UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF ADDITION OF 5% COPPER IN AL A356 DURING COOLING SLOPE PROCESS

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Manufacturing process) with Honours.

by

MUNIR MUHAMAD MUDA BIN SALIMAN

B071510880

921104-06-5017

FACULTY OF ENGINEERING TECHNOLOGY

2018

Faculty of Mechanical and Manufacturing Engineering Technology

EFFECT OF ADDITION OF 5% COPPER IN AL A356 DURING COOLING SLOPE PROCESS

Munir Muhamad Muda Bin Saliman

Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

2018

EFFECT OF ADDITION OF 5% COPPER IN AL A356 DURING COOLING SLOPE PROCESS

MUNIR MUHAMAD MUDA BIN SALIMAN

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **EFFECT OF ADDITION OF 5% COPPER IN AL A356 DURING COOLING SLOPE PROCESS**

SESI PENGAJIAN: **2018/19 Semester 1**

Saya **MUNIR MUHAMAD MUDA BIN SALIMAN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.

☐ TERHAD (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ SULIT (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:

No. 184 Felda Keratong 4
26900 Bandar Tun Abdul Razak
Pahang Darul Makmur

Cop Rasmi:

Tarikh: _____

Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Effect of Addition of 5% Copper in AL-A356 During Cooling Slope Process” is the results of my own research except as cited in references.

Signature :

Author’s Name : Munir Muhamad Muda Bin Saliman

Date : 1st January 2019

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

……

(En. Zolkarnain Bin Marjom)

(Project Supervisor)

ABSTRAK

Kajian ini adalah mengenai pemprosesan logam semi pepejal aloi aluminum A356 + 5% tembaga menggunakan proses cerun penyejukan. Dalam kajian ini, matlamatnya adalah untuk melihat kesan evolusi mikro struktur dan juga untuk menguji kekerasan dan tegangan aluminum A356 aloi + 5% tembaga selepas menggunakan cerun tuangan penyejuk dan menggunakan terus dituangkan ke tuangan. Semua bahan eksperimen akan dilakukan dengan menggunakan aloi aluminum A356 + 5% Tembaga. Spesimen tulang anjing telah disediakan melalui teknik proses konvensional (as-cast) dan teknik cerun penyejukan dengan pelbagai eksperimen. Separuh sampel tulang anjing dirawat dengan rawatan haba iaitu 540 ° C selama 9 jam, Seterusnya, sepuh lindap kejutan dalam air selama 15 minit. Kesemua sampel kemudian diujikaji oleh mikroskop optik Nikon, ujian kekerasan Rockwell serta ujian tegangan. Untuk kajian ini, hasil yang akan ditunjukkan pada suhu mencurah 700 ° C, panjang cerun penyejukan adalah 400mm dan 300mm, untuk sudut kecondongan adalah 45 darjah dan 60 darjah, aloi A356 + tembaga 5% mempamerkan ciri mikrostruktur sfera kerana semua struktur dendritik telah diubah menjadi globule AL dan rosette setelah di rawatan haba T6. Nilai kekerasan Rockwell diperoleh dari cerun penyejukan akan menjadi kekerasan yang rendah berbanding tuangan konvensional iaitu 32.36 HRB menggunakan rawatan haba T6. Selain itu, pada ujian tegangan, kekuatan tegangan akhir untuk teknik cerun penyejukan C mendapat tinggi pada 197.59 MPA menggunakan rawatan haba T6. Dan hasilnya, cerun penyejukan C mendedahkan hasil positif yang mana CS C memperbaiki sifat pengedaran dan tegangan mikro sebagai menentang tuangan konvensional kecuali ujian kekerasan.

ABSTRACT

This study is about the semi solid metal processing of aluminum A356 alloy + 5% Copper using cooling slope casting. In this study, the goal is to see the effect of microstructural evolution and also to tested the hardness and tensile of aluminum A356 Alloy + 5% Copper after using cooling slope casting and using directly poured to casting. All the experimental material will be accomplished by using aluminum A356 alloy + 5% Copper. The pattern dog bone was prepared through the conventional casting(as-cast) and cooling slope technique with various of experimental. Half of the dog bone sample was treated a heat treatment that is 540° C for 9 hours, Next, faster quenching in water for 15 minutes. All of the samples then characterized by Nikon optical microscope, Rockwell hardness test as well as tensile tests. For the experiment procedure, the result will be revealed that at pouring temperature 700°C, length of cooling slope is 400mm and 300mm, for the tilt angle is 45 degrees and 60 degrees, the A356 alloy +5% copper exhibits the spherical microstructural feature due to all dendritic structures was altered into s AL globule and rosette after heated treatment T6. The Rockwell hardness valued got from cooling slope is lower hardness then conventional casting that is 32.36 HRB. Furthermore, for tensile testing, the ultimate tensile strength for cooling slope C is at 197.59 MPA used heated treatment T6. From the resulted, the cooling slope C revealed the positive resulted which that CS C improved the microstructural distribution and tensile properties as opposed to conventional casting excepted for hardness.

DEDICATIONS

I dedicate this thesis journal to my father Haji Saliman Bin Selamat and to my late mother Hajah Patimah binti Zuriat.

ACKNOWLEDGEMENTS

Alhamdulillah, First and foremost is I would like to thanks to Allah S.W.T for the blessing to enable me completing this thesis in time. Also, I would like to thank my supervisor, En. Zolkarnain Bin Marjom, for their expertise, ideas, feedback, time and encouragement.

I want to express my gratitude to my family especially my parents, and my brothers, also friends, who helped and encouraged me throughout this semester. Special thanks to all the people who along the way believed in me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

D, d	-	Diameter
F	-	Force
g	-	Gravity = 9.81 m/s
I	-	Moment of inersia
1	-	Length
mm	-	Milimeter
m	-	meter
C	-	celcius
CS	-	Cooling slope
OM	-	Optical Microscope
AL	-	Aluminum
Si	-	Silicon

LIST OF ABBREVIATIONS

PCA	Principal Component Analysis
AFS	American Foundrymen's Society
MPA	Mega Pascal

CHAPTER 1

INTRODUCTION

Chapter one introduces the background information of this study and the organization of the thesis. The information in this thesis is organized to disclose the originality of this study. Descriptive information is given on the study: background, problem statement, objectives, significance, scope, limitations and thesis structure.

1.1 Background

Castings produced by a foundry are acceptable if their quality level, as required by the customer's specifications, is found satisfactory. Otherwise, the casting is termed as defective; each casting rejected contributes to the wastage and loss of value to the foundry. A sound casting involves systematic blend of experience and engineering basics. For improving the cast metal yield, we need to optimize the gating system design, optimize mould filling, avoid shrinkage defects, voids, hot tears etc. Casting simulation packages were found to be of immense help in achieving the above said objectives. With the advent of modern computing facilities, application of commercial software, packages such as the casting simulation tools, enable the foundry industry to accomplish successful casting design.(Deore, Chaudhari, Chaturvedi, & Gunjal, 2015)

The Cooling Slope (CS) casting process is the advanced semisolid process which engages with simple equipment and employs low operating cost. Cooling slope method is made by the simple process of pouring the lightly superheated melt down a cooling

slope and consequent solidification in a mould. According to Legoretta et al. (2008), there are several parameters have been highlighted in the cooling slope casting process such as mould material, mould temperature, length of cooling slope, angle of cooling slope, superheat and temperature of pouring molten metal which directly contribute to the final microstructure of the solidified slurry. Granular crystals nucleate and grow on the slope wall and are removed from the wall by fluid motion. In addition, the melt which consists numerous amount of these nuclei crystals, solidifies in the mould or die ensuing to a fine globular microstructure. The size of ingot then is determined by the weight of molten metal and the diameter of the mould. Eventually, the ingots can be utilized directly for rheo thixoprocessing after desirable reheating.

Therefore, this study is focusing on the microstructure result of aluminum alloy type of metal by applying the cooling slope casting process. The microstructural behavior and the mechanical properties of aluminum alloy are to be examined alter the cooling slope process is conducted on this material. The primary crystal of the ingot cast by semisolid casting using the cooling slope becomes globular when the ingot is remelted. Thus, this present study is also to determine the most influential factor that affects the globalization of the primary crystal in this process.

1.2 Statement of the Purpose

The purpose of the research is to investigate the effect of addition 5% copper to A356 alloy during cooling slope process on the mechanical properties such as tensile, hardness and microstructure properties which is % area of porosity, grain size and secondary dendrite arm spacing.

1.3 Problem Statement

In the previous study by Toshio Haga et al.(2001), the effects of melt temperature, contact length between the melt temperature and the cooling slope, and the material used to construct the mould (cooling rate) on the morphology of the primary crystal were investigated. It was observed that cooling slope casting produced more homogenous microstructure than conventionally casting. It was found that the information regarding the parameters which influenced the globalization of a-Al during slope casting is still in shortage. The primary crystal of the ingot used to boost. Since, after many study had issue with porosity and containing many defects at properties aluminum. Then those variations in microstructures are expected to affect the mechanical property of the aluminum alloy. Therefore, by applying good prediction method on the phase development and transformation during solidification of the alloy can be useful in order to attain the desire microstructure through controlling the cooling rate

1.4 Objectives of study

The objectives of this project are:

i. To produce A356 alloy + 5% copper dog bone specimen using cooling slope process.

ii. To determine the mechanical properties Aluminum A356 using tensile and hardness test.

iii. To investigate the microstructure evolution, porosity, grain size and secondary dendrite arm spacing (SDAS) of A356 alloy + 5% copper after cooling slope process.