AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Design and Production Engineering

The Effect of Additives on Structure-Properties Relations of Aluminum Bronze Alloys

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Design and Production Engineering)

by

Ahmad Majed Ashraf Abdel Fattah Ibrahim

Bachelor of Science in Mechanical Engineering
(Manufacturing Engineering)
Faculty of Engineering, Ain-Shams University, 2014

Supervised By

Prof. Dr. Nahed El Mahallawy
Design and Production Engineering, Ain Shams University

Prof. Dr. Moustafa Gouda
Mechanical Engineering, The Higher Institute for Engineering Technology

Cairo – (2019)

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Design and Production Engineering

The Effect of Additives on Structure-Properties Relations of Aluminum Bronze Alloys

by

Ahmad Majed Ashraf Abdel Fattah Ibrahim

Bachelor of Science in Mechanical Engineering
(Manufacturing Engineering)
Faculty of Engineering, Ain-Shams University, 2014

Supervising Committee

Name	Signature
Prof. Dr. Nahed El Mahallawy	…….
Prof. Dr. Moustafa Gouda	…….

Date: June 2019

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Design and Production Engineering

The Effect of Additives on Structure-Properties Relations of Aluminum Bronze Alloys

by

Ahmad Majed Ashraf Abdel Fattah Ibrahim

Bachelor of Science in Mechanical Engineering
(Manufacturing Engineering)
Faculty of Engineering, Ain-Shams University, 2014

Examiners' Committee

Name and Affiliation	**Signature**
Prof. Dr. Nahed El Mahallawy	
Prof. Dr. Ahmad Refaat El Dessouky El Sissy	
Prof. Dr. Waleed Mohamed Abdel Aziz Khalifa	

Date: 29 July 2019

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain Shams University.
The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Ahmad Majed Ashraf Abdel Fattah Ibrahim

Signature

……...…….

Date: 29 July 2019

Researcher Data

Name	: Ahmad Majed Ashraf Ibrahim
Date of birth	: 10.06.1992
Place of birth	: Heliopolis, Cairo
Last academic degree	: B.Sc. in Mechanical Engineering
Field of specialization	: Manufacturing Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: 06.2014
Current job	: Teaching Assistant at GUC, Cairo

Acknowledgment

Firstly, I would like to express my sincere gratitude to my supervisor Prof. Dr. Nahed El Mahallawy for the continuous support of my study and related research for her patience, motivation, and immense knowledge. Her guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my M.Sc. degree. I would like to thank Prof. Dr. Moustafa Gouda for his teachings, guidance, and support. His rich knowledge enlightened me through this research adventure. My sincere thanks to Eng. Osama Lotfy, CEO of Misr for Copper products, who provided me with technical and financial support. I thank Eng. Shahenda Abouelnasr and Eng. Kareem Salama for their assistance and not to forget all the fun we had. My genuine gratefulness for Tech. Fawzy, Tech. Ashraf, and Tech. Mohamed Ibrahim for their continuous cooperation, innovation and efficient implementation of new creative ideas. Last but not least, I would like to thank my family: my parents and to my brother and sister for supporting me spiritually throughout writing this thesis and my life in general.

Abstract

The following research investigates the application of a relatively novel technique for transforming the microstructure and surface properties of a copper alloy. The technique is based on friction and stirring mechanisms that cause heat generation and material mixing. The effect of process parameters, such as; rotation speed, traverse speed, forced convection were investigated in this research. The following treatments were used 800/40, 800/64, 800/93, 1000/93, 1200/93 with and without the application of air cooling of 4.5m^3/min. The minimum grain size of 1.9μm at 800/93/AIR. The highest β' phase % was achieved at 800/40/AIR. The highest average hardness value was achieved at 1200/93/AIR. The air cooling prevented post-recrystallization grain growth, increased the β' phase %, and enhanced the hardness values. The NiAl Bronze alloy matrix reinforced with SiC particles was successfully achieved. NAB/(9.7%SiC+0.24%WC) surface composite layer was achieved through the groove filling method. The effect of incorporation of SiC particles on microstructure and hardness of the NAB alloy was investigated in this research. Other dispersion methods were also studied. SiC particles were dispersed to the sample surface using groove, hole, and surface coating methods. The minimum grain size and maximum hardness values were 2.6μm and 288 HV5. These results were achieved by FSP-Groove.

Keywords: Aluminum bronze, NAB, NAB/SiC, MMC, microstructure, Silicon carbide reinforcement, recrystallization, friction stir processing, hardness, thermal analysis, optical analysis.

Table of Contents

List of Figures

List of Tables

List of Equations

List of Abbreviations

AB	: Aluminum Bronze
BM	: Base Metal
CTE	: Coefficient of Thermal Expansion
DRX	: Dynamic Recrystallization
FSA	: Friction Stir Alloying
FSP	: Friction Stir Processing
FSW	: Friction Stir Welding
IMC	: Intermetallic Compounds
MMC	: Metal Matrix Composite
NAB	: Nickel Aluminum Bronze
PSN	: Particle-Stimulated Nucleation
SPD	: Severe Plastic Deformation
SZ	: Stir Zone
SMMC	: Surface Metal Matrix Composite
SCMC	: Surface Copper Matrix Composite
UTS	: Ultimate Tensile Strength