CHAPTER 1
INTRODUCTION

1.1 Background

The International Labor Organization (ILO) reports that 2.78 million workers die each year due to occupational accidents and occupational diseases. Around 2.4 million (86.3%) of these deaths were due to occupational diseases, while more than 380,000 (13.7%) were due to work accidents. Work accidents that occur can cause various kinds of organ damage, including fractures [1]. To restore the position of the broken bone to its original anatomical condition and maintain that position until the healing process occurs, the thing that can be done is the installation of implants. Treatment of fractures using implants is considered quite effective in accelerating the growth of new bone tissue [2] . The materials used for orthopedic implants, especially for load-bearing applications, should possess excellent biocompatibility, superior corrosion resistance in the body environment, excellent combination of high strength and low modulus, high fatigue and wear resistance, high ductility, and be without cytotoxicity [3].

Materials that are usually used as bone implants are metals such as stainless steel, Co-Cr alloys, and titanium and their alloys [4]. Pure titanium and its alloys have better biocompatibility and biomechanical properties than other metals and are biologically inert, while stainless steel and cobalt chromium have lower biocompatibility and corrosion resistance than titanium. Pure titanium and its alloys have better biocompatibility and biomechanical properties than other metals and are biologically inert, while stainless steel and cobalt chromium have lower biocompatibility and corrosion resistance than titanium [5].

Pure titanium has mechanical properties that match human bone, which is lightweight, has a low modulus of elasticity, and has high strength [6]. As an implant material, titanium alloy has better performance than pure titanium. Titanium alloys have better mechanical properties due to the formation of a solid solution by the alloying metals [7]. Ti–29Nb–13Ta-4.6Zr (TNTZ) is a β-type titanium alloy that designed for orthopedic implant application. This material has superior mechanical properties such as high strength to work on load bearing or dynamic bearing, elasticity that is close to the human bone, contained non-toxic materials, and biocompatible [8]. However, as an implant material, TNTZ still has a drawback: it is not bioactive. The bioactivity of the implant material is required to accelerate bone growth after implantation and to form good osseointegration [9].

The way that can be done to give TNTZ bioactive properties is to coat it with bioactive materials. The bioactive material that is suitable for use as a coating is hydroxyapatite (HA). This is because HA is the main compound that makes up the human bone with high biocompatibility [10]. Current techniques that are used in the coating of HA onto metallic substrates. The coating was carried out in a previous study using the electrophoretic deposition method. Indicates the presence of agglomeration of HA particles so that it occurs in several surface areas of TNTZ. Moreover, limitations of the technique include low adhesion strength and cracking on the coated surface due to post-process shrinkage [11]. The bond strength between the coating layer and the metal substrate is critical. The weak bonding strength will decrease the value of osseointegration in the implant material. Thus, it later affects the growth of new bone tissue [12].

The implant coating method that can be used to overcome the weak adhesion strength of implants is the dip coating method. Dip coating is popular in the industry and laboratory applications due to its low cost, simple processing steps, and high coating quality [12]. This method can form a better coating surface compared to the electrochemical deposition technique. The dip coating technique is able to produce an adhesive thin coating layer without severe cracking by using a lower annealing temperature [13]. To increase the adhesion strength of the coating, a sintering process is carried out. The appropriate sintering temperature will affect for optimum quality of hydroxyapatite coating [14].

In previous research conducted by Jafari et al., after observing with a Scanning Electron Microscope (SEM), Jafari et al. found porosity in the hydroxyapatite layer sintered at 600 °C, and the porosity decreased when sintered at 700 °C [15]. This porosity can make the coating denser, and the adhesion strength of the coating increases.

Some studies also mention that sintering the hydroxyapatite layer at 875-975 °C can increase the adhesion strength of the hydroxyapatite layer on titanium. However, the temperature around 875 °C can affect hydroxyapatite decomposition resulting in the tricalcium phosphate (TCP) phase that could be a reduction of adhesion strength (mechanical properties) [16].

Based on the information in the background above, the sintering temperature may affect the adhesion strength of the coating. The use of a low sintering temperature results in the appearance of much porosity. However, if sintered at a high temperature, it will form a tricalcium phosphate (TCP) phase, which reduces the adhesion strength. Low adhesion between the coating layer and substrate may result in the detachment of the coating layer during implantation. This causes the release of the oxide layer (TiO_2) produced by the titanium into the body's tissues and triggers an inflammatory response [17]. It is necessary to have the right sintering temperature to prevent detachment of the coating layer. Therefore, research will be conducted on the effect of sintering temperature on the adhesion strength of the hydroxyapatite coating layer of titanium TNTZ prepared by dip coating method with sintering temperature variations of 700 °C, 800 °C, and 900 °C.

1.2 Problem Statement

Based on the information in the background above, then there are some things that need to be investigated further :

1. The effect of the sintering process on the adhesion strength of the hydroxyapatite layer on the TNTZ titanium surface.
2. Suitable sintering temperature to obtain high adhesion strength of the hydroxyapatite coating layer on the TNTZ titanium surface.

1.3 Research Objective

This research will investigate the effect of sintering temperature variation after the dip coating process on the adhesion bonding of the hydroxyapatite layer on TNTZ titanium so that it can be determined suitable sintering temperature.

1.4 Benefit

The advantage of this research is to obtain Hydroxyapatite coated TNTZ titanium with a high adhesion strength of the coating layer that is needed to improve the bioactivity and corrosion resistance of metal implants made of TNTZ titanium.

1.5 Research Scope

1. Using commercial hydroxyapatite

2. Using the pull-off test to measure the adhesion strength
3. Using the dip coating method with optimized withdrawal speed and immersion time
4. Using sintering temperature variations of 700 ℃, 800 ℃, and 900 ℃.
5. This experiment is only carried out to in vitro studies.

1.6 Report Outline

This study consists of five parts. Chapter 1 contains an introduction that describes the background, research purposes, research advantages, problem limitations, and writing systematic. Chapter 2 consists of literature review which contains the basic theories used in this study. Chapter 3 describes methodology that was used in order to find the result. Chapter 4 explains the result of this study. Chapter 5 explains the conclusion of this study.