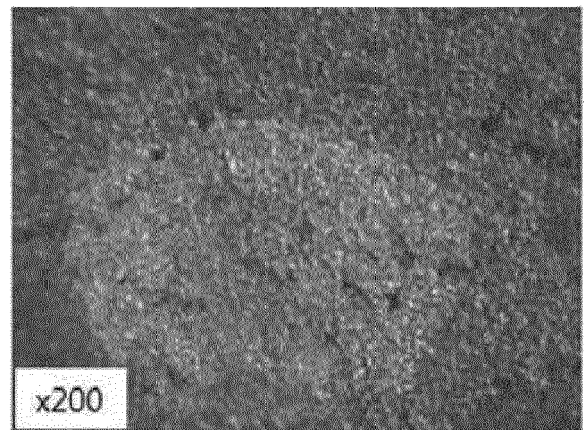


FIG. 3A

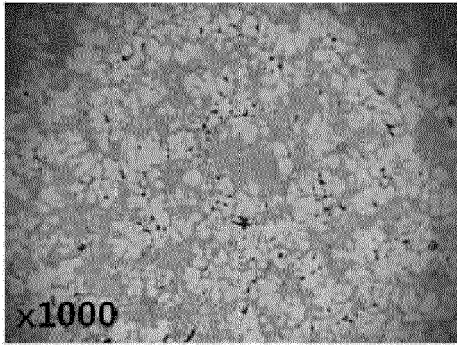


FIG. 3B

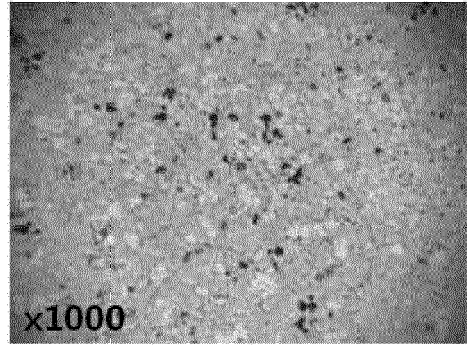


FIG. 3C

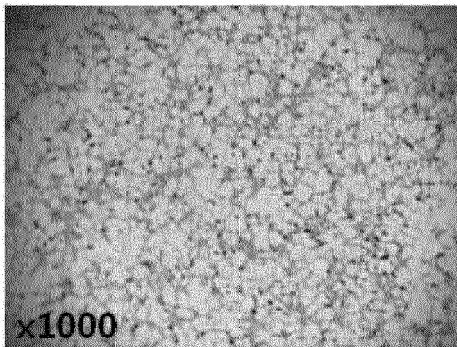


FIG. 3D

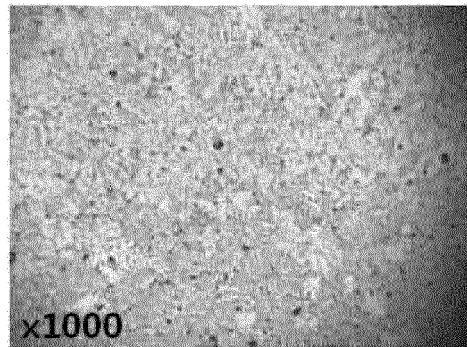


FIG. 4A FIG. 4B FIG. 4C

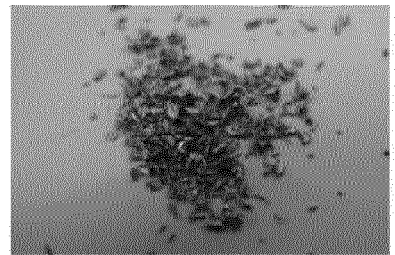
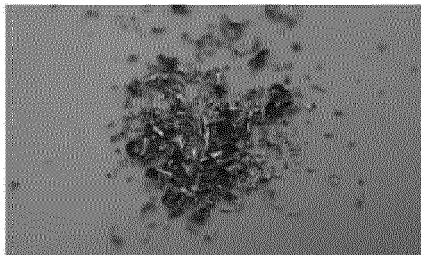
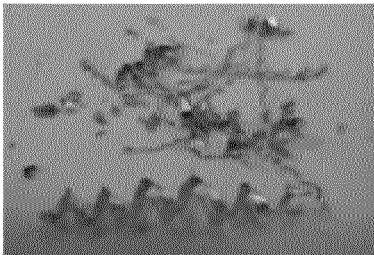
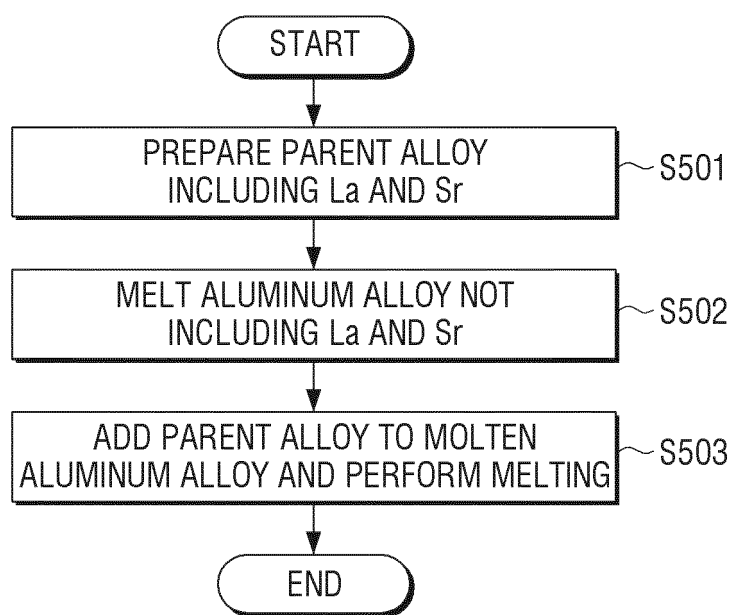


FIG. 5





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