FINAL PROJECT

MATERIAL AND FORMING ENGINEERING

The Effect of Thermo-Mechanical Fatigue on Mechanical Properties of Not Peened (NP) and Shot Peened (SP) Materials

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By:

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ABSTRACT

The influence of NP and SP on mechanical properties of cast aluminum alloy, AC4CH, has been investigated. A servo electro hydraulic machine was used for thermo-mechanical fatigue test. A triangular thermo-mechanical loading was applied in strain-control between an applied mechanical strain range of 1.0% and 0.75% by a temperature range of 323-523K during 400 sec/cycles. It was generally seen that the fatigue life of NP is 27% higher than SP in range of mechanical strain 0.75%. The micro Vickers hardness of SP was 14% higher than NP material in nearest surface before and after thermo-mechanical fatigue. However, the micro-Vickers hardness, tensile and yield strength after the material applied thermo-mechanical fatigue trend are almost similar. The grain boundary of SP was found refiner than NP material before thermo-mechanical fatigue by Ga wetting. However, after fracture specimen, the grain boundary of the both specimens can not be seen. Only coarsening of dendrite structure and Si particles can be found.

CHAPTER 1
INTRODUCTION

1.1. Background of the Research

Application of Aluminum alloy has been found in a variety of uses, especially in automobile engine and aircraft industries. The primary reason for using aluminum alloy is due to its characteristics such as high corrosion resistance, good workability, excellent mechanical properties and light in weight.

The automotive use of cast aluminum alloy has greatly increased during the past decade in automotive structural applications, especially for elevated temperature applications in order to reduce weight.

The cast aluminum alloy tested was JIS AC4CH, which is used as a material for mechanical parts, where both lightness in weight and strength are required. The aluminum alloy JIS AC4CH is similar material with ASTM A356.0.

Repeated engine start-up and shut down operations subject components to cyclic strains which are generated both thermally and mechanically. Thermo-mechanical fatigue (TMF) refers to the damage induced by simultaneously alternating temperature and mechanical loads. TMF loading occurs in hot exhaust of automobile engine. The stress-strain responses of materials under TMF conditions are complex and depend on phasing between thermal and mechanical loads. Therefore, high intensity and quality of heatproof of fatigue improvement is required [1-3]. Thermo-mechanical fatigue cycles cause micro structural material damage to the components, and lead ultimately to fatigue crack initiation and failure. The influence of porosity on the fatigue properties for cast aluminum has been investigated earlier [4] and it is generally accepted that fatigue strength is decreased by the presence of porosity hence it will affect fatigue life. Advanced high temperature fatigue life prediction methodologies are needed to decide when to replace engine components, in order to increase reliability and service life, and reduce maintenance costs.

1.2. Objectives of the Research

This research aims to determine fatigue life and to get grain boundary by using Gallium wetting in the surface by mechanical strain range 0.75%. And also to determine mechanical properties by mechanical strain range 1.0% of material SP and NP cast aluminum alloy, AC4CH after thermo-mechanical fatigue testing, respectively.

1.3. Scopes

- ✓ Used material cast aluminum alloy, AC4CH as material tested
- ✓ Mechanical strain range is 0.75% for to determine fatigue life and mechanical strain range is 1.0% for to determine mechanical properties of NP and SP materials
- ✓ Specimen shape is cylinder

1.4. Structure of the Thesis

The content of the thesis are presented in five chapters composed as follow:

Chapter 1 contains background of the research, objectives of the research, scopes and outline of the thesis.

Chapter 2 deals with literature review and theory about objectives of the research. The theory is related material and thermo-mechanical fatigue which related by this research.

Chapter 3 contains test material, procedures of process and equipment is used.

Chapter 4 deal with results and discussions of all process

Chapter 5 conclusion is presented.

References

CHAPTER 5
CONCLUSION

Thermo-mechanical fatigue test has been conducted in order to investigate the fatigue life and mechanical properties of material SP and NP. The fatigue life of the too materials were observed in a range of 0.75% of mechanical strain. The finding is the fatigue life of NP in 0.75% of mechanical strain was higher than that of SP, even though previous research showed opposite results when the tests were conducted for mechanical strain in a range of equal or greater than 1.0%. However, the fatigue life of SP increased about 29%.

Tensile strength, 0.2% proof stress and elongation were observed for material SP and NP in a range of 1.0% of mechanical strain. The number of cycles applied to material during the thermo-mechanical fatigue test correlated oppositely with the stress and the strain of the material. The increase of the number of cycles applied to the material would lower it's the tensile strength, 0.2% proof stress and elongation. Comparison of tensile test was made between tensile tests of material SP and NP. The tensile strength of both NP and SP increased gradually during TMF.

Thermo-mechanical fatigue would lower the micro-Vickers hardness for material SP and NP. In addition, the number of cycles contributed also in lowering the micro-Vickers hardness of material. The number of cycles of material SP and NP corresponded in reverse with the micro-Vickers hardness.

With current method in which the microstructure of materials observed using Ga wetting, the grain boundary were hardly to bee seen. It is recommended to expand the investigation using more precise methods such as electron etching, Baker's liquid etc. Those phenomenon attributed to over-aging due to coarsening precipitate.

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