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MODIFICATION OF DIE CAST HYPOETECTIC AL-SI ALLOY WITH DIFFERENT SOURCES OF NICKEL AND ITS EFFECT ON MECHANICAL PROPERTIES

Dr. Vandana J. Rao[1*], Chintan Joshi[2], Anuradha Bapat[2] and Manan Kosambia[2]

[1]Associate Professor, [2]UG Students

Department of Metallurgical and Materials Engineering, Faculty of Technology & Engineering, The M.S. University of Baroda, Dandia Bazar, Kalabhavan, Gujarat, India

E-mail: vandana11866@yahoo.co.in (**Corresponding Author*)

Abstract: The mechanical properties of Al-Si alloys are strongly influenced by the size, shape and distribution of Si phase present in the microstructure. In order to improve the mechanical properties these alloys subjected to modification. Normal additions like those that Na, P, Ti B, Sr etc used for this purpose but in present investigation, two sources of Ni like 5wt% $NiCl_2.6H_2O$ and 5wt % $NiCl_2$ added which can alter the microstructure and mechanical properties similarly as the addition of Na, P, Ti, B, Sr etc. The hardness value remains almost same but tensile strength and % elongation improves very well after the additions of 5wt% $NiCl_2.6H_2O$ and 5 wt% $NiCl_2$.

Keywords: Hardness, Microstructure Modification, $Nicl_2.6H_2O$, $NiCl_2$, % Elongation and Tensile Strength

INTRODUCTION

Al-Si alloys are some of the most widely used material for casting domestic, military, automotive and aerospace components [1]. Most of the Al casting alloys contain Si as a major alloying element. Si is eutectic former to control the shrinkage that occurs in casting. The machining of this alloy is difficult because of the presence of hard Si particles [2]. Addition of trace quantities of certain elements like P, Na, Ti, B, Sr [3] to a hypoeutectic Al-Si alloy, transforms the structure of Si phase from a plate like structure to fine fibrous structure [4]. This morphology transformation significantly enhances the mechanical properties and overall performance of the component that made from these alloys [5]. The reason behind this morphology modification may be that the eutectic silicon phase nucleates on the primary aluminum dendrites during solidification of the hypoeutectic alloys and that modifying trace elements inhibit the growth of the eutectic Si phase and thus transforming the morphology of the Si phase from a plate like structure to fibrous [6,7]. This can be achieved by two ways (1) By chemical modification [2,8,9] and (2) Rapid cooling rate called quenching technique [10,11]. However, the main purpose of this work is not to deal with the mechanism involved

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but rather to give information about some other sources that can modify Si morphology in still better way and these sources are $NiCl_2.6H_2O$ and $NiCl_2$.

EXPERIMENTAL WORK

The melt work accomplished in electric resistance heating furnace using commercially pure LM25 alloy. Table 1 shows the chemical composition of the base metal used for experimental work. Chemical analysis confirmed by using spark emission spectroscopy.

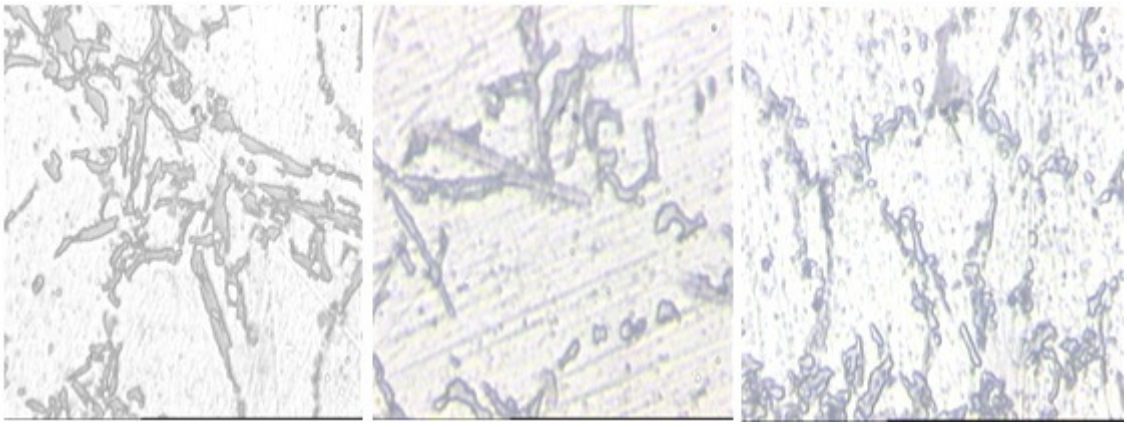
Table 1. Chemical composition of the base metal before modification

Element	Si	Fe	Mn	Cu	Ti	Mg	Ni	Al
%	7.19	0.419	0.06	0.012	0.025	0.39	0.002	Rest

The addition of different sources of Ni like $NiCl_2.6H_2O$ and $NiCl_2$ added to the liquid melt with 5 wt%. The dehydrated $NiCl_2$ sample powder prepared after heating the samples at 120˚C for 10-15 minutes until the color change takes place. The treated melt poured in a metallic die. After solidification, samples were prepared for microstructure, hardness and tensile test. For Microstructural analysis, the samples sectioned transversely and prepared by standard polishing procedure. The microstructure of the specimens observed under optical microscope. Hardness test was carried out on 20mmX10mm long cylindrical bar machined from cast cylindrical bar in the as cast condition using a Brinell hardness tester. Tensile properties of modified and unmodified samples determined by standard test bar machined from a cast cylindrical bar using Monsanto tensometer with a strain rate of 0.05 mm/min.

RESULT AND DISCUSSION

1. MICROSTRUCTURE ANALYSIS



(a)LM 25 As cast (b)LM25+5%$Nicl_26H_20$ (c)LM 25 +5%$NiCl_2$

Fig 1 Optical Microphotograph of untreated and treated samples at 400X without etchant

Fig 1(a) indicates the micrograph of unmodified alloy casting in as cast condition. It shows the microstructure in which eutectic Si phase dispersed in the Al matrix with needle like morphology. Addition of 5-wt % $NiCl_2.6H_2O$ to the alloy cast results in changes in the microstructure of the alloy. Fig 1(b) represents the same. The fig 1(b) indicates that most of the eutectic Si converted into the form of rod and some are broken down in small size particles. Fig 1(c) shows the micrograph of LM25 alloy with 10-wt % $NiCl_2$. Here it is observed that the eutectic Si morphology completely transferred into the small rod structure and remaining are converted into the small size particles located at the edge of the grains.

2. MECHANICAL PROPERTIES

The results of mechanical properties of LM 25 and modified LM25 presented in table 2.

Table 2: Mechanical property comparison of unmodified and modified LM25 alloy

System	Tensile Strength (MPa)	% Elongation	Hardness (BHN)
LM25	130	3	55
LM25+5 wt% $NiCl_2.6H_2O$	175	9	58
LM25+5wt% NiCl2	176	12	55

Addition of 5 wt% $NiCl_2.6H_2O$ and 10 wt% of $NiCl_2$ to alloy produce the highest UTS of 175 MPa and 176 MPa respectively along with %elongation of 9% and 12% respectively. The hardness property of modified alloy becomes almost same as that of the raw LM25 alloy. The increase in tensile property and % elongation is only possible due to the change of the microstructure of the alloy. Absence of sharp edged Si needles controls the elongation property from 3 to approximately 10%. This phenomenon is quite attractive in the cast component. The hydrated $NiCl_2.6H_2O$ offers less % elongation than dehydrated $NiCl_2$.It may be due controlling the % H_2 gas and reducing the chances of porosities.

CONCLUSION

The structural modifications of LM25 with two different sources of Ni and its effects on mechanical properties investigated. The following conclusions made from the experimental results. The dehydrated source of Nickel reduces the chances of hydrogen related porosity and offers best microstructure compared to hydrated source.

1. Sources of Nickel chloride like $NiCl_2.H_2O$ and pure $NiCl_2$ change the morphology of eutectic Si in LM25 alloy. In case of 5wt% $NiCl_2.6H_2O$, the structure shows the rod shape morphology of Si needle and some are present in the form of small sized particles.
2. In case of 10 wt% $NiCl_2$. Structure becomes highly modified and majority of Si needles converted in the form of small sized rods as well as smaller size particles.
3. The dehydrated source of Nickel ($NiCl_2$) gives better elongation (12%) properties than hydrated sources ($NiCl_2.6H_2O$).

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