AMMT – 2004
National Conference on Advanced Materials and Manufacturing Techniques, March 08-09, 2004
JTNTU College of Engineering, Hyderabad and CITD, Hyderabad

STRUCTURE AND MORPHOLOGY OF RECYCLED IRON-RICH Al-Si ALLOYS CAST IN THIN-WALLED INVESTMENT SHELL MOULDS

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ABSTRACT: Investment casting shells were used to cast Fe-rich Al-Si alloys. The investment shell moulds were prepared with zirconia flour as a filler material along with colloidal silica binder. The intermediate phases such as $Al_{15}(FeMn)_3Si_2$ and Al_5FeSi would enhance the hardness of Al-Si alloys.

Keywords: *Investment casting, zirconia, colloidal silica binder, iron-rich Al-Si alloy, intermetallic phases.*

1. INTRODUCTION

Today an increasing amount of the aluminum going into producing new aluminum alloy products is coming from recycled products. The main impurities that exist in recycled Al–Si foundry alloys are iron, manganese, copper, and zinc. Iron is considered the most harmful element since its presence enhances the precipitation of many iron intermetallic phases. The presence of additional elements in the Al-Si alloys allows many complex intermetallic phases to form, such as binary phases (e.g. Mg_2Si, Al_2Cu), ternary phases (e.g. β-Al_5FeSi, Al_2CuMg, AlFeMn, $A1_7Cu_4Ni$ and AlFeNi and quaternary phases (e. g. cubic α-$Al1_5(FeMn)_3Si_2$ and $Al_5Cu_2Mg_8Si_6$), all of which may have some solubility for additional elements [1]. Hard and brittle β-Al_5FeSi have detrimental influence on the alloy properties.

The aim of current work was to study the effect of thin-walled investment shell moulds on the structure and morphology of iron-rich hypereutectic Al-Si alloys.

Figure 1: Zirconia investment shell mould.

2. EXPERIMENTAL PROCEDURE

The investment slurry used for making investment shell moulds plays a major role in determining final properties of the mold such as thickness of the shell, permeability and strength. The colloidal silica binder was used to fabricate the investment shell moulds from zirconia flour as reinforced filler material. The silica content in the colloidal silica binder was 30%. Two grades (primary and backup sands) of stuccoing sand were employed in the present investigation. Finer grade silica sand having AFS grain fineness number 120 was employed for primary coats. This is synthetic sand. This sand was used for first two coats, called prime coats to get good surface finish and every detail of the wax pattern. Coarser grade sand having AFS grain fineness number 42 was employed for back up coats. This is river sand. The backup sand was employed to develop more thickness to the shell walls with minimum coats. The thickness of shell moulds were 10 mm. After all coats, the shells were air dried for 24 hours. Two shells of each treatment were made. The Al-Si alloy was melted by recycling the scrap and old products in an electrical resistance furnace under vacuum. The chemical composition was adjusted to get three types of alloys as mentioned in Table 1. The liquid alloy was gravity poured into the pre-heated investment shell moulds. The shell moulds were knocked off by hand hammer after solidification of the molten (figure 1). The castings were cleaned with soft brush and visually inspected for pins and projections [2-18].

Table 1: Chemical composition of iron-rich Al-Si alloys

Alloy	%Si	%Cu	%Fe	%Mn	%Mg	%Ti	%Ni	%Al
Alloy-1	13.0	3.0	0.4	0.6	0.4	0.15	0.2	Balance
Alloy-2	13.0	3.0	0.6	0.6	0.4	0.15	0.2	Balance
Alloy-3	13.0	3.0	0.8	0.6	0.4	0.15	0.2	Balance

The microstructures were analyzed using optical microscope and scanning electron microscopy (SEM). The tensile tests were also conducted universal testing machine.

3. RESULTS AND DISCUSSION

Structural and morphology parameters in Al-Si are vital as the mechanical properties are primarily controlled by the cast structure. Of principal importance are dendrite arm spacing, microstructural phases and grain size. In Fe-rich Al-Si alloy, with 0.3% Fe, α-Fe appears as incomplete Chinese script clusters with sizes below 10µm (figure 2a). When Fe content is 0.6%, fine α-Fe clusters distribute homogenously throughout matrix (figure 2b). Upon increasing Fe content to 0.8%, α-Fe tended to be slender and fiber like structure (figure 2c). Excess Mn may reduce Al_5FeSi phase (figure 3a) and promote formation Fe-rich phases $Al_{15}(FeMn)_3Si_2$. Also, the formation of Al_5FeSi in the Fe-rich Al-Si alloys.

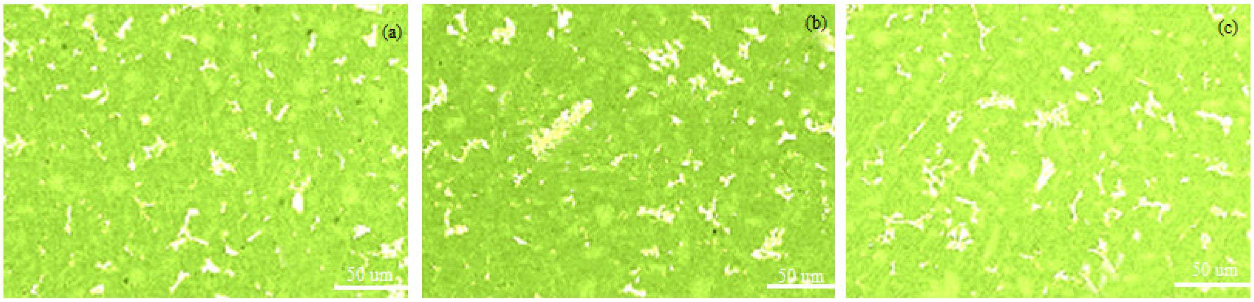

Figure 2: Optical microstructures of Fe-rich Al-Si alloys: (a) 0.4%Fe, (b) 0.6%Fe and (c) 0.8%Fe.

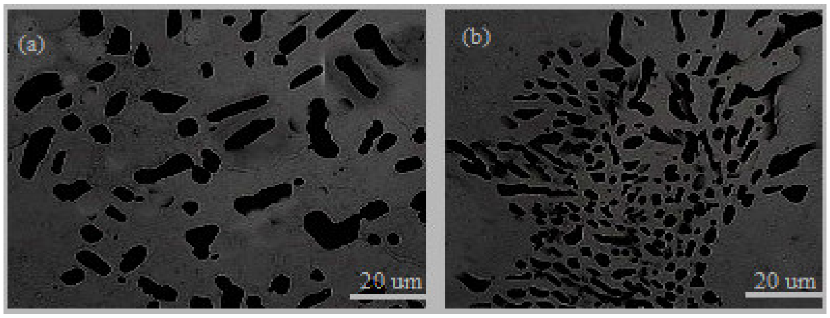

Figure 3: SEM images of Fe-rich Al-Si alloys: (a) $Al_{15}FeSi$ and (c) Al_5FeSi.

The tensile strength decreased with increase of Fe in A-Si alloys as mentioned in Table 2. At the same time, the hardness increased with increase of Fe in A-Si alloys.

Table 2: Effect of Fe on tensile strength of Al-Si alloys

Alloy	Tensile strength, MPa	Brinell hardness, BHN
Alloy-1	282	118
Alloy-2	259	124
Alloy-3	220	132

4. CONCLUSIONS

The scanning electron microstructures reveal the formation intermetallic phases such as $Al_{15}(FeMn)_3Si_2$ and Al_5FeSi. The brittleness has increased with increase Fe content in Al-SI alloys.

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