Effect on Hardness and Wear characteristics of Al-20Si alloys by addition of Phosphorous

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***Abstract*—Modification of hypereutectic A1-Si alloys was conducted. The influences of Phosphorus (P), on the mechanical properties of alloys were investigated. The complex modifications of Phosphorus make the coarse block primary silicon obviously refined and the large needle eutectic silicon modified to the fine fibrous or lamella ones. Phosphorus mainly refines the primary silicon, but excess Phosphorus is unfavorable to the refinement of primary silicon. The alloys with the additions of 0.02% P to 0.03 % P have the optimal grain size and the improved mechanical properties, Compared with the unmodified alloy. The hardness is decreased from 81 to 57 by Vickers hardness which in turn increases its plasticity , strength and wear resistance .**

***Index Terms*— hypereutectic AI-Si alloy; wear characteristics; Hardness number**

I. INTRODUCTION

Hypereutectic AI-Si alloys have been widely investigated because of their excellent properties, which Include excellent wear and corrosion resistance, high temperature strength, low coefficient of thermal expansion, good cast performance, and high specific strength. Therefore, the hypereutectic A1-Si alloys are widely used in aeronautic, astronautic, and automobile industries. It has been documented extensively that the microstructure of hypereutectic Al-Si alloys, prepared by conventional casting routines, usually consist of a coarse primary silicon phase in a fibrous eutectic matrix. The brittleness of coarse Si crystals (both eutectic and primary silicon) is the main reason responsible for the poor properties of Al-Si alloys because coarse silicon crystals leads topremature crack initiation and fracture in tension. In order to refine the primary silicon, many methods have been carried into execution, such as high-pressure casting, rapid solidification technique, and melt overheating treatment in the present study; the P complex modification of hypereutectic AI-20% alloys was conducted. The influences of P, on the mechanical properties of hypereutectic Al-20% alloy were investigated.

Objectives of the work

[1] To characterize Al-20 Si ,A1-20 Si+0.02 P, to Al-20 Si+0.15
[2] Measurement of Hardness in Percentage of "P" in "Al-20Si"
[3] To study the wear characteristics of Al-20Si and Al-20Si+002P.

II. EXPERIMENTAL DETAILS

Al -20Si will be prepared via foundry technique . Calculated quantities of commercial Purity aluminium (99.7Wt%purity) and A1-20 Wt% Si master alloy are melted in a resistance furnace under a cover flux (45% NaCl +45% KCL + l0% NaF). The melt is held at 720˚C ± 50˚C . After degassing the melt with solid hexacloroethane (C2Cl6) , CuP chips duly packed in the aluminium foil will be added to the melt for grain refinement . The melt will be stirred for 30 seconds with zircon coated iron rod , after the addition of grain refiner. After which no further stirring will be carried out . Melts will be poured after holding for about 5 minutes into cylindrical graphite mould (25 mm dia and 100 mm height) surrounded by fire clay brick with its top open for pouring. The so prepared samples will be taken for measurement of Hardness and wear characteristics. primary Si particles sizes . With this optimum addition of phosphorous to the melt is noted and will be used for further research work .

Fig1.Casting furnace

Fig3 .Hardness Specimen

PROCESS

A1P and Si are both diamond cubic with very similar lattice parameters 0.542 nm for silicon, 0.545 nm for Alp). When P is added into the melt of hypereutectic A1-Si alloys, the reaction Al+P-AlP takes place in the modification. AlP can act as the inhomogeneous nucleus of primary silicon the refinement of the primary silicon particles in the solidification of hypereutectic A1-Si alloys, which results in particles.

Fig 2 Casting furnace

Fig 4 .Casting Mould

Measurement of Hardness

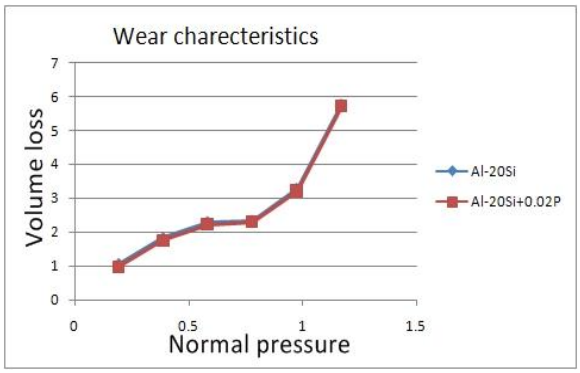
Composition of alloy	Vickers Hardness No.
Al-20Si+ 0P	81
Al-20Si+0.01P	72
Al-20Si+0.02P	65
Al-20Si+0.03P	69
Al-20Si+0.04P	77
Al-20Si+0.05P	81
Al-20Si+0.06P	72
Al-20Si+0.07P	75
Al-20Si+0.08P	57
Al-20Si+0.09P	70
Al-20Si+0.10P	70
Al-20Si+0.11P	67
Al-20Si+0.12P	74
Al-20Si+0.13P	71
Al-20Si+0.14P	64
Al-20Si+0.15P	65

Table (1) Hardness tests for Al-20%Si

Normal pressure(MPa)	Al-20Si	Al-20Si+0.02%P
0.195	1.0584	0.9854
0.39	1.8248	1.7518
0.584	2.2993	2.2263
0.78	2.3358	2.2993
0.975	3.2847	3.2117
1.17	5.7664	5.6934

Table(2)

From the above hardness table it is very much clear that the optimum addition of phosphorous the hardness of the specimen Al-20Si+0.08P. The hardness decreases Vickers hardness number from 81 to 57. And hence there is a decrease in hardness at optimum addition which means as hardness decreases and tensile strength, Plasticity increases.



Graph (1)

Graph(2)

Sliding speed dependant m/min	Al-20Si	Al-20Si+0.02%P
0.942	2.1533	2.0803
1.884	3.2847	3.2117
2.827	1.3139	1.2409
3.768	0.6934	0.5839

Table (3)

By conducting different kinds of test on the prepared samples of Al-20Si , each test is analyzed separately and results are drawn Vickers hardness test has been conducted and observed comparatively less hardness Optimum addition of Phosphorous for Al-20Si is 0.08 % P which is justified by the decrease in hardness from 81 VHN to 57 VHN. Which in turn increases plasticity.

Wear characteristics is also studied by conducting experiments at varying :

1. Normal pressure
2. Sliding speed
3. Sliding distance

III. CONCLUSION

The complex modification of P can obviously modify the primary silicon and the refinement effect of P on the primary silicon is more distinct. The size of primary silicon decreases with increasing P content but the optimum addition of P lies between 0.02% P To 0.08%P. Excess P is unfavorable to the refinement of primary silicon as average particle size increases with addition of more than 0.08%P to the as cast Al-20Si alloy. The optimal refinement effect of primary silicon is obtained when the alloy contains 0.02% to 0.08% P. The mechanical properties of hypereutectic Al-2OSi alloys are improved obviously with the addition of P. When the tested alloys are modified with 0.08% P the hardness is decreased to 57 and the optimal combination of strength and plasticity is obtained. Wear resistance of the as cast Al-20Si is also increased marginally by addition of 0.02% P.Optimum addition of Phosphorous for Al-20Si is 0.08 % P which is justified by the decrease in hardness from 81 VHN to 57 VHN. This in turn increases plasticity

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