EFFECT OF SOAKING TREATMENT ON THE MICROSTRUCTURE AND WEAR BEHAVIOR OF THE ULTRASONIC TREATED B-390 ALUMINUM ALLOY

By

Mona Fadl Abou El Wafa Fadl

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Metallurgical Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

Effect of Soaking Treatment on the Microstructure and Wear Behavior of Ultrasonic Treated B-390 Aluminum Alloy.

Key Words:
Soaking, Hypereutectic Al-Si, Wear, Microstructure, Ultrasonic.

Summary:
Hypereutectic alloys such as B390 alloy exhibit very specific and interesting properties, such as high wear resistance, high strength and hardness, and low thermal expansion coefficients. As a result, they are used in heavy wear applications, often at elevated or medium temperatures, such as in pistons, cylinder blocks and AC compressors. However, their use has always been handicapped by several difficulties: in particular, their high latent heat and consequent long solidification time resulting in die wear, difficulty in avoiding segregation of massive primary silicon particles, and generally their unfavorable shrinkage behavior. In this study SSM and ultrasonic treatment should overcome most of these difficulties. In the first, the ultrasonic treatment most of the silicon plates were disconnected and broken, forming spheroidized crystals. In the second, to study the thixotropic behavior ultrasonically treated and non-treated specimens were used under semi-solid conditions. Semi-solid materials (SSM) are now becoming increasingly popular for the manufacturing of automotive parts.

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Mona Fadl Abou El Wafa Fadl

Table of Contents

List of Tables

List of Figures

Nomenclature

d_t	Particle Size.
d_0	Starting Particle Size.
K	Growth Rate Constant.
t	Soaking Time
LSW	Lifshitz Slyozov and Wanger Relationship
UST	Ultrasonic Treatment.

Abstract

The hypereutectic Al-Si alloys constitute an important family of alloys because of their excellent wear resistance and low thermal expansion. The current work aimed at studying the effect of soaking treatment on the microstructure and wear behavior of the ultrasonic melt-treated B-390 hypereutectic Al-Si alloy. The results showed that the ultrasonic treatment resulted in uniform distribution and refinement of the primary silicon particles. The soaking treatment resulted in coarsening of the primary silicon particles, with larger particles obtained at longer soaking times. It was also observed that particle coalescence is the primary ripening mechanism for the primary Si, especially in the ultrasonic-treated samples. The wear weight loss changed with the soaking time, with the ultrasonic-treated samples exhibiting more consistent trend with little variations of weight loss at different soaking times. The optimum particle size and distribution is obtained after 5 min. soaking of the conventionally cast samples, and 10 min. for the ultrasonic-treated samples. The worn surface of these conditions is characterized by fine and shallow wear scratches with little particle detachments. Soaking at high temperature leads to reducing the volume fraction of the primary silicon, which consequently, caused high weight losses during wear test.

Chapter 1: Introduction

Automotive industry aims at weight reduction to decrease fuel consumption, decrease CO_2 emissions, excellent wear resistance and low thermal expansion. Because of these properties, hypereutectic Al-Si alloys, containing from 14% to 25% Si, are used for applications in cylinder bodies, pumps and brakes system [1].The leading properties of these alloys depend primarily on the morphology and size of the primary Si particles and the eutectic Si. In conventional casting solidified at a moderate cooling rate, the primary silicon crystallizes in the form of hexagonal plates connected together at the center into star-shaped particles. These coarse platelet particles have harmful effect on the mechanical properties of the alloys [2].

These microstructural features can be controlled by the addition of phosphorus as a refiner for the primary Si and modifiers such as Sr or Na for the eutectic Si and/or by controlling cooling rate encountered during solidification. However, the addition of both agents, i.e., refiners and modifiers, leads to counteracting effects because of their chemical incompatibility, which leads to the formation of strontium and sodium phosphides, with evident weakening of both additions. Consequently, other techniques are used for primary Si refining in the hypereutectic Al-Si cast alloys, which has no interaction with the eutectic Si modification. The ultrasonic treatment (UST) was proven to be an effective method for this function. The ultrasonic treatment exhibits potential effects in refining the primary Si and Fe-intermetallic phases in hypo- and hyper-eutectic Al-Si alloys, as well [3,4].

It was also found that the use of ultrasonic in the manufacture of billets for thixocasting is beneficial, since the UST produces a much slower-growing aluminum grains during soaking treatment, with a uniquely very small amount of entrapped eutectic, giving a merit of better formability in the semisolid state [5].

In addition, the advantage of ultrasonic treatment in preparing ingots of hyper-eutectic Al-Si alloys with improved deformation in the semi-solid state was previously reported [6, 7].

Based on this, the objectives of the current study are to investigate the effect of soaking treatment, which is the first step in thixocasting, on the microstructure and wear behavior of ultrasonic-treated and untreated ingots of the B390 hypereutectic Al-Si alloy. These objectives were achieved through wear testing and metallographic studies on optical microscope.