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Procedia Materials Science 6 (2014) 812 – 820

Procedia Materials Science

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3rd International Conference on Materials Processing and Characterisation (ICMPC 2014)

Optimization of process parameters of Al-Si alloy by centrifugal casting technique using Taguchi design of experiments

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Abstract

In this paper, the influence of process parameters on the mechanical properties during centrifugal casting of aluminum alloy (4600) is studied. Taguchi method of design of experiments was employed to optimize the process parameters and to increase the mechanical properties. The investigation has indicated that increase in pouring temperature reduces mechanical properties while increase in die speed increases mechanical properties and density. Results were analyzed using ANOVA technique to know the percentage of contribution of each casting process parameters. Microstructures were studied under optical microscope and SEM were analyzed with process parameters by correlating with the mechanical properties of as cast structures.

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Selection and peer review under responsibility of the Gokaraju Rangaraju Institute of Engineering and Technology (GRIET)

Keywords: *Centrifugal casting, Mechanical properties, microstructure.*

1. Introduction

Al-Si Alloys are extensively used for Marine 'on deck' castings, water-cooled manifolds and jackets, and intricate castings. The general use of these alloys is the corrosion resistance of marine atmospheres or service conditions, which are especially suitable for castings that are to be casted in defence, aerospace and automobile industries. As it exhibits excellent castability, good corrosion resistance with good mechanical properties these alloys are widely used (Daniel, 1968, Striter 1946).The use of Al casting alloys structural materials are determined by their physical properties and their mechanical properties.

These alloys are strongly influenced by their poly-phase microstructure. i.e., features such as morphologies of dendritic α-Al, Si-particles and either intermetalics that are present in microstructure (Chirita 2008).

To improve the mechanical properties of these alloys either grain refining is to be done by adding grain-refining elements or by using cast technology depending upon particular alloys. Each technology has particular aspects that interface a microstructure and consequently on mechanical properties.

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doi:10.1016/j.mspro.2014.07.098

Traditionally, the centrifugal casting process was mainly used for obtaining cylindrical parts with axisymmetry. There are essentially two basic types of centrifugal casting machines: the horizontal types, which rotate about horizontal axis, and vertical types, which rotate about vertical axis. These are the casting process, which makes use of centrifugal force generated by rotating cylindrical mould to force the molten metal against the mould wall to form the desired shape (Cook, 1980).

However, the problems associated with these castings are unknown to the type of machine, the size of the tube and the type of alloy (Janco, 1988), but the quality of tubular parts obtained during centrifugal casting is strongly influenced by various process parameters like pouring temperature, Die-speed and pre-heat temperature of the mould.

The present investigation is focused on the optimization of process parameter during centrifugal casting of 4600 Al-Si alloy of IS 617:1975 by Taguchi method using Analysis of Variance(ANOVA) which is a statistical tool applied on the results. Taguchi approach is a standardized version of design of experiments (DOE), where systematic approach of design and analysis of the experiments for the improving the quality characteristics is done (Ller, 1988, Ross, 1996). ANOVA was used for analyzing the results of designed experiments.

2. Experimental procedure

2.1 Casting Process

In horizontal centrifugal casting machine, the centrifugal force is generated by a rotating cylindrical mould to throw the metal against the mould wall and form the tubular shape. Here the casting mould is a heat resisting cast iron drum with an inner diameter of 100 mm and a length of 235 mm with mould wall thickness of 28 mm whose cast tubular part. Pro-E 3D model of the horizontal casting machine is shown in Fig 1.

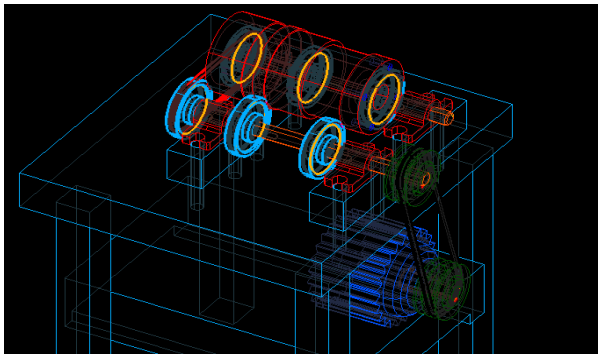

Fig 1: Pro-E 3D Model of Centrifugal Casting Machine

The opening end of the mould was exposed to receive the pouring melt and the closed end was coaxially connected to the shaft of a speed variable motor outside the box. The different types of coatings, which are applied inside the mould, are spirit based graphite coating and water based zirconium silicate coating for good surface finish and easy withdrawal of the casting.

Two different speeds of rotation at 900 and 1440 rpm are been used and recorded with the help of a tachometer placed in front of the drum. The front end of the machine is fixed with a ring cover so that the molten metal is being prevented from splashing. The alloy was prepared in a pit type furnace from commercially pure Al, Si, Mg and Mn. The nominal composition of the alloy is tabulated in table 1.

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