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# Effect of high Cerium and Lanthanum on Impact toughness of Al-11Si-Cu eutectic cast alloy

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## Abstract

The effect of additive elements on impact toughness of Al-11Si-Cu alloy was investigated. The impact test bars were used as impact specimens. The energy of Al-11Si-Cu was improved with Sr modifier addition. The high ability of Ce and La to form large structure intermetallic in Al-Si-Cu will reduce the energy. The RE-intermetallic has an effect on impact analysis, which facilitates to increase the porosity pore.

## Introduction

The Al–Si–Cu alloy ADC12 is a cast aluminum alloy widely used due to its excellent material properties, namely high cast-ability, low density, high productivity, low shrinkage rate and relatively high strength. However, cast aluminum alloys have not been always suitable for automotive parts. This is because various cast defects are included in the cast components. Producing defect-free Al castings becomes more important. Aluminum alloys are used extensively due to their high strength to weight ratio, good machinability, corrosion resistance, optimum surface finish, and high electrical and thermal conductivity[1]. All alloying elements that are used for aluminum alloy design can be classified into three principal groups: basic alloying elements, ancillary additions, and impurities depending upon the nature of an alloy, the same elements could play different roles[2] .The increasing of application of Al-Si alloy depends on the transformation of silica morphology. Small quantities of elements add (such as sodium, antimony, and strontium) to the Al–Si melt leading to change of needle-shaped silicon crystals to very fine fibrous eutectic silicon in a solid solution matrix and improve the mechanical properties[3,4]. Various additives are usually used to modify industrial alloys[5] Typically, modified Al-Si alloys give better mechanical properties than unmodified alloys[6,7]. "Tsai, Y.-C., et al" reported the ultimate tensile strengths are not changed with increasing the concentration of La element. However, the elongation of A356 alloy is improved when the amount of La and Ce increases up to 0.6wt%. The modification efficiency of the mechanical properties of A356 alloy with 1.0wt % La is similar to that of the commercial modifier Sr[8].The small amount of Ce also had improved tensile strength of A360 alloys with 0.01 wt.%[9].Intermetallic compounds have very strongly effective on mechnincal properties , Depending upon alloy composition and solidification conditions, iron can form various intermetallic compounds, such as a-$Al_{15}(Fe,Mn)_3Si_2$ or $Al_8Fe_2Si$ (in Al–Si–Mg alloys), ß-Al5FeSi, or л-$Al_8FeMg_3Si_6$. Another negative effect of iron is that it reacts with Cu to form Cu2FeAl7, thus reducing the effective Cu content of the alloy[10].The additions of Ce, La significantly change the characteristic parameters of the Al–Si eutectic phase and reduced the particles size of Si [11] while had negative effecting on fluidity of Al-Si-Cu cast alloy[12].Charpy impact testing was thus chosen for use in this study while this particular test has always been found to be extremely susceptible to the addition of alloying elements and to silicon morphology, despite the fact that data on impact properties is comparatively rare for these alloys. According to prior studies, impact strength is the most sensitive of all the mechanical properties to silicon content for alloy compositions containing 3– 15% Si[13]In this research the Al-11Si-Cu alloys was used as based alloy. The purpose of the present work was to evaluate the effect ofSr, 1 wt % Ce and La additions on the Impact roughness. Charpy impact test was use for investigated the impact properties.

**Experimental produce**

Material used in this study was Al-11.7Si-Cu alloy as a base alloy for all castings. The Laand Ce 99.9% was used as rare earth element.The chemical composition of base alloy is shown in Table 1. The additives level, range 1.0 wt % Ce and 1.0 wt % La and 0.06%Sr modifier were added in solo into the melt, and then the melt was stirred for 30s. The pouring temperature was 750 ± 5 ºC. the permanent steel mold was used to cast the specimen of impact. Upon melt, homogenization and skimming of the melt surface, the molten metal was poured directly from the crucible to the permanent moulds, which was preheated to 500°C for 30 minutes in a firing furnace. All impact specimens were cast under conditions similar to confirm high fluidity and fill up the mold. Each casting provided four impact test bars as showed in figure 1.The impact test was conducted based on Charpy type using Zwick impact testing machine (D-7900) using 15J hammer to measure the total absorbed energy and the dimension is in accordance to ASTM standard for notched Charpy impact test as shown in figure 2.

Table 1: Chemical Composition of Al-11Si-Cu-Mg cast alloyAlloy

| Al | Si | Fe | Cu | Mn | Mg | Zn | Ni | Cr | Aluminum (Al) |
|---|---|---|---|---|---|---|---|---|---|
| Bal. | 11.7 | 0.84 | 1.79 | 0.242 | 0.236 | 0.817 | 0.064 | 0.033 | Remainder |

Figure1: Impact test specimen casting.

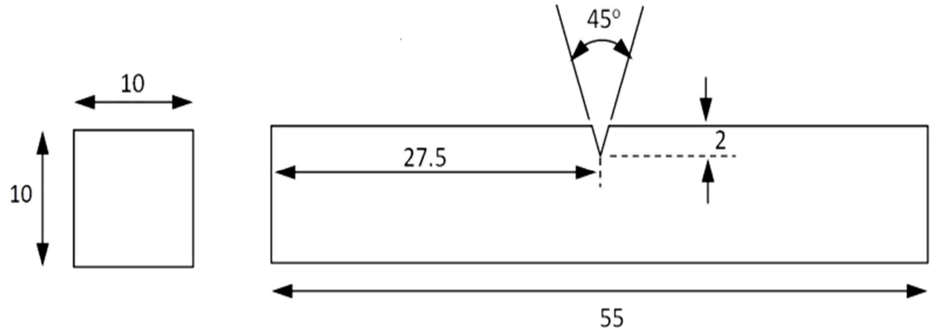


Figure 2: Dimension ofCharpy impact test bar according to standard in (mm)

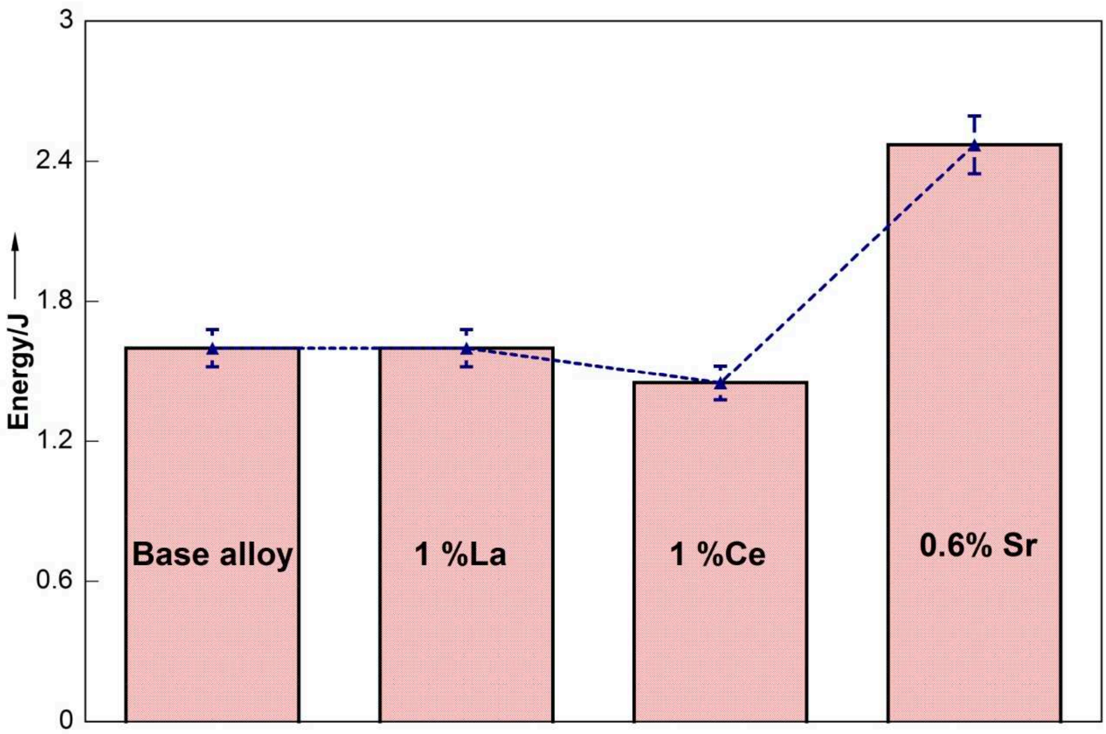


Figure 3: Energy observe of fracture for base alloy and treated with different addition of Ce , La and Sr.

**Results and discussions**

Figure 3 shows the relationship between absorbed energy and condition of samples in the form of untreated (base alloy) and treated alloys with concentration of addition elements Sr, Ce and La. The base alloy obtained 1.6 J and it has little effect by the La addition. The high level of Ce or La at 1.0 wt. % can modifier the Si particles by reducingthe size of Si particles of Al-11Si-Cu cast alloy but never change the morphology to fibre structure [11,12]. The Sr–Mg interaction is known to reduce the porosity volumefraction of Al–Si–Cu alloys .The addition of both Mg and Sr can lead to severe segregation of the Al2Cu phase in 319.2 alloys, resulting in large amounts of the coarse block-like phase, com- pared to the finer eutectic-like form.[14]This reduction absorbed to 1.45J of Ce may due to the RE intermetallic compound and porosity formation. It is well known that the rare earth La and Ce had limited solid solubility in aluminum under an equilibrium condition, and Ce is one of the strong active elements, which can easily react with Al or Si atom[9,15]. Ce formed intermetallic compound with Al, Si,Cu and Mg .Reduction of impact also may due to Mg+RE intermetallic phase which had reported accurse to reducing the energy of Al-Si-Cu alloy. In other hand, the Sr master alloy was indicted increasing in impact to 2.47J . this improvement due the fibrous nature of the modified Si particles and increase the α-Al matrix [10]. Also it has reported that Sr reducing the solidification temperature which lead to improve the properties of Al-Si [16]. It had reported RE-Cu intermetallic forming large than Si particles and interrupted the modification of Si also it increased the pore porosity which reflect on mechanical property such as impact[17].

## Conclusion

The effect of Cerium Lanthanum, Strontium on Al-Si-Cu-Mg eutectic complex alloy was achieved by Charpy impact testing. The result of impact showsthat the absorbed energy of Ce and La alloyswas never improved because the rich intermetallic formed by additives. While the Sr modifier increased the energy for base alloy, which due to the Si modification of Si particles. However , the Ce and La can act as a modifier for the Si particles, but the intermetallic compounds have strongly effect on properties of base alloy .In addition, the porosity was increased with the increase of the Cu-RE intermetalic, thusthe mechanical property was also decreased.

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