



# Impact of Strontium on the Hardness and Impact Test of Eutectic Al-Si+1.0% Manganese Alloy

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## To cite this article:

Okwonna Chukwuebuka Onochie. Impact of Strontium on the Hardness and Impact Test of Eutectic Al-Si+1.0% Manganese Alloy.

*International Journal of Mechanical Engineering and Applications*. Vol. 9, No. 4, 2021, pp. 72-74. doi: 10.11648/j.ijmea.20210904.12

**Received:** April 1, 2021; **Accepted:** May 20, 2021; **Published:** September 23, 2021

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**Abstract:** This experimental research portrays the impact of strontium seen on hardness and impact strength of Al-1.0%mn-12%Si alloy. Strontium was added with respect to the amount of silicon present in the alloys (12% of Si; 0.02-0.03% of Sr) and 1.0% manganese which serves as a modifying agent). Higher amount of aluminum and silicon were dissolved and cast as cylindrical ingots. Impact and Hardness test were tested using charpy impact testing machine and Rockwell hardness testing machine (ASTM E18-11) respectively. The addition of Sr appears to decline as soon as the addition exceeds the 0.026% level which shows negative effect to the mechanical properties because of the presence of some compounds like  $Al_4SrSi_2$  and releases of brittle  $Al_3SrSi_3$  phase are bound to set and coarsening of the eutectic silicon can occur which will reduce the properties of the alloy causing them to revert to values more typical of unmodified material. The results showed that when strontium was used as a modifier to modify eutectic Al-Si alloy modifies the Al-Si, that the morphology of the alloy changed that lead to positive enhancement/increment in mechanical properties of the alloy.

**Keywords:** Strontium, Aluminum Alloy, Eutectic Alloy, Impact Strength, Hardness

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## 1. Introduction

Aluminum becomes the common structural material because of following properties: less weight, less energy needed to fabricate and machine, not easily affected by atmospheric corrosion, good thermal as well as electrical conductivities, high metallic soft glow and its non to conduct and non-shine in nature [2]. Al-Si alloy belongs to aluminum die-casting alloys because of its applications especially in the automotive industry, as well as, the aerospace industry. Aluminum which is needed much in the automobile industry because the propulsive force of materials required is proportional to the design of lighter components which will help reduce the rate of intake of fuel but will not affect the quality and environment [3]. Aluminum alloys are becoming important in the industry because of the way it combines with the properties of base alloy. These properties include high strength, high wear resistance, high rate of stiffness, high temperature strength, efficient of the thermal expansion that is controlled and damping capacity that is improved [7]. Aluminum-Silicon alloys plays vital role in engineering industries because the ratio of the strength to weight is high,

they equally posses high wear resistance, low density and the level of coefficient of thermal expansion is low. Complex shapes can formed through casting with Al-Si alloys but the brittle needle-like shape formed because of the presence of silicon particles reduces the impact strength in the cast structures. One of the main reasons for using these alloys to make high-quality castings is eutectic modification, which was accidentally discovered by AladarPacz in the 1920's while using an alkali-fluoride treatment in Al-Si melts. This treatment results in a considerable improvement in mechanical properties, especially elongation by altering the form of the silicon which is a major constituent of these alloys and plays a significant role in determining the mechanical properties of the alloys.

The use of aluminum cast alloys is still limited when compared with wrought alloys, not withstanding that casting would save more money during production [9]. Apart from the emerging money saving processing techniques that joins quality and ease of operations, researchers are, at the same time changing to aluminum-silicon mix and isotropic

properties, especially in connection to applications that does not need high loading or high heat conditions, for example automobile components [4]. Silicon that appears in brittle needle-like particles and that causes reduction in impact strength especially cast structures. The finger-like structure formed reduces the stress raisers that bring cracks which will reduce the mechanical strength of the alloy [8]. Also, there are plenty impurities found in commercial aluminum which can only be expunged at great cost. Iron is found to be the most important impurity tending to reduce harm in cast aluminum and its alloy reduces the mechanical properties like fracture toughness. The best method improving the stability of aluminum-silicon alloy usage in the industry is to improve the mechanical properties by making sure that Al-Si is structurally sound and dimensionally accurate during castings and when the parts are been fabricated at reduced price. The best way to improve the mechanical properties of Al-Si is by first understanding the relationship that exists between the structure, the property and application of the aluminum-silicon alloy additives. Good in-depth understanding of the coexistence between the microstructure and the properties in cast Al alloys in conjunction with improved foundry practice will allow greater application of the castings in low mass structures. The reasons why modifiers are added to Al-Si alloys are to improve the strength of the alloy, the mechanical properties of the alloy and equally reduce porosity and shrinkage as they change and improve the eutectic structure [1]. Modifier additions during casting of Al-Si alloys improves the mechanical properties especially the ductility of the cast Al-Si alloy [5, 13, 14]. The improvement in mechanical properties of the cast Al-Si alloy is as a result of the change in the form, shape, structure and size of the eutectic silicon phase particles [15]. However when eutectic silicon particles changes from acicular to fiber that its form, shape and size of dendritic  $\alpha$ -Al phase are changed as well.

## 2. Materials and Method

The materials used for alloy preparation, casting of test bars and testing are: aluminium, silicon, manganese, strontium, Weighing machine, Mild steel pot (fabricated) and laboratory size tungsten-arc electric furnace for melting. Four different make ups of alloys were produced with number of strontium ranging from 0.02-0.03 wt%. Before casting, sample A which was the control sample was analyzed chemically to check its makeup and after the casting the samples were also analyzed to check the effect strontium had on the alloys as seen in Table 1. Compositions were melted in a crucible furnace separately in alumina crucible and after crucible were removed from the furnace then modifiers addition followed. The crucibles were taken back to the furnace and furnace temperature raised from 750oC to 800oC because the modifiers suppose not to melt instead form intermetallic phase in the Al-Si alloy. The hardness test was done in accordance with [10, 11]. The techniques to follow for the experiments are:

- i. Pattern making/Moulding
- ii. Casting/Preparation of samples
- iii. Machining
- iv. Characterization and testing

**Table 1.** Chemical analysis of the alloys.

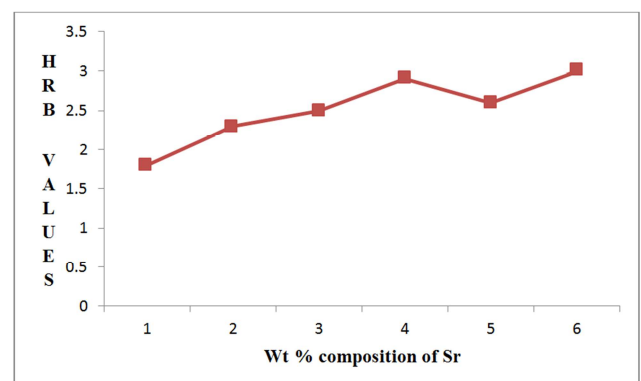
Samples	% Si	% Mn	% Sr	% Fe	% Al
Sample A	11.54	1.0	0.02	0.78	Bal
Sample B	11.55	0.92	0.024	0.73	Bal
Sample C	11.55	1.01	0.026	0.60	Bal
Samples D	11.58	1.00	0.028	0.55	Bal
Sample E	11.56	1.00	0.03	0.48	bal

## 3. Results and Discussions

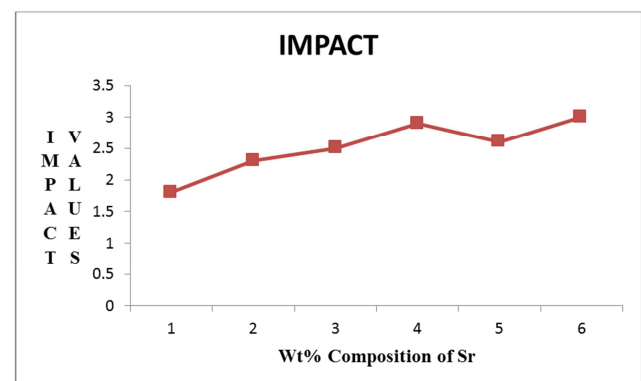
The table and graph below shows the result of the impact of manganese and strontium additions on the hardness and impact strength of Al-12%Si alloy. Table 2 and Figures 1 and 2 showed the result of the hardness and impact strength carried out on the modified Al-Si eutectic alloys.

**Table 2.** Result of impact and hardness test of modified Al-Si eutectic alloy.

Sample	hardness	Impact strength
Sample A	53.5	2.3
Sample B	61.3	2.5
Sample C	59.6	2.9
Sample D	62.2	2.6
Sample E	60	3.0



**Figure 1.** Impact of Sr on the hardness of Al-12%Si alloy.



**Figure 2.** Impact of Sr on the impact strength of Al- 12%Si + 1%Mn alloy.

The addition of Sr increases resilience and durability of the

material up to the point 0.028wt% when addition of Sr tends to decrease the material strength in term of impact load. Figure 2 portrays the impact of addition of Sr on the impact strength. When Sr was added, Al-12%Si alloy increases its fracture energy 2.3 Joule to 2.6 Joule and 3.0 joule. On the other hand, the addition of 0.028Sr tends to decrease the fracture energy of Al-12%Si alloy to 2.1 Joule not withstanding that it equally increased the fracture energy when there was no addition of strontium to the alloy. However, the effect appears to decline as soon as the addition exceeds the 0.026% level which shows negative effect to the mechanical properties because of the presence of some compounds like  $Al_4SrSi_2$  and releases of brittle  $Al_3SrSi_3$  phase are bound to set and coarsening of the eutectic silicon can occur which will reduce the properties of the alloy causing them to revert to values more typical of unmodified material [6].

## 4. Conclusion

The following can be drawn from the research such as when low level of strontium was added the amount of porosity in the alloy modified the eutectic Si morphology from acicular to fine fibrous form with increase in hardness and impact strength. Fine dispersion of silicon particles seen in the alloy changed the structure of the alloy thereby improving the final mechanical properties of Al-Si alloy. Hence it can be seen that addition of strontium produced better and good mechanical properties because of the change in the shape of silicon.

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