REFINEMENT OF PRIMARY SILICON IN HYPER—EUTECTIC Al—Si ALLOY BY P ADDITIONS PREPARED BY I/M METHOD

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Abstract

Although some experimental investigations have been indicated that the Al—Cu—P alloy prepared by P/M method has good refining effect[1—2], it is certain that the cost of modifier prepared by P/M method is higher. In this work the effect of two addition methods of P on refining the primary silicon has been investigated. The first addition method of P is that of I/M Al—Cu—P alloy, the second was the conventional direct addition of Cu—P alloy.

The results showed that the refining effect of Al—Cu—P modifier prepared by I/M method was much superior to that of Cu—P modifier when they were added to the molten metals and prolonging holding time of molten metals was more effective on refining the primary silicon of hyper—eutectic Al—Si alloy by the addition of Al—Cu—P modifier.

Introduction

Among the various cast aluminum alloys, Al—Si alloys are studied in detail because of their excellent properties, such as high strength to weight ratio, good corrosion resistance, low coefficient of thermal expansion and good bearing properties, etc. Al—Si alloys are widely used in tribological applications, for example, piston, cylinder blocks in internal combustion engines[3]. The major problem met in the founding is that of the coarse primary silicon, the problem can be solved by the modification of P addition to refine the primary silicon. Up to now the modifying agents used in some factories are still Cu—P aloy, amorphous—phosphus, etc. It was reported that the modifier of Al—Cu—P alloy could be prepared by P/M method and the refining effect on the primary silicon of hyper—eutectic Al—Si alloy was more obvious compared with Cu—P alloy, but the process of preparing is too complex and the cost may be increased, so it is necessary to find a more economical road to prepare the modifier. In this paper the I/M method for preparing Al—Cu—P modifier was investigated and the refining effect of the modifier was compared with that of the conventional Cu—P alloy.

Experimental Method

The Al—Cu—P alloy for refining the primary silicon was melted and cast using commercial purity Al and Cu—P master alloy, the chemical compositions of Al—Cu—P and Cu—P alloys are shown in Table 1. The Al—Si alloys added by P were prepared using commercial purity Al (no less than 99.7%), Al—25%Si and Al—50%Cu master alloys. The experimental alloys included Al—18%Si binary alloy and A390 alloy, the chemical compositions of two alloys are shown in Table 2. The alloys were held at 750—760 C for 5 minutes after the Al—Cu—P alloy was added to the molten metals and the die preheating temperature was held at 150—200 C before casting.

Table 1. Chemical compositions of P addition agents

P addition agents	Chemical composition (wt, %)		
	Cu	P	Al
AL—Cu—P	17.1	0.35	Bal.
Cu—P	Bal.	14.6	——

Table 2. Chemical compositions of A390 and Al—18%Si alloys

Materials	Chemical composition (wt, %)								
	Si	Cu	Mg	Fe	Mn	Zn	Ti	Cr	Al
A390	18.0	4.0—5.0	0.4—0.6	0.15	0.01	0.02	0.02	0.00	Bal.
Al—18%Si	18.0	0.02	0.20	0.01	0.02	0.02	0.02	0.00	Bal.

The samples for optical observation were not etched and the sample of Al—Cu—P alloy was etched in 0.5%HF for 60s before SEM observation, small particles in the matrix of etched Al—Cu—P modifier were extracted and observed under SEM.

Results and Discussion

Microstructure of Al—Cu—P Alloy

The optical microstructures and SEM morphology of Al—Cu—P alloy are shown in Fig. 1. It can be seen that bar—shaped particles were present in the matrix in the process of casting.

Fig. 2 shows SEM morphology and the results of EDAX analysis of the bar—shaped particles extracted from the etched sample. The bar—shaped particles were AlP compounds from the EDAX analysis(Fig. 2b).

Fig. 1. Microstructure of Al—Cu—P alloy by optical observation

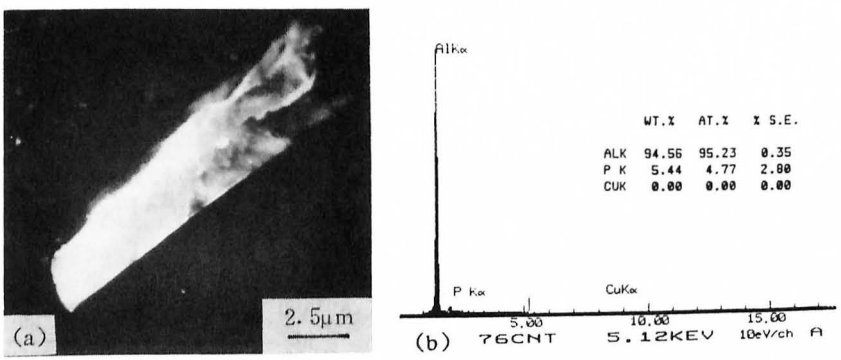

Fig. 2. Observation results of bar—shaped particle from,
(a) SEM morphology (b) EDAX analysis

Examination of Refining Effect

The microstructures of modified and unmodified Al—18%Si binary alloy are given in Fig. 3. In the unmodified alloy the coarse faceted primary silicon crystals were present and their distribution and size were hetergenous. In contract, in the modified alloy by Al—Cu—P alloy the primary silicon crystals were obviously small and their distribution were more homogenous. The results of the experiment indicated that when the content of P addition by Al—Cu—P alloy were changed from 10ppm to 80ppm, the average size of primary silicon would change from 40μm to 25μm. Fig. 4 shows the influence of P content on the average size of primary silicon. It is clear that the average size of primary silicon de creases with increasing content of P addition and the average

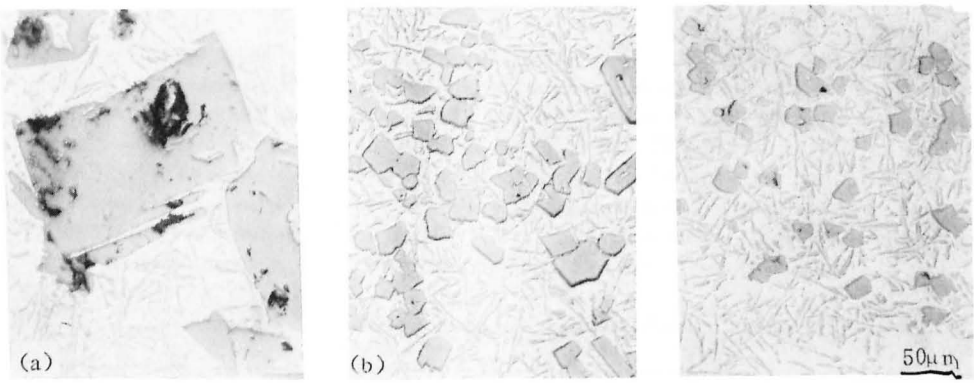

Fig 3. Microstructures of Al—18%Si alloy by Paddition of Al—Cu—P alloy from (a) unmodified (b) 40ppm P addition (c) 80ppm P addition

size of primary silicon nearly became constant when the content of P addition increased to 70ppm. This implied that when the content of P addition increased to a certain degree, the average size of primary silicon would not decrease becaese P did not increase the number of primary Si—crystals.

The results also show that when the holding time was prolonged, the refining effect by P addition of Al—Cu—P alloy was more obvious (Fig. 5). From Fig. 5 the average size of primary silicon decreased with prolonging holding time.

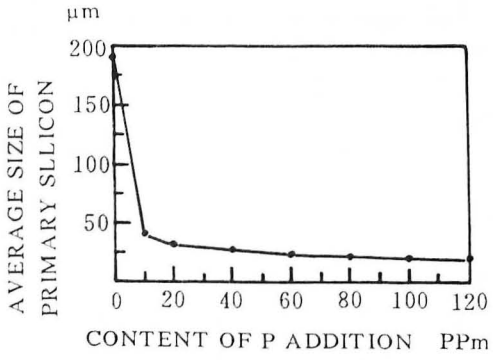

Fig. 4 Influence of the P content on the average size of primary silicon

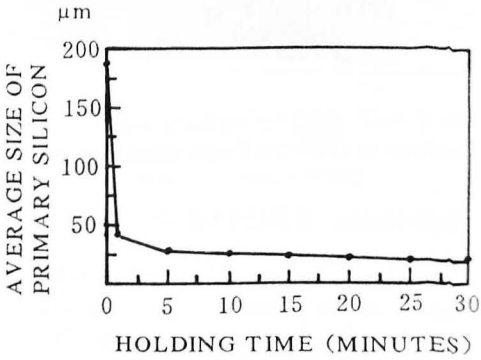

Fig. 5 Influence of the holding time of molten metals on the average size of primary silicon after 70ppm P was added

It seems clear that the modifier of Al－Cu－P alloy was more effective on refining the primary silicon, the reason is that AlP compounds had been formed in the process of preparing Al－Cu－P alloy, they were added to the hyper－eutectic Al－Si alloys to promote nucleation of primary silicon crystals.

The microstructures of A390 alloy are shown in Fig. 6. The results using Al－Cu－P modifier in A390 alloy were similar to that of Al－18%Si binary alloy and the refining effect of Cu－P alloy was not obvious in this study(Fig. 6)

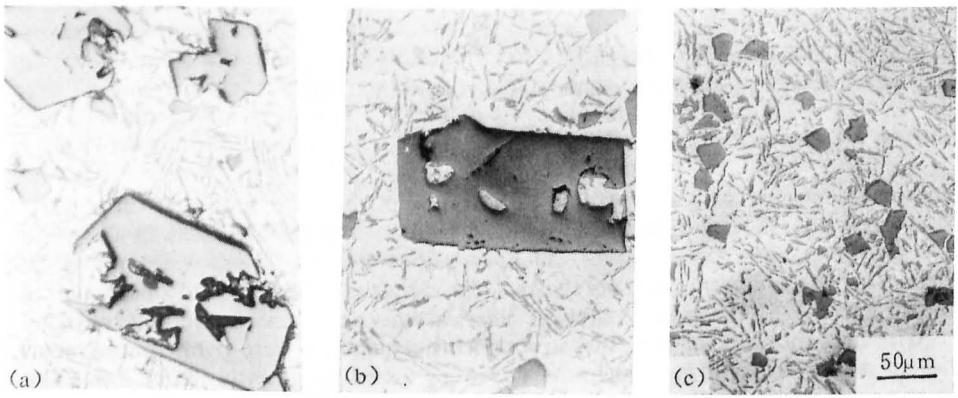

Fig. 6 Microstructures of A390 alloy from, (a) unmodified (b) 80ppm P addition of Cu－P alloy (c) 80ppm P addition of Al－Cu－P alloy

Conclusions

1. Al－Cu－P alloy can be prepared directly by I/M method and AlP compounds are formed in the process of preparing.
2. At the same condition, the refining effect of Al－Cu－P alloy is much superior to that of conventional Cu－P alloy.
3. The average size of primary silicon in Al－18%Si and A390 alloys is less than 30μm when the content of P addition by Al－Cu－P alloy is in the range 60ppm to 80ppm.

References

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