PHD REPORT

TITLE: THE DIFFERENT HEAT TREATMENT EFFECTS FOR THE NITRIDATION EFFICIENCY OF THE 3D PRINTED TITANIUM ALLOY

Presented By : Minhalina Binti Ahmad Buhairi

Supervised By : Tünde Kovács & Dr László Tóth

Obuda University | Semester I (23/24)

OVERVIEW

- Introduction
- Literature Review
- Problem Statement
- Objectives
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- Research Plan
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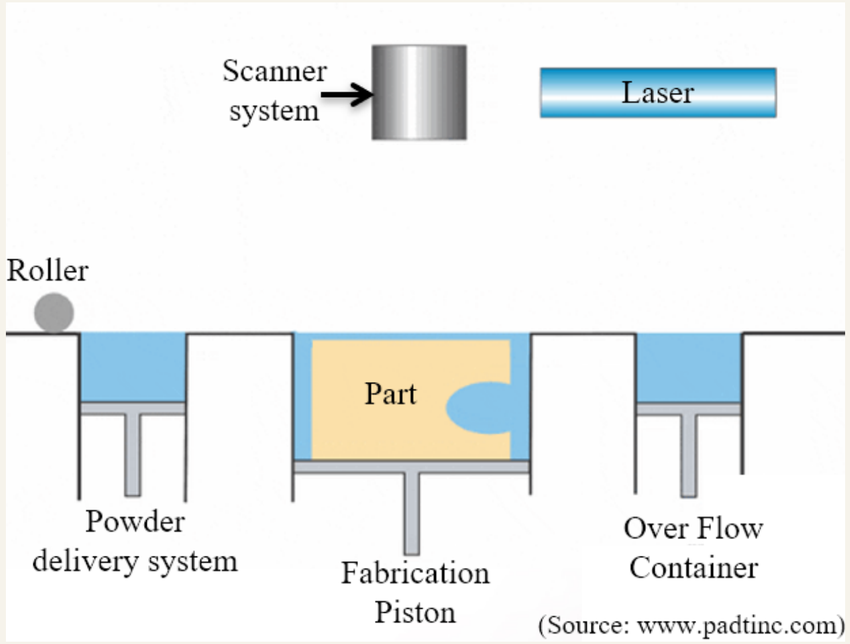
- Future Work

INTRODUCTION

- 3D printing – a process of joining materials, layer by layer, to produce objects or components based on the CAD data
- Ti6Al4V is commonly used – limitation in wear and corrosion resistance
- Thermochemical surface treatment is needed – nitriding

SLM process



LITERATURE REVIEW

Authors (year)	Material	Parameters	Summary	Limitation (s)
Luo et al. (2023)	Ti6Al4V	- electrode: Ti6Al4V, platinum sheet and saturated calomel electrode - in simulated body fluid	- corrosion resistance improved by increasing scanning rate and laser power (high laser power reduces anodic corrosion tendency) within a certain range - best corrosion resistance (3.16MΩ.cm2): P (240W) & V (1200mm/s)	- poor corrosion resistance due to rapid melting and solidification - unfused holes and pores reduce corrosion resistance
Wu et al. (2019)	Ti6Al4V	- electrode: Ti6Al4V, Ag/AgCl, platinum film - composition: NaCl 0.137M, KCl 5.4mM, NaHCO3 4.2 mM, MgSO4 1.0mM, KH2PO4 0.44 mM, CaCl2 1.3 mM, Na2HPO4 0.25 mM	- Ecorr decreased initially with electropolishing treatment, then increased with prolonged electropolishing - Icorr decreased with decreasing surface roughness (slower corrosion reaction) OCP curves become smoother with increasing immersion time, indicating passive film formation	- over electropolishing can induce nano pitting and degrade bio-corrosion performance

LITERATURE REVIEW

Authors (year)	Material	Parameters	Summary	Limitation (s)
Raju & Biswas (2023)	Ti6Al4V	- electrode: Ti6Al4V, platinum, Ag/AgCl - composition: NaCl 7.996g, NaHCO3 0.350g, KCl 0.224g, K2HPO4.3H2O (0.228g), MgCl2.6H2O 0.305g, 1M-HCL 40ml, CaCl2 0.278g, Na2SO4 0.071g, (CH2OH)3CNH2 6.057g	- compared untreated samples with anodized samples & corrosion resistance improved by 2 times (anodic oxidation produced nanotubular oxide layer) - corrosion products: Al2O3, TiO2, V2O5	- anodized samples show improved corrosion resistance compared to polished samples
Sharp et al. (2022)	Ti6Al4V	- electrode: Ti6Al4V, platinum mesh, Ag/AgCl - in phosphate buffer saline solution	- 60% porous gyroid samples has lowest resistance to corrosion and increased susceptibility to pitting -corrosion initiate and focus on the corners and raised edges of most samples; while for porous samples, distinct and isolated patches of corrosion across the surface	- cyclic potentiodynamic polarisation (CPP) testing does not account for movement at modular joints resulting in fretting corrosion

PROBLEM STATEMENT

Challenges arise concerning the wear and corrosion resistance of 3D-printed Ti6Al4V alloy, which affects the alloy's potential for use in crucial industries like the military and medical. Enhancing these characteristics is necessary to fully utilize 3D-printed Ti6Al4V.

First Problem

Corrosion resistance of 3D printed Ti6Al4V alloy is insufficient in hostile media

Second Problem

Lack of comprehensive understanding on the relationship between 3D printing parameters and the nitridation capability

OBJECTIVES

Objective 1

To study the suitable heat treatment processes for 3D-printed Ti6Al4V alloy via selective laser melting (SLM)

Objective 2

To evaluate the effects of nitridation on the microstructure and mechanical properties of heat-treated samples

Objective 3

To analyze the relationship between phase transformation and nitridation efficiency of 3D-printed Ti6Al4V alloy

Objective 4

To optimize technological parameters to obtain suitable mechanical and tribological properties of 3D-printed Ti6Al4V parts

RESEARCH SCOPE

- Addresses the challenges of corrosion resistance associated with Ti6Al4V
- Investigates the application of thermochemical surface treatments, specifically nitriding, to enhance wear resistance and anticorrosion properties
- Understanding the relationship between 3D printing parameters and nitridation capability

RESEARCH PLAN

- Semester I -Literature review on corrosion resistance
- Semester 2 - Experimental heat treatment based on literature

- Semester 3 -Nitridation experiments on heat treated
- Semester 4 - Analysis on heat treatment and nitridation

- Semester 5 -Validation experiment using optimal parameter
- Semester 6 - Control study

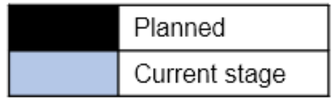
- Semester 7 -Thesis writing
- Semester 8 - Public defense

EXPECTED OUTCOMES

- Determination of the heat treatment parameters of the titanium alloy to achieve the wanted phases
- Relationship between the diffusion path length and the phase state of the titanium alloy during nitriding
- Relationship between the hardness and corrosion resistance achieved by nitriding
- Determination of the optimal microstructure for the properties to be achieved

GANTT CHART

Duration of Study: 4 years (9/2023 – 6/2027)



Gantt Chart	2023		2024				2025				2026				2027	
	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6
Literature review																
Heat treatment processes on 3D printed Ti6Al4V alloy																
Nitridation experiments on heat treated samples																
Parameters optimization based on relationship between heat treatment and nitridation efficiency																
Publication and conference																
Thesis writing																

Semester I (23/24)

FUTURE WORK

- Literature review on heat treatment of 3D printed Ti6Al4V alloy
- Heat treatment process of alloy
- Corrosion test on heat treated samples

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THANK YOU

Presented By : Minhalina Binti Ahmad Buhairi