UNIVERSITI TEKNOLOGI MARA

MICROSTRUCTURAL AND MECHANICAL PROPERTIES OF WELDED Ti-15-3 BETA TITANIUM ALLOY USING GTAW WITH BORON-MODIFIED FILLERS

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ABSTRACT

Mechanical properties of titanium alloys are dictated by their microstructure, particularly the size, shape and distribution of hexagonally close-packed (hcp) α and body-centred cubic (bcc) β phases. For metastable β titanium alloys the morphology and distribution of α precipitates have largely contributed to its mechanical properties. Welded zones in gas tungsten arc welding (GTAW) of metastable β titanium alloys exhibit retained β structure with inferior mechanical properties due to coarse columnar prior β grains and lack of α precipitates in the matrix in as-welded condition. In this work refinement of prior β grains and α was achieved in GTAW welds of metastable β titanium alloy, Ti-15V-3Cr-3Al-3Sn (Ti-15-3) by current pulsing and modification of welding fillers. Autogenous pulsed current GTAW were performed at 0, 2, 4 and 6 Hz pulsing frequencies to determine optimum frequency for pulsed current welding of thin plates Ti-15-3 alloy. Welding of Ti-15-3 alloy using commercially pure α titanium (CP-Ti) alloy filler resulted in the precipitation of α phase from β phase during cooling to ambient temperature due to dilution of melted base metal with the filler metal. The GTAW welds with CP-Ti filler exhibit high hardness, higher tensile strength but lower % strain as compared to the autogenous weld owing to precipitation of α phase precipitation at β grain boundaries. Addition of 0.5 wt.% and 1.0 wt.% boron to CP-Ti fillers resulted in significantly refined fusion zone β grains in welds with CP-Ti-0.5B and CP-Ti-1.0B fillers due to growth restriction mechanism associated with partitioning of boron during solidification. X-ray diffraction (XRD) analysis of autogenous welds showed only bcc β-Ti phase while indexed peaks for the weld samples with CP-Ti filler showed the presence of very small hcp α-Ti phase along with bcc β-Ti phase. Welds with CP-Ti-0.5B and CP-Ti-1.0B fillers showed additional orthorhombic TiB peaks. Mechanical tests show that hardness of the fusion zone and tensile strength in welds with boron-added CP-Ti fillers are higher than that in autogenous welds and welds with CP-Ti filler. Post-weld heat treatment (PWHT) of the welded samples increased α precipitation in all samples while FESEM and TEM analysis of the fusion zones showed α with higher aspect ratios in aged welds with boron-added CP-Ti fillers than autogenous weld and weld with CP-Ti filler, attributed to the additional nucleation sites provided by increase in boundary area of refined prior β grains with the addition of boron. PWHT weldments displayed higher hardness values, compared to similar regions in as-welded samples, and higher tensile strength after aging.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xv
LIST OF ABBREVIATIONS	xv
CHAPTER ONE: INTRODUCTION	1
1.1. Background of Study	1
1.2. Problem Statement	1
1.3. Research Objectives	6
1.4. Scope and Limitations of Research	6
1.5. Significance of Study	7
CHAPTER TWO: LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Solidification of Titanium	8
2.3 Titanium Alloys Phase Diagrams	9
2.4 Phase Transformations in Titanium Alloys	10
2.5 Classification of Titanium Alloys	12
2.5.1 α Alloys	12
2.5.2 $\alpha + \beta$ Alloys	13
2.5.3 β Alloys	13
2.6 Ti-15-3 Alloy	13
2.7 Titanium- Boron (Ti-B) System	14
2.8 Grain Refinement Mechanism by Boron Addition	16
2.9 Boron Additions to Titanium Alloys	21