High-strength and tough aluminum alloy for high-vacuum die-casting Development and application

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I. Introduction

In recent years, due to the requirements of the automotive industry, aluminum alloy die-casting components need to have high impact energy absorption, weldability, stress corrosion resistance and high plasticity. Such requirements have promoted the development of new die-casting alloys. The target product of high-vacuum die-casting is automobile and motorcycle structural parts, which has very high requirements for elongation. However, traditional die-casting aluminum alloys such as ADC10 and ADC12 have low elongation and cannot obtain high-strength die-casting parts, so they cannot meet the performance of high-vacuum die-casting parts. Requirements, it is also not suitable for use in security structural parts. A series of special aluminum alloys for high-vacuum die-casting have been developed abroad. The materials of high-vacuum die-casting parts are different from those of ordinary die-casting parts. In order to achieve the purpose of welding and heat treatment, every step of die-casting must be paid attention to.

II. Characteristics of die-cast aluminum alloy and main alloying elements Effect

1. Features of traditional die-cast aluminum alloy

In addition to ensuring smooth die-casting and meeting the working performance requirements of the manufactured parts, die-casting aluminum alloy should also have better plastic rheological properties, smaller linear shrinkage, narrow crystallization temperature range, certain high-temperature solid strength, and easy demoulding and not easy to inhale and oxidize. Common die-cast aluminum alloys are mainly concentrated in Al-Si-Cu, Al-Si-Mg and Al-Mg series, their typical grades, main alloy composition and mechanical properties are shown in Table 1. Among them, Al-Si-Cu series alloys are the most widely used, such as ADC10 (A380) and ADC12 (A383) .

Table 1 Composition and mechanical properties of commonly used die-cast aluminum alloys

Alloys group	GB	ASTM	JIS	Main elements composition	Mechanical properties
Al-Si	YL101	A360	ADC3	AlSi10Mg(Fe)	$\sigma \geq 220$ MPa; $\delta \geq 2\%$
	YL102	A413	ADC2	AlSi12(Fe)	$\sigma \geq 279$ MPa; $\delta \geq 2.7\%$
Al-Si-Cu	YL112	A380	ADC10	AlSi9Cu3(Fe)	$\sigma \geq 320$ MPa; $\delta \geq 3.5\%$
	YL113	A383	ADC12	AlSi11Cu3	$\sigma \geq 230$ MPa; $\delta \geq 1\%$
	YL117	B390	ADC14	AlSi17Cu5Mg	$\sigma \geq 220$ MPa; $\delta \leq 1\%$
Al-Mg	YL302	518	ADC5	AlMg5Si1	$\sigma \geq 220$ MPa; $\delta \geq 2\%$

Note: Mechanical properties are tensile strength and elongation
Source: Material Review, November 2018

The composition of die-cast aluminum alloy determines the mechanical properties of the casting. For castings with different requirements, not only different die-casting methods must be selected, but also the appropriate aluminum alloy composition must be used. In summary, the main alloying elements in ordinary die-cast aluminum alloys are Si, Fe, Cu, etc. Si can improve the fluidity of the alloy, Fe is good for demoulding, and Cu can increase the strength of the casting. However, Fe is easy to form needle-like β-Al5FeSi phase (Figure 1), resulting in general elongation of ordinary aluminum alloy die castings less than 3%. In order to prevent the mold sticking produced in the die casting process, the Fe content in die casting alloys is generally higher, and high content of iron will weaken the toughness of the casting. According to JIS H 5302:2000, the tensile strength of ADC12 is 228 MPa, and the elongation is 1.4%; even when the oxygen-filled die-casting technology is applied, the elongation of ADC12 is only 1.9%, which shows that the elongation is inherently low.

2. Modification of ordinary die-cast aluminum alloy

In order to improve the mechanical properties of die-casting parts, many modification studies have been done on the basis of traditional die-casting aluminum alloys abroad. For example, adding 1.0% Sm to ADC12 alloy significantly refines the size of the eutectic silicon in ADC12 alloy. The secondary dendrite spacing is reduced from 51μm to 15μm, and its tensile strength and elongation reach 220 MPa and 3.1%, respectively. It is also used to add 0.05% Sr to refine the crystal grains in ADC12 alloy and improve the morphology of eutectic silicon, so that its tensile strength and elongation can reach 269.5 MPa and 3.2%, respectively.
A380 is the most widely used die-cast aluminum alloy in the United States, with excellent mechanical properties and casting properties. 383 and 384 are modified alloys of A380, and their Si content is closer to the eutectic composition than A380, which further improves the fluidity of the alloy; 383 alloy has a lower Cu content and

has a lower tendency to form hot cracks during die casting. Professor Makhlouf from the United States has long studied die-casting aluminum alloys, including new alloy development, die-casting process optimization, and alloy performance evaluation. He developed the iSelect-Al2.0 software and used the software to optimize the chemical composition of A380 aluminum alloy. The composition adjustment mainly includes increasing the content of Si, Mn and Mg, reducing the content of Fe and Cu, and adding Sr for modification. After optimizing the composition, the tensile strength of AMC380 aluminum alloy is 7.0%～9.9% higher than that of A380, the yield strength is increased by 20.5%～24.8%, but the elongation rate has decreased. The elongation of A380 aluminum alloy is increased to 4.6%, an increase of 17%-22.6%, but the increase in tensile strength and yield strength is less than 5.9%. Scholars added 0.6% Li to the A380 alloy to make the β-AlFeSi phase and eutectic silicon in the alloy more dispersed and uniform. The tensile strength and elongation of the final die castings were increased from 274MPa and 3.8% to 300MPa and 6%, respectively. Scholars added 0.04% Sr and subsequent heat treatment to make the tensile strength and elongation of A380 aluminum alloy reach 258MPa and 4.2%, respectively. There is also the addition of 0.05% Be to the A380 alloy to reduce the effect of Fe and refine the size of the eutectic silicon, which increases the tensile strength of the casting from 270MPa to 295MPa, and the elongation from 3.7% to 4.7%. In summary, the research on the modification of ordinary die-casting aluminum alloys has greatly improved the strength of the alloy, especially the yield strength and elongation. However, due to the high content of Fe, the elongation of the castings has not increased much, and the elongation after the modification is basically below 5%.

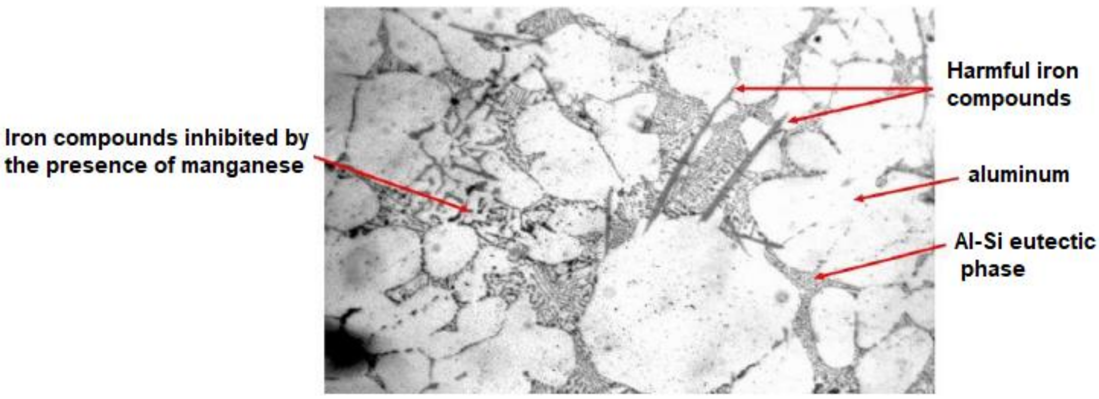


Figure 1 Microstructure of traditional die-cast aluminum alloy

Source: Light Metal Manufacturing Technology and Application Seminar, Sep. 05, 2019

III. the characteristics and classification of high vacuum die-cast aluminum alloy

Some stress parts and security parts in automobiles have much higher requirements for strength, toughness, and fatigue than ordinary die-casting parts, and generally require an elongation rate of more than 8%. However, the elongation rate of ordinary aluminum alloy die-casting parts is less than 5%. The use of high-vacuum die-casting technology can significantly improve the mechanical properties of ordinary die-cast aluminum alloys. For example, the tensile strength and elongation of ADC12 high-vacuum die-casting parts are increased by 6.6% and 25% respectively compared with ordinary die-casting parts. Even so, it is difficult for ordinary die-cast aluminum alloys to meet the performance (especially elongation) requirements of automobile stressed structural parts through high-vacuum die-casting technology. Therefore, in addition to the high-vacuum die-casting method, it is necessary to adopt better performance die-cast aluminum alloy.

In order to further improve the mechanical, corrosion resistance and fatigue properties of die castings, foreign researchers are committed to developing new low-cost, high-performance aluminum alloys for high-vacuum die-casting. At present, they are mainly concentrated in Al-Si and Al-Mg series alloys. The more well-known aluminum alloy grades in the industry include Silafont®-36, Magsimal®-59, Aural-2 and Aural-3, etc., which are mainly based on optimization or addition of alloying elements. The newly developed types of aluminum alloys are mainly Japanese the DiASil aluminum alloy developed by Yamaha, the main high-strength and tough aluminum alloy grades and components currently used in the industry are shown in Table 2.

(I) Al-Si series high vacuum die-cast aluminum alloy

Due to its good casting performance, Al-Si series alloys are also the main research and development materials for high vacuum die-casting aluminum alloys. Among them, Al-Si series high-vacuum die-casting aluminum alloys are all hypoeutectic alloys-AlSi10MnMg alloys, which are compared with ordinary die-casting aluminum alloys, the main difference is:

Table 2 Major high-strength and tough aluminum alloy grades and compositions

Material grade	Element content (%)										
	Silicon	Manganese	Magnesium	Strontium	Titanium	Iron	Copper	Zinc	Beryllium	Molybdenum	Zirconium
EN AC-43400[7]	9.0~11.0	0.55	0.2~0.5	–	0.02	1	1	0.15	–	–	–
Silafont®-36[8]	9.5~11.5	0.5~0.8	0.1~0.5	0.01~0.02	0.15	0.15	0.03	0.07	–	–	–
Magsimal®-59[9]	1.8~2.6	0.5~0.8	5.0~6.0	–	0.2	0.2	0.03	0.07	0.04	–	–
Castasil®-37[10]	8.5~10.5	0.35~0.6	0.06	0.006~0.025	–	0.15	0.05	0.07	–	0.1~0.3	0.1~0.3
Aural-2[11]	9.5~11.5	0.45~0.55	0.27~0.33	0.01~0.16	0.08	0.15~0.22	0.03	–	–	–	–
Aural-3[11]	9.5~11.5	0.45~0.55	0.4~0.6	0.01~0.16	0.08	0.15~0.22	0.03	–	–	–	–
DiASil[12]	20	–	–	–	–	–	1	–	–	–	–

Source: Industrial Materials Issue 395, November 2019

A. High Si: to ensure that the alloy has good casting performance and can produce parts with a wall thickness of only 1.1mm;
B. Avoid Cu as much as possible: to ensure that the stressed structural parts of the automobile have better corrosion resistance;
C. Minimize the Fe content: Relatively increase the Mn content to ensure that the alloy has better Die Soldering Resistance. At the same time, when the Mn/Si ratio is appropriate, it can avoid the formation of needle-like β-Al5FeSi compounds. The finely dispersed α-Al15 (Mn, Fe) 3Si2 quaternary phase ensures that the material has good comprehensive properties;
D. Adding Sr and Ti: Adding Sr can not only change the morphology of the eutectic silicon phase by its modification effect to increase the elongation of the alloy, but also reduce the tendency of mold sticking during die casting. The addition of Ti can refine the size of the α-Al dendrites and the second phase, thereby improving the mechanical properties of the casting.
1. Silafont®-36
In 1994, Rheinfelden Alloys of Germany launched the high toughness die-cast aluminum alloy Silafont®-36 for the first time. Silafont®-36 was developed based on the European grade EN AC-43400. Table 2 shows the composition difference of EN AC-43400 and Silafont ®-36. The iron content of Silafont®-36 is quite low, but too low iron content is likely to cause sticking in castings. The addition of manganese can reduce sticking and will not produce needle-like intermetallic compounds with aluminum. In addition, the addition of strontium can modify the eutectic silicon, so that the eutectic silicon that originally appeared in the shape of thick needles in the casting can be transformed into fine fibrous eutectic silicon, which improves the toughness of the alloy and has a negative effect on the corrosion resistance. Cu and Zn are impure elements and are strictly restricted.
Figure 2 shows the microstructure of Silafont®-36. Compared with the AlSi9MnMg alloy without Sr, the eutectic Si shape of Silafont-36 with Sr will change from layered to fine spheroidization. Also due to the change in the shape of the eutectic Si, even the F material can obtain high ductility with an elongation of 10%. Through the implementation of solution treatment, although the eutectic Si will grow larger, it will also be spheroidized. The spheroidization of the eutectic Si is the reason to make the T7 material (solution treatment + over aging) high ductility. Silafont®-36 undergoes high-vacuum die-casting technology and heat treatment to precipitate strengthening phases such as Mg2Si to increase the strength of the alloy. Table 3 is a comparison of the mechanical properties of Silafont-36 and ADC12. Currently, Silafont-36 has become a commercial standard alloy, and its grade in the Aluminum Association is AA365.0.

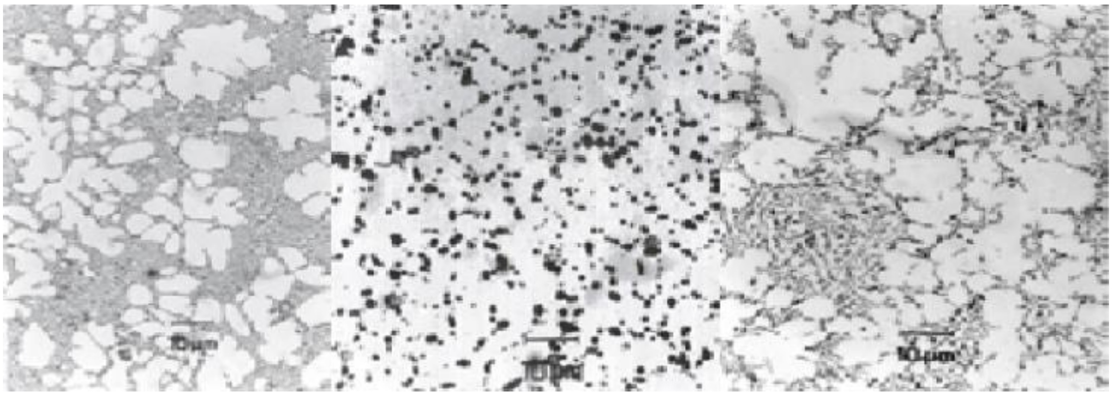


Figure 2 Silafont®-36 microstructure
(Left: as-cast, middle: solution treatment, right: no Sr added)
Source: Sokeizai, September 2009

Table 3 Comparison of mechanical properties of Silafont-36 and ADC12

Alloy	Heat treatment state	Yield strength N/mm^2	Tensile strength N/mm^2	Elongation %	Hardness HB
Silafont-36	F	120-150	250-290	5-11	75-95
Silafont-36	T4	95-140	210-260	15-22	60-75
Silafont-36	T5	155-245	275-340	4-9	80-110
Silafont-36	T6	210-280	290-340	7-12	90-110
Silafont-36	T7	120-170	200-240	15-20	60-75
ADC12	F	154	228	1.4	74.1

Note: The data of ADC12 is the average of 27 test pieces taken from 11 types of products and the results of tensile test [5]

2. Castasil-37

Castasil-37 is also an Al-Si-Mn high-strength die-cast aluminum alloy developed by Rheinfelden Alloys. It has good castability and does not require heat treatment. It can achieve high ductility (elongation above 12%) in the as-cast state, and it will not be affected by Material changes due to aging in a high temperature environment. The Mg content is below 0.06%, and Mo and Zr are added. By limiting the content of Mg, it is possible to prevent age-hardening of castings during use. On the other hand, the addition of transition elements Mo and Zr are used to compensate for the reduction in yield strength caused by the decrease in Mg content. The eutectic Si of Castasil-37 can be refined like Silafont-36 after being modified with Sr, and it is finer than Silafont-36. Figure 3 shows the cast microstructure of Castasil-37.

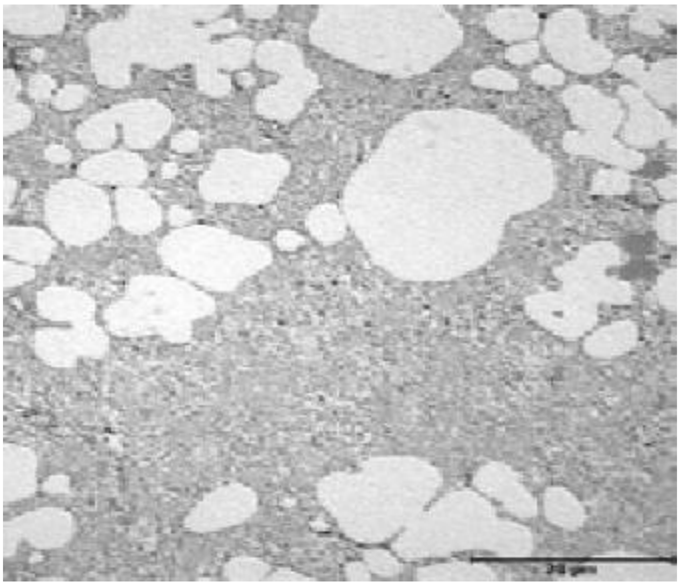


Figure 3 Castasil-37 as-cast microstructure
Source: Sokeizai, September 2009

3. Aural-2/3

Aural-2/3 is an Al-Si-Mg series of high-strength aluminum alloy developed by Alcan Company. When its Mg content is 0.27%~0.33% (called Aural-2), it is a kind of filling fluidity with strong fluidity, suitable for the production of complex large-scale Thin-walled aluminum alloy die-casting is a high-strength and tough aluminum alloy, and when the Mg content is increased to 0.4%~0.6% (Aural-3), coupled with high-vacuum die-casting, the casting has excellent weldability and heat-treatability. The yield strength of Aural-3 alloy after heat treatment can reach 250MPa, and the elongation can even reach 5%~12%. When die-casting Al-Si-Mg alloys, since Mg cannot be completely dissolved in the α-Al solid solution, Mg is supersaturated in the α-Al solid solution during chilling, and the strengthening phase Mg2Si will be precipitated during the aging treatment. Can improve the tensile strength and yield strength of the alloy.

4. C448

C448 (AlSi9Mg) is a heat-treated, easy-cast high-strength aluminum alloy developed by Alcoa. Its elements are about 10% silicon and 0.2% magnesium. The alloy undergoes precipitation hardening (Mg2Si), which requires solution heat treatment, then quenching and aging. For hypoeutectic alloys with Si in the range of 7%-12%, in order to avoid the primary phase of Al5FeSi, the content of Fe must be lower than 0.8% of the ternary eutectic point. Figure 4 shows the addition of Al-Si-Mg-Fe alloy, the effect of Mn assumes that 0.8% of Mn completely replaces Fe at the eutectic point, and then compares the above-mentioned high-strength and toughness die-cast aluminum alloys to avoid the formation of primary Fe/Mn intermetallic compounds.

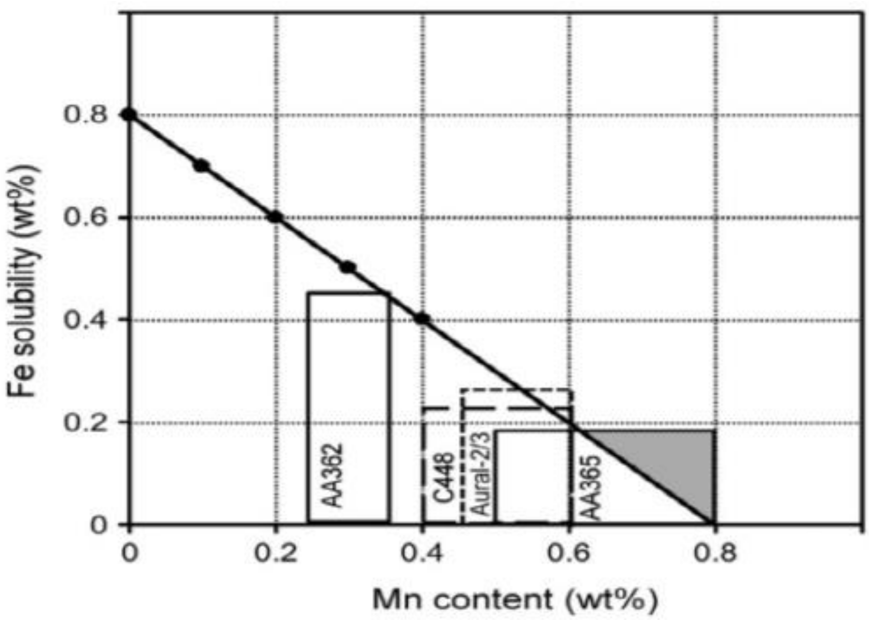


Figure 4 The effect of adding Mn to replace Fe in the high strength and toughness Al-Si-Mg-Fe alloy
Source: "Fundamentals of Aluminium Metallurgy: Recent Advances", 2018

In AA365, the Mn range is 0.5%-0.8%, while in Aural-2/3 and C448 alloy, the upper limit is 0.6% Mn. The maximum iron content in Silafont-36 is 0.15%, C448 is 0.20%, and Aural-2/3 is 0.25%. It seems that the highest Mn content allowed in AA365 is responsible for the formation of Fe/Mn-containing primary phases, as shown in the shaded area in Figure 4. According to experience, Aural-2/3 and C448 alloys use lower Mn content to avoid the formation of iron/manganese primary phases and reduce ductility. The manganese content of AA362 is low (0.25-0.35%) and the maximum iron content is high (0.4%), but its composition range is still lower than the predicted line of Fe/Mn primary phase formation in Figure 4. AA367 and AA368 alloys (9% silicon) with a maximum iron content of 0.25% have Mn content as low as AA362, so they are also far below the predicted line.

According to the concept of Fe(max)=0.80-Mn(max), high Mn requires low Fe to avoid precipitation of Fe/Mn primary phase. When the maximum value of Mn is 0.35% (such as Mercalloy alloy), in order to avoid the formation of Fe/Mn primary phases and reduce the elongation, Fe must be less than 0.45% (see Figure 5). In terms of providing anti-sticking properties, because strontium (Sr) has been found to be ten times more effective than Mn or Fe, Silafont-36, Aural-2/3 and Alcoa's C448 all allow the reduction of Mn content. This means that a higher iron content can be used, so the life of the mold and the barrel can be increased. As shown in Figure 5, choosing the Mn range of 0.25%-0.35% (maximum Mn content 0.35%) means that Fe must be less than 0.45% to avoid the precipitation of intermetallic compounds.

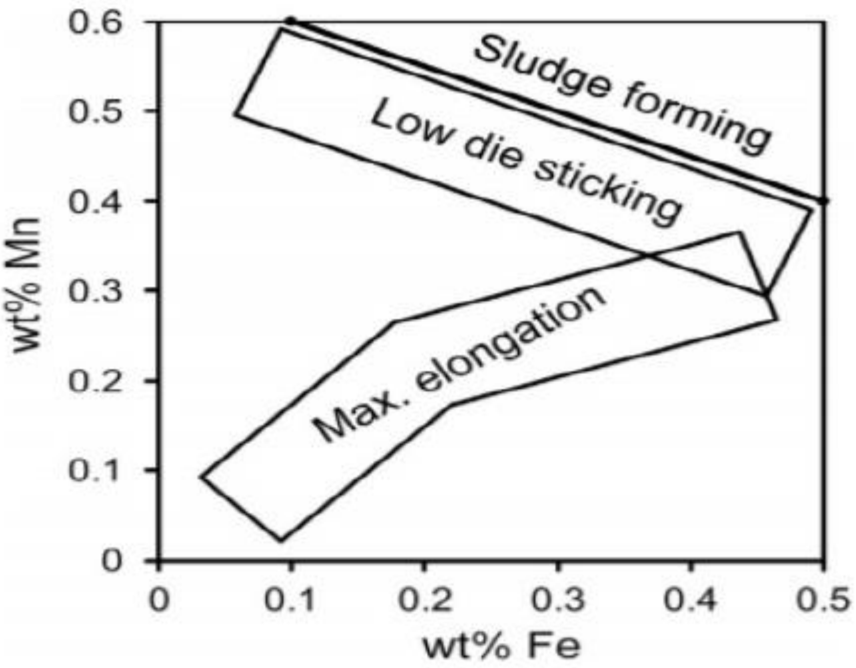


Figure 5 Relationship between Mn/Fe content and elongation of high strength and toughness aluminum alloy
Source: "Fundamentals of Aluminium Metallurgy: Recent Advances", 2018

Although AlSi10MnMg alloys have excellent properties, the current commercial alloys are mainly prepared directly from electrolytic aluminum ingots, and cannot accept the addition of secondary aluminum, the cost is high, and the Fe content after recovery is likely to exceed the standard. At present, the research on AlSi10MnMg alloy with high Fe content based on secondary aluminum is still in the experimental stage. The production cost of this type of alloy is greatly reduced, but the low elongation of its castings is still the biggest problem facing industrialization.
Existing research findings are listed as follows:
A. When the Fe content in the alloy is between 0.47% and 0.6%, the strength and elongation of AlSi10MnMg alloys will decrease with the increase of Fe content, but when the added Mn/Fe ratio is about 2/3, the elongation rate of the casting can be maintained above 8%.
B. The high Fe AlSi10MnMg alloy is mainly composed of α-Al, eutectic silicon, Fe-rich intermediate alloy phase (such as α-Al15 (MnFe) 3Si2, Al5FeSi, etc.), Mg2Si,

$Al_8FeMg_3Si_6$, etc., when the Fe content is less than 0.7% When the Fe content increases, the tensile strength of the alloy also increases, and the elongation has been decreasing.
C. The elongation of AlSi10MnMg alloy castings containing 0.55% Fe can be increased by adjusting the ratio of Mn/Fe and increasing the cooling rate.

In addition, Japan's Ryobi company adjusted the AC4CH composition on the basis of its own high vacuum die-casting technology and developed a hypoeutectic AlSiMg heat-treated high-toughness die-casting aluminum alloy. The elongation rate is 5% to 15% during T5 heat treatment, T4 heat treatment is as high as 10% to 25%. In 2002, Japan Yamaha Company developed a high-silicon aluminum alloy DiASil cylinder with 20% silicon and 1% copper. Under high vacuum die-casting conditions, the size of the primary crystal silicon is less than 50μm, and the strength and wear resistance of the material have been obtained. It has been successfully applied to die-casting of motorcycle cylinder blocks. However, the toughness of this alloy is poor and it is not suitable for other stressed structural parts. In summary, the development of high-vacuum die-casting Al-Si series alloys is mainly focused on AlSiMg series alloys. This series of alloys has good casting performance and high strength and can be used in automotive parts with complex shapes and high requirements for comprehensive mechanical properties. Improving the mechanical properties of castings mainly relies on subsequent heat treatment, but it is inevitable that castings will be deformed during the heat treatment process, and correction procedures need to be added will increase manufacturing costs.

(II) Al-Mg series high vacuum die-cast aluminum alloy
Al-Mg alloys do not need solution treatment to obtain high tensile strength and elongation. However, due to the addition of Mg in Al-Mg alloys, it is easy to oxidize or form slag during smelting. Die-casting control is more difficult than Al-Si series alloys. Mainly used for die castings with special appearance and anti-corrosion requirements and low requirements for mechanical properties.

1. Magsimal®-59
Magsimal®-59 is a high-strength die-cast aluminum alloy developed by Rheinfelden Alloys in 1995. The elongation in the as-cast state can be maintained above 15%, and the yield strength is higher than 120 MPa. It is mainly used for automotive parts. Magsimal-59 is also smelted on the basis of primary aluminum ingots with a purity of 99.8% or more. This alloy belongs to AlMg5Si2Mn alloy. The main constituent elements are Mg, Si, and Mn. The structure is composed of α phase and Mg_2Si

eutectic. Among them, Mg , Si content should be adjusted to the Mg_2Si eutectic ratio of 40-50% (area ratio) to obtain good castability and molten metal replenishment, while the Mg/Si ratio is 2.5 or more to ensure its corrosion resistance and alpha phase strength. In addition, by controlling the Fe content below 0.2% and the Cu content below 0.03% to increase the elongation; controlling the Na and Ca content below 0.001%, increase the melt fluidity and enhance the hot crack resistance; When the Mg content exceeds 2%, it is easy to burn at high temperature. In addition, since the Al-Mg alloy is prone to generate oxidized dross when it is melted, adding a small amount of Be to form a higher density of BeO on the molten surface, thereby reducing the diffusion of Al and Mg to the surface to oxidize. Figure 6 shows Magsimal®- 59 as-cast microstructure.

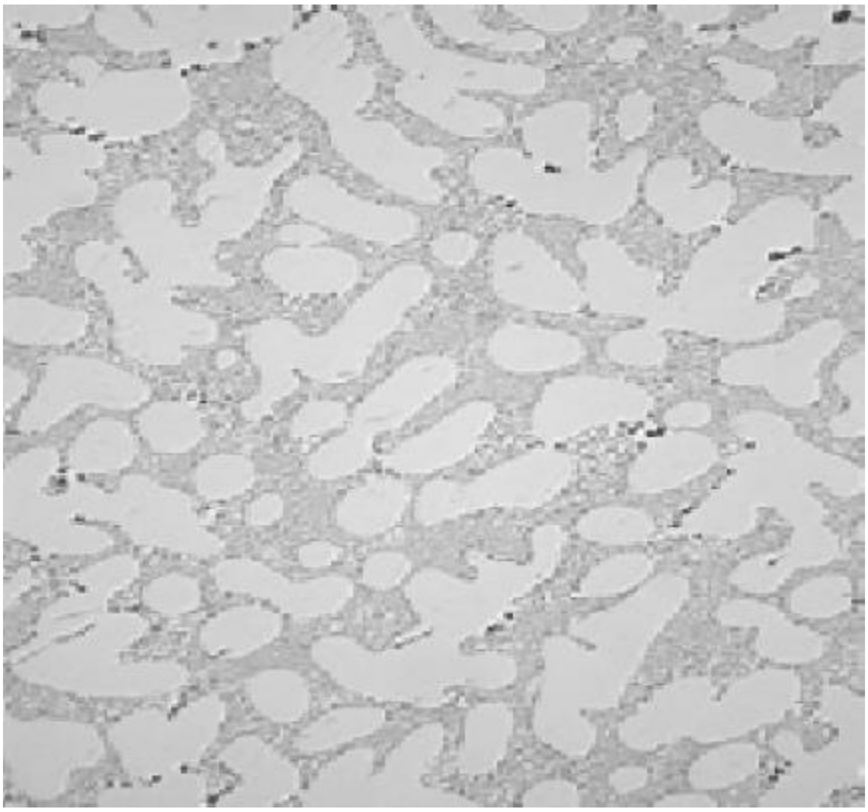


Figure 6 Magsimal®-59 as-cast microstructure
Source: Sokeizai, September 2009

Scholars studied the influence of Mg content, structure, and aging treatment on AlMg5Si2Mn alloy, and developed a new type of AlMg5Si2Mn alloy. The tensile strength and elongation of the castings are 324MPa and 8.3%, respectively. After artificial aging treatment at 250℃×1h, the tensile strength and elongation are 369MPa and 8.5%. Due to its excellent mechanical properties, this alloy has been used in the production of the rear subframes of Chinese brand cars. Guangdong Hongtai Company invented an Al-Mg-Si-Mn series alloy with Fe content below 0.25%

and Mg content controlled at 4.5% to 6.3%. After high vacuum die casting, the yield strength of castings can reach 217.2 MPa, and the elongation higher than 7 %. Al-Mg series alloys have a large solidification interval, poor casting performance, and high Mg content. It is difficult to melt protection and molten metal treatment. It is mainly used for parts with relatively simple shapes and no thin walls. The mechanical properties of Al-Mg alloys are mainly related to the size of crystal grains and alloy phases. The mechanical properties of Al-Mg alloys mainly depend on the wall thickness of the casting. On the whole, the application range of Al-Mg alloys is much narrower than that of Al-Si alloys.

2. C446

C446 (AlMg3Mn) is an Al-Mg high-strength aluminum alloy developed by Alcoa that does not require heat treatment. Its elements are about 3.5% magnesium and 1.3% manganese, and iron <0.2%. The alloy is based on solution treatment strengthening, so no heat treatment is required. The iron and copper contents of C446 and C448 are very low. Table 4 is a comparison of the mechanical properties of these two alloys.

Table 4 Comparison of mechanical properties of C446 and C448 high strength and toughness aluminum alloys

	C 448 T7 Heat treated	C 446 Non heat-treateable
Chemical Designation	AlSi9Mg	AlMg3Mn
Yield Strength (min / typ) [MPa]	120 / 140	120 / 150
Ultimate Strength (min / typ) [MPa]	180 / 200	190 / 250
Elongation (min / typ) [%]	10 / 15	10 / 20
Fatigue Limit [MPa]	> 100	> 120
Weldability	WIG / MIG / Laser	WIG / MIG / Laser
Self Piercing Riveting	Very good	Very good
Resistance to Corrosion	resistant	Relatively resistant
Formability	Very good	Very good
Surface quality	Good	Excellent
Castability	Very good	Design changes necessary

Source: "The Aluminium Automotive Manual", EAA, 2002

IV. The application of high-strength and toughness die-casting aluminum alloy

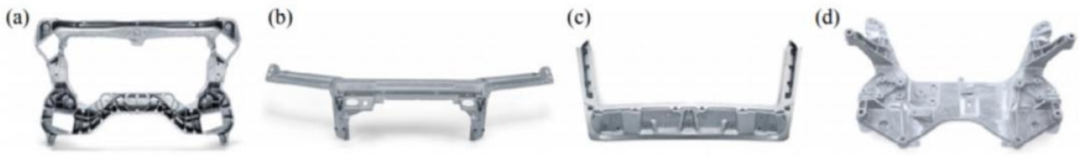
With the expansion of the use of high-strength and toughness die-cast aluminum alloys for automotive components, major companies around the world continue to develop aluminum automotive structural parts. Because Silafont®-36 can be strengthened by heat treatment, it is suitable for the production of many automobile chassis security components, such as engine brackets, automobile front frames, tailgate frames and chassis components (see Figure 7), and Magsimal®-59 has been used It is used in automobile gearbox beams, front wheel suspension brackets and automobile oil pan (see Figure 8).

The alloy materials used in the top three aluminum alloy excellent castings at the 2018 European Die Casting Exhibition are all based on the alloy composition of AlSi10MnMg and then make fine adjustments. AlSi10MnMg is also the main element added by Silafont®-36. The introduction of the award-winning castings is as follows:

First place: automotive connection structure (Figure 9), manufacturer: Swiss DGS, casting size: length 797mm × width 437mm × height 304mm, casting weight: 3.043Kg, alloy: AlSi10MnMgZnZr, heat treatment: T6.

Second place: high-voltage accumulator housing (Figure 10), manufacturer: Magna BDW, Germany, casting size: length 1120mm × width 540mm × height 60mm, casting weight: 7.27 Kg (top), 14.12Kg (bottom), alloy : EN AC-AlSi10MnMg(Fe), heat treatment: T7.

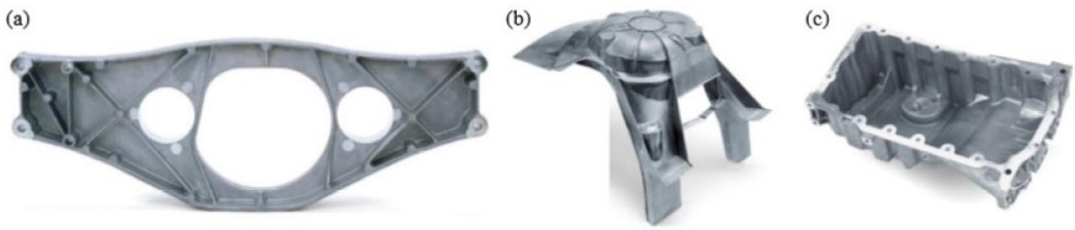
Third place: Hybrid vehicle fuel tank shell (Figure 11), manufacturer: Swiss GF, casting size: length 980mm × width 626mm × height 236mm, casting weight: 10.9Kg, alloy: EN AC-AlSi10MnMg, heat treatment: T7.



(a) Car engine bracket ; (b) The front frame of the car ; (c) Automobile tailgate frame ; (d) Automobile chassis components[8]

Figure 7 Application of Silafont®-36

Source: https://rheinfelden-alloys.eu/Industrial Materials, November 2019



(a) Automobile gearbox beam ; (b) Automobile front wheel suspension bracket ; (c) Automobile oil pan[9]

Figure 8 Application of Magsimal®-59

Source: https://rheinfelden-alloys.eu/Industrial Materials, November 2019

Figure 9 Vehicle body structural member
Source: https://kknews.cc

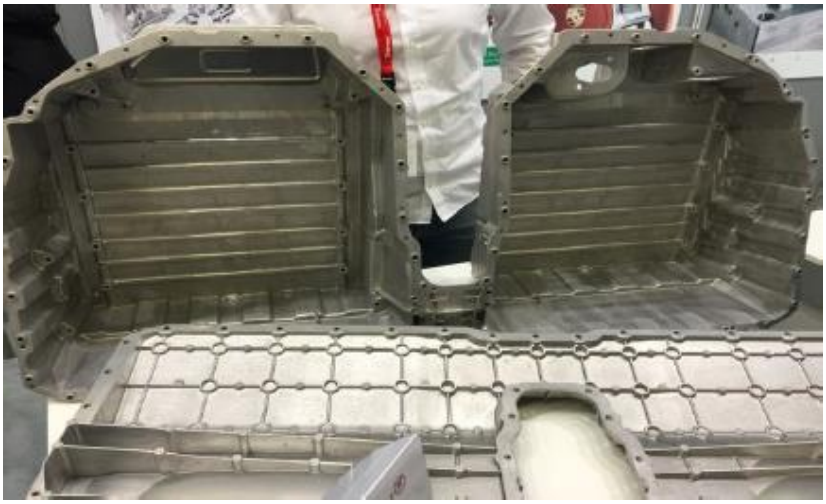


Figure 10 High-voltage accumulator housing
Source: https://kknews.cc

Figure 11 Hybrid vehicle fuel tank shell
Source: https://kknews.cc

V. Conclusion

With the advancement of automotive industry technology, its power, safety, comfort, noise, exhaust emissions and other standards continue to be higher. Following this, aluminum alloy die castings are required to have thin walls, high strength and toughness, high quality, and complex shapes. The development of the integration direction also provides a driving force for the development of high vacuum die casting technology. In the future, the aluminum alloy die-casting materials used in automotive components should still be based on Silafont®-36 to develop related automotive components. After all, it is very difficult to develop new alloy materials. The research history for high-strength and toughness vacuum die-casting aluminum alloy and forming technology is relatively short in our country, and the gap between foreign enterprises is obvious. If the foundry industry of our country wants to catch up with advanced countries in the automobile industry, in addition to developing vacuum die-casting technology and equipment, we also needs to do more basic and applied research on high-vacuum die-casting high-strength aluminum alloys composition optimization, molten metal treatment, alloy phase strengthening mechanism, etc.

Reference

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