IMPACT OF BORON COATED INVESTMENT SHELL MOULDS ON SURFACE MODIFICATION OF HYPOEUTECTIC AL-SI ALLOYS

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Abstract: The impact of boron coated investment shell moulds on the surface modification has been investigated. The quantity of delta ferrite was powerfully affected by the steel chemical composition, but less affected by the cooling rate. The increase in mechanical properties were due to the breakage of the elongated primary α-Al grains into more uniformly distributed α-Al grains by refinement and the plate like eutectic silicon to fine broken particles of silicon.

Keywords : Investment casting, hypoeutectic Al-Si alloy, colloidal silica binder, alumina, boron.

1. INTRODUCTION

For Al-Si alloys, the grain refining mechanism has been studied by many researchers. The addition of boron (B) results in the refinement of eutectic silicon phase and that AlB_2 particles act as nucleates for the silicon phase [1]. In another research work, the microstructure and eutectic silicon growth mode of Al–10Si alloys were compared with different B levels [2]. The results appeared that boron did not cause modification of the eutectic silicon, and boron-containing samples display eutectic nucleation and growth characteristics similar to that of unmodified alloys. The said-two works are contradictory one another. The refinement mechanisms are still the subject of research. The other elements such as sodium or strontium were also studied to modify the eutectic silicon in foundry alloys.

The idea behind this work is that the metal-mould reactions are inevitable with the liquid state manufacturing process like casting. Instead of adding boron as a modifier to liquid Al-Si alloy, the boron coating was given as primary coat on the investment shell moulds to improve surface characteristics rather than of core Al-Si alloy. The present work was to investigate the impact of boron coated investment shell moulds on the surface modification of hypoeutectic Al-Si alloys.

2. EXPERIMENTAL PROCEDURE

The chemical compositions of hypoeutectic Al-Si alloy is given in table 1. In the present work, hypoeutectic Al-Si alloy was cast in the investment shell moulds. The colloidal silica binder was used to fabricate the investment shell moulds from alumina as reinforced filler material. The silica content in the colloidal silica binder was 30%. In order to achieve the modification effect on the surface layer of the casting, during preparation of investment shell mould, the suitable content of boron was added: 5, 10, 15% mass in aluminum filler material. 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. Type R (Pt-13%Rh, Pt) thermocouples were inserted into the mold cavity in contact with the steel to measure the cooling curves at different positions during solidification. The hypoeutectic Al-Si alloy was melted in a resistance furnace under vacuum. 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 [3-22].

Table 1: Chemical composition of Ni-base super alloy

Element	Si	Cu	Mg	Fe	Sr	Ti	Mn	Al
Al-Si alloy	7.0	18.9	0.083	0.225	0.076	0.0044	0.932	Balance

Tensile tests were carried out on Universal testing machine according to ASTM E8 [21] standard. Also, Brinell hardness test was carried out to measure the surface hardness of the as-cast samples.

Figure 1: Hypoeutectic Al-Si alloy cast in Boron coated investment shell mould.

3. RESULTS AND DISCUSSION

The microstructures shown in figure 2 show the grain size versus the content of boron. It is evident that at higher level of boron amount, the grain size of Al–7Si alloy decreases rapidly at the surface of the test samples with the increase of boron content in the primary coats. The microstructures in core areas of the test samples are unchanged. The size of eutectic silicon is controlled by the growth condition of silicon phase. The growth of the eutectic silicon phase is limited to the space available between proeutectic dendrites which decrease with the decrease of grain size. With the presence of boron addition, the grain size and the space available between proeutectic dendrites decrease. Thus large silicon plate formation is restrained.

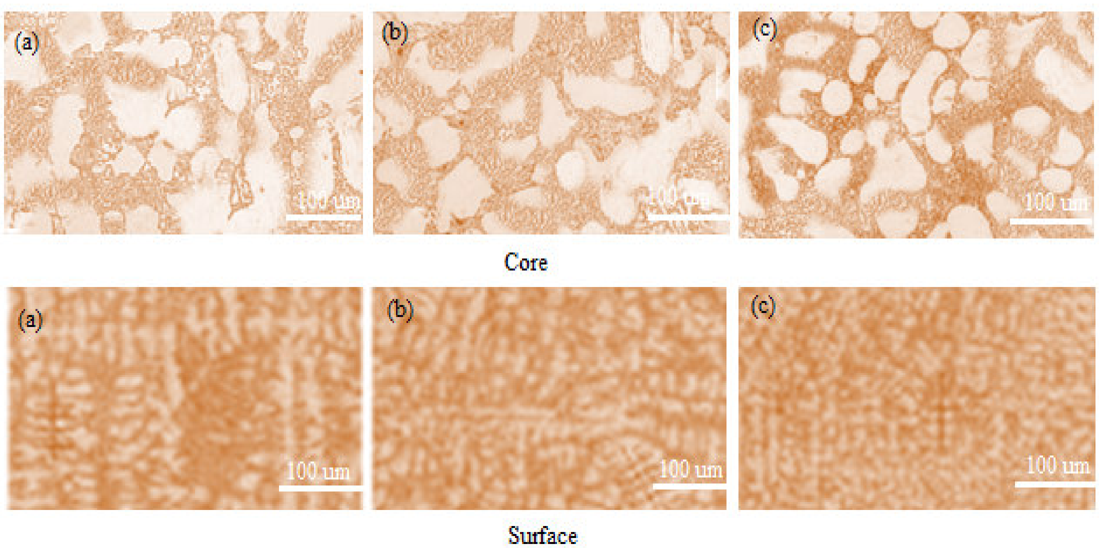

Figure 3: Microstructure of hypoeutectic Al-Si alloy (a) 5%, (b) 10% and (c) 15% B in primary coats of investment shell moulds.

Figure 4: Effect of B content in primary coats on tensile properties of Al-Si alloy

S.No.	Boron content in primary coats, %	UTS, MPa	Surface Hardness, (BHN)	0.2% YS, MPa
1	5	12.88	16.5	8.75
2	10	15.62	21.4	9.68
3	15	19.24	28.6	17.22

The ultimate tensile strength, hardness and yield strength increased with increase of B in the primary coats of investment shell moulds due to fine grains formed on the surface of test specimens.

4. CONCLUSIONS

Mechanical properties of Al–7Si alloy cast in investment shell moulds depend on the shape, size and size distribution of α´-Al grains, silicon particles and $CuAl_2$ phases on the surface of the test samples. The increase in mechanical properties consists of two parts:

- the breakage of the elongated primary α´-Al grains into more uniformly distributed α´-Al grains by refinement
- the plate like eutectic silicon to fine broken particles of silicon.

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