EFFECT OF MATERIAL STRUCTURE MACHININGCHARACTERISTICS OF HYPEREUTECTIC AL-SI ALLOY

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To My Beloved Mother, Father, Brothers and Sisters

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ABSTRACT

In the present research, experimental results of an investigation of dry turning of hypereutectic aluminium silicon alloy using polycrystalline diamond (PCD) tools are presented. Attention is focused on the effect of workpiece microstructure on the performance of the cutting tools in terms of tool wear, surface roughness and chip formation. The experimental study involves turning operations at three different cutting speeds: 500, 600 and 700 m/min and constant depth of cuts and feed rates. The results obtained showed that PCD tools are important in cutting this hard Al-Si alloy of reduced machinibility. The lowest cutting speed provides good machinibility and surface finish. The change of workpiece structure was induced by modifying the primary Si phase in Al-Si alloy with strontium (Sr). This attempt found that Sr alone does not lead to a significant reduction in the size of primary Si phase. However, the results indicated that if the structure is modified the tool wear improves compared to the unmodified alloy.

ABSTRAK

Penyelidikan ini membentangkan keputusan hasil ujikaji terhadap pemesinan bahan aloi aluminium silicon hipereutektik tanpa menggunakan bahan penyejuk dengan menggunakan mata alat intan polikristal (PCD). Fokus utama adalah untuk melihat kesan mikrostruktur bendakerja terhadap mata alat dari segi kadar kehausan mata alat, kekasaran permukaan dan pembentukkan tatal. Kajian eksperimen melibatkan proses melarik dengan menggunakan tiga tahap kelajuan pemotongan yang berbeza iaitu 500, 600 dan 700 m/min. Kedalaman pemotongan dan kadar uluran adalah tetap. Hasil kajian menunjukkan bahawa mata alat PCD sangat penting kerana ia dapat memudahkan pemesinan aloi AI-Si yang keras ini. Halaju pemotongan yang paling rendah didapati memberikan kadar pemesinan yang paling baik dan hasil permukaan yang licin. pembahan mikrostuktur bendakerja adalah dihasilkan melalui pengubahsuaian fasa utama Si di dalam aloi Al-Si dengan strontium (Sr). Kajian ini mendapati bahawa Sr sahaja tidak memberi kesan yang nyata dalam pengurangan saiz fasa utama Si. Walau bagaimanapun hasil kajian ini menunjukkan bahawa sekiranya struktur ini diubahsuai, maka kadar kehausan mata alat dapat dikurangkan berbanding dengan aloi yang tidak diubahsuai.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Hypereutectic aluminum–silicon (Al–Si) alloys have been used for many lightweight, high-strength applications. A390 is one of hypereutectic Al–Si alloys, with 18wt% Si, and has been used for internal combustion engine parts, cylinder bodies of compressors and pumps, and brake systems, etc., because of its low thermal expansion coefficient, high hardness, and good wear resistance. In hypereutectic Al–Si alloys, the high silicon content, exceeding the eutectic composition (about 12 wt%), is purposely introduced to enhance the wear resistance at high temperatures, however, the excess silicon, in the form of proeutectic silicon grains (order of 10 mm), is hard, highly abrasive, and significantly impact the machinability.

Tool wear in machining of high-Si aluminum alloys has been characterized as abrasion due to scratching of crushed primary Si particles and adhesion/abrasion induced micro-chipping of the cutting edge due to periodic removals of the built-up workpiece material at the tool surface.

The wear mechanisms of PCD are various in machining different materials. Nowadays, the development of construction industry accelerates the increase of man-made boards. Much attention has been focused on the machining of wood based materials by diamond tools.

1.2 Problem statement

The properties of Al- Si alloy are controlled by the reinforcement and the interface. In particular, many of the considerations arising due to fabrication, processing and considerations performance of Al- Si alloy are related to process that take place in the interfacial region between matrix and reinforcement.

A continuing problem with Al- Si alloy is that they are difficult to machine, tool wear is rapid due to the hardness and abrasive nature of the Si and other reinforcing particles. Polycrystalline diamond (PCD) is an exception, as its hardness is approximately three or four times that of the silicon (Si). This is the reason why PCD is recommended by many researchers, who studied the turning of these materials.

Evaluate the performance of Diamond tool become important depends to application of Al- Si alloy to improve their machinability and to obtain economical tool life in machining Al- Si alloy.

1.3 Objective

The main objective of this thesis is to evaluate the influence of work-piece material structure on machining characteristics of hypereutectic Al-Si cast alloy and to examine the type of chips formed during turning of hypereutectic Al-Si cast alloy.

1.4 Scope of the Project

a) Work-piece materials preparation
    - Unmodified hypereutectic Al-Si cast alloy.
    - Sr-Modified hypereutectic Al-Si cast alloy
b) Microstructure Analysis.

c) Evaluate effect of material structure on machining characteristics during turning using diamond tools.

d) Performances the tools are evaluated based on wear and tool life criteria.