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Studies on the Effect of Minor Addition of Sr and Mg on the Microstructure and Mechanical Properties of A413 Alloy

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***Abstract* - In the present work, an attempt has been made to study the effect of minor addition Sr and Mg in the form of master alloys on the microstructure and mechanical properties of A413 alloy. The cast alloys and master alloys were characterized by optical microscopy. The results suggest that the improvement in the mechanical properties of 413 alloy with the individual and combined addition of Mg and Sr when compared to the as cast conditions.**

Key Words: Alloys, Al-20Mg, Al-10Sr, mechanical properties.

1. INTRODUCTION

Among the commercial aluminium alloys, perhaps Al-Si are the most common particularly due to some very attractive characteristics such as high strength to weight ratio, excellent castability, good thermal conductivity and corrosion resistance[1]. Use of Al-Si alloys find applications in automobile, aerospace and general engineering industries. Aluminium-Silicon alloys containing 11-13wt%Si are termed as eutectic alloys and those having less than 11wt%Si are termed as hypoeutectic and those having more than 13wt% are termed as hypereutectic Al-Si alloys[1-3].

The microstructure of A413 alloy contains eutectic mixture (α-Al + eutectic Si). It is well known that normally in the untreated condition A413 alloy is likely to consist of columnar α-Al dendrites and irregular eutectic, as the rate of cooling is faster than the equilibrium cooling[2-3]. It is essential that A413 alloy solidify fine equiaxed α-Al dendrites and silicon. Such a structure ensures improved mechanical properties, improved feeding during solidification, reduced and evenly distributed shrinkage porosity, uniform distribution of second phase particles on a fine scale and good surface finish resulting in improved machinability[1-5]. In the present work an attempt has been made to study the effect of minor addition of Sr and Mg in the form of master alloys on the microstructure and mechanical properties of A413 alloy.

2. EXPERIMENTAL DETAILS

Melting of commercial A413 alloy was carried out in a resistance furnace under a cover flux

(45%NaCl+45%KCl+10%NaF) and the melt was held at 720^{o}C. After degassing with solid hexachloroethane (C_2Cl_6), master alloy chips (Al-10wt%Sr, Al-20wt%Mg) duly packed in an aluminium foil were added for modification. The melt was stirred for 30s with Zircon Coated steel rod after the addition of modifiers, after which no further stirring was carried out. Melt were poured at ‘0’min. and ‘5’ into the cylindrical graphite mould (25mm diameter and 100mm height surrounded by fire clay brick with its top open for pouring (microstructure studies) and also the melt was poured into the split type graphite mould (12.5mm diameter and 125mm height for preparing tensile specimen. ‘0’min. refers to the melt without the addition of modifier. The details of tensile, impact and fracture toughness studies are shown in Table 1. The composition of the cast master alloys were assessed using Atomic Absorption Spectrometer (VARIAN-AA240) and are shown in Table 2. Tensile tests were conducted with computerized universal testing machine (UNITEK-9450) 5 tones capacity; the results of the tensile tests were average of the three reading. Fracture toughness and impact tests conducted were conducted on as cast and modified specimens. Fig.1a-c shows the line diagrams of tensile, impact and fracture toughness specimens

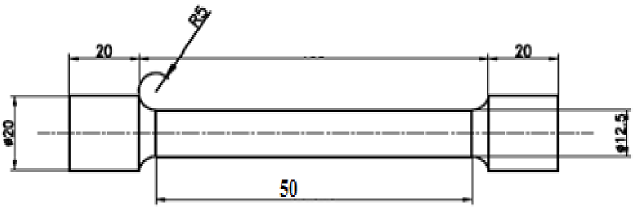
Table1: Details of tensile, impact and fracture toughness studied

Alloy No	Alloy composition	Holding time in minutes
1	A413	0
2	A413 +0.02wt%Sr	5
3	A413+0.02wt% Mg	5
4	A413++0.02wt%10Sr+0.02wt% Mg	5

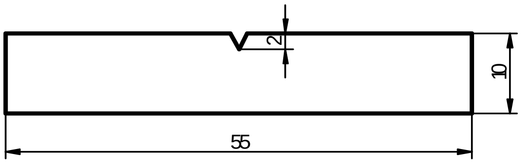
Table2: Chemical composition of cast and master alloys

Alloy composition	Composition (wt%)					
	Si	Mn	Fe	Sr	Mg	Al
A413	11.7	0.50	0.50	-	0.10	Bal
Al-10Sr	0.10	-	-	10	-	Bal
Al-20Mg	-	-	-	20	-	Bal

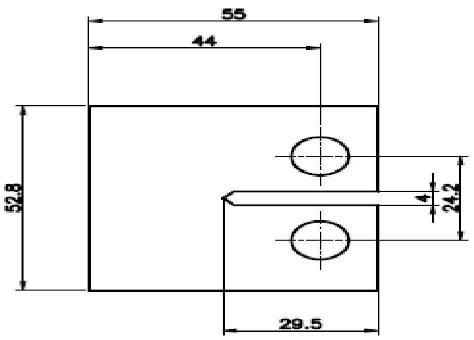
3. SPECIMEN PREPARATION



(a)



(b)



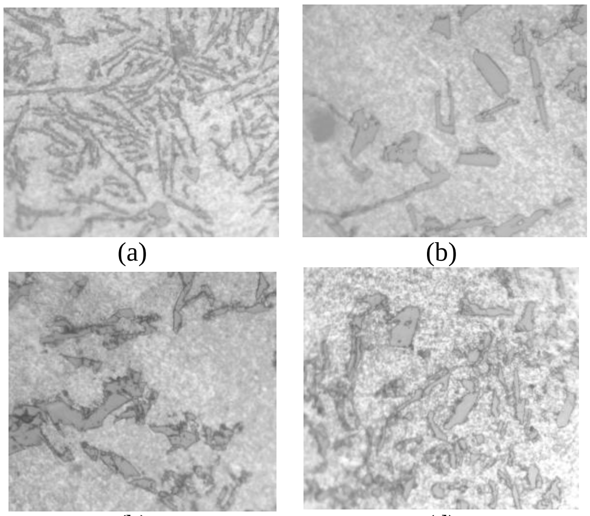
(c)

Fig.1 Line diagram of specimens studied (a) tensile specimen (b) Impact test specimen and (c) Fracture toughness specimen (all dim are in mm)

4. RESULT AND DISCUSSION

4.1Microstructural studies

Fig.2a-d shows the optical photomicrographs of A413 alloy. Fig.2a shows the microstructure of A413 alloy in unmodified condition. The microstructure shows eutectic mixture (α-Al + eutectic Si) with considerable amount of α-Al dendrites and eutectic Si particles in acicular and plate like form. With the addition of 0.02wt% of Sr to A413 alloy marginal changes in eutectic silicon from acicular to course silicon particle was observed (Fig.2b). Fig.2c shows the influence of 0.02wt%Mg on the microstructure of A413 alloy. However, combined addition of Sr and Mg shows conversion of acicular and plate like eutectic silicon to small particles (Fig.2d)



(a) (b)

(b) (d)

Fig.2a-d Shows Optical photomicrographs of A413 alloy at 500X (a) in the absence of master alloys (b) with 0.2wt%(Al-10Sr) (c) with 0.2wt%(Al-20Mg) and (d) with 0.2wt%(Al-10Sr)+ 0.2wt%(Al-20Mg)

4.2 Mechanical Properties

Table 3 shows the influence of modification on the mechanical properties of A413 alloy. From the table it is clear that improvements in mechanical properties of A413 alloy are achieved with the addition of modifiers (Sr and Mg). Results also suggest that, the combined addition of Sr and Mg shows much more improvements in mechanical properties when compared to the individual addition of Sr and Mg and in an unmodified condition. The improvements observed in the mechanical properties were due to the change in microstructure after modification[2-3].

Table 3: Tensile test data of A413 alloy

Alloy No.	0.02%Proof stress	UTS	%E
1	85.5	211	3.45
2	90.0	232	8.41
3	88.0	214	5.68
4	90.0	233	8.48

Table 4 shows the influence of modification on the impact strength of A413 alloy. From the table it is clear that the impact strength remains constant in the cases studied. However further in-depth investigation is necessary to know the influence of individual and or combined addition of Sr and Mg on impact strength of A413 alloy.

Table 4: Impact test data of A413 alloy

Alloy No.	Impact Energy Joules	Impact Strength kJ/m^2
1	2	20
2	2	20
3	2	20
4	2	20

Table 5 shows the effect of minor addition of Sr and Mg on fracture toughness and load bearing capacity of A413 alloy. It is clear that fracture toughness and load bearing capacity increases with the individual and combined addition of Sr and Mg. It is also clear that combined addition shows better results

Table5: Fracture toughness test data of A413 alloy

Alloy No.	Fracture Toughness MPa√m	Maximum load - N
1	15.02	6420
2	17.39	7430
3	20.00	8820
4	22.70	9540

5. CONCLUSIONS

- Proof stress, Ultimate tensile stress and percentage of elongation increases with the individual addition of modifiers (Sr and Mg) to A413 alloy as compared to as cast conditions.

- Combined addition modifiers to A413 alloy show better tensile properties as compared to individual addition and as cast conditions. However the impact strength of as cast and modified alloys remains constant.

- Fracture toughness and load bearing capacity increases with the addition of modifiers due to the changes observed in microstructure.

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