CHAPTER I

INTRODUCTION

1.1 Background

Indonesia becomes the No.1 in the increasing number of traffic accident (Global Status Report on Road Safety by World Health Organization). In the same data, about 78% the traffic accident in Indonesia caused the bones fracture **[1,2]**. Besides the traffic accident cases, the fracture of bones also caused by osteoporosis. Data from Indonesia Ministry of Health in 2011, there are about 100.000 cases of osteoporosis, and its predict that in 2050, osteoporosis increased until reach 3 times **[3]**. Fractured bones can heal by biomaterials which is orthopedic implant.

Over the last 30 years considerable progress has been made in understanding the interactions between the tissues and the materials, called biomaterials **[4]**. It is commonly used in medical aspects such as implant material which are widely used as orthopedic implants (to replace the bones and fix the injured bones to heal) and dental implants. The material used as an Implant should has similar characteristics and has good interaction with the living body system.

A wide range of materials encompassing all the classical materials such as Metals (gold, tantalum, Ti6Al4V, 316L stainless steel, Co-Cr Alloys, titanium alloys), Ceramics (alumina, zirconia, carbon, titania, bioglass, hydroxyapatite(HA), Composite (Silica/SR, CF/UHMWPE, CF/PTFE, HA/PE, CF/epoxy, CF/PEEK, CF/C, Al2O3/PTFE), Polymers (Ultra high molecular weight polyethylene (UHMWPE), Polyurethane (PE), Polyurethane (PU), Polytetrafuoroethylene (PTFE), Polyacetal (PA), Polymethylmethacrylate (PMMA), Polyethylene Terepthalate (PET), Silicone Rubber (SR), Polyetheretherketone (PEEK), Poly (lactic acid) (PLA), Polysulfone (PS)) have been investigated as biomaterials **[4]**.

Different kinds of implant material, different application to part of body implanted **[5]**. Metal processed as an Implant in this research because of their superior mechanical properties and some of them processed practically and simple. Metal such as 316L Stainless Steels and Titanium become the greatest number of metal used as an Implant material. Cost comparation made 316L Stainless Steel more affordable than Titanium. Instead of Magnesium alloy as a new material, stainless steel has a greater mechanical properties, and it is used world wide. But for biodegradable and bioabsorbable, this material coated by Hydroxyapatite that become supporting material to absorb by our body and it helps bones healing.

The excellence mechanical properties of Stainless Steel such as high strength and toughness, high corrosion resistance, biocompability and non-toxicity made this metal famous used as Implant; Fracture fixation, stents, surgical instrument **[5]**. To interact with living body system, the characteristics of supporting material needs to be similar with the part of the body implanted, so that it will help stainless steel to interact.

The greatest potential for bone substitution is shown by materials based on hydroxyapatite (HA), $Ca_{10}(PO_4)_6(OH)_2$, which can develop tight bonding with bone tissue, exhibits osteoconductive behavior, is stable toward bioresorption, and has no adverse effects on the human organism **[6]**. Hydroxyapatite (Ca10(PO4)6(OH)2 is one of the ceramics material which is bioactive and has a similar characteristic and composition with bones and teeth. Besides that, HA produced by human body so that it has a good interact with bones and teeth. Some condition when there is an injured bones, HA will help bones healing. HA doesn't have a good mechanical properties compared with SS 316 L.

Coating HA on SS 316 L will become solution make it as an Implant. 316 L Stainless Steel become the Implant because its excellent mechanical properties and HA become the coating material because its ability interact with surrounded. In the

other hand, HA can make the increasing of corrosion resistance of SS 316 L and help accelerating of bones and teeth healing.

There are kinds of coating methods used to coat HA to SS 316 L. Various methods including plasma spray, electro disposition, electrochemical disposition, sol-gel, pulsed laser disposition **[7]** and the other method found was Investment Casting. Investment casting makes HA coated to implant material which is alternative of biometallics coating, practical, excellent tolerance and economical process **[8]**.

Investment Casting is one of the casting process which produced close tolerance metal with a competitive cost that compared with other casting methods. In the journal before, SS 316 L coated HA with Investment Casting process with dipping the pattern directly into HA slurry **[8]**. This method makes it easy to control and maintain a consistent HA coating thickness applicable to small and complex shapes. Another methods in investment casting to coat HA to SS 316 L is pouring methods. This method is similar with dipping method. The differences is dipping method mix the HA slurry in pattern while the Pouring method pour the HA slurry into the mould before it coated with SS 316 L. This two methods have same advantages so its flexible to use one of them. This research will use pouring method to coat HA slurry. To make better properties, the process finished with sintering process after the coating the HA into SS 316 L. In Indonesia, this coating method still haven't used as commercial process to produce an Implant. It need more research for this method.

1.2 Problem Statement

To increase the bioactive of the Stainless Steel to be a good implant material, it needs a coating process of hydroxyapatite as supporting material on Stainless Steel 316 L. In the process, coating the HA into SS 316 L should be finished with the sintering process to make better coating properties. In the research before, given an information about optimum sintering temperature on coated HA in SS 316 L is about 800 – 1000^{o}C. Specifically, this research will searching for the best sintering

temperature in effect of microstructure with SEM and analysis to surface morphology, hardness, Ca/P ratio, thickness of HA coated on SS 316 L.

1.3 Objectives of Research

The main purpose of this research are:

1. To produce the Hydroxyapatite coated on Stainless Steel 316 L with investment casting technique.
2. To investigate the optimum sintering temperature between 850, 900 and 950 ^{o}C from the comparation properties of HA coated with Investment Casting technique.

1.4 Benefits of Research

To produce the Stainless Steel 316 L coated with hydroxyapatite and match with the Implant properties recommendation.

1.5 Scopes of Research

1. The implant material used in this research is SS 316 L of medical grade.
2. The HA used to coat the SS 316 L was commercial HA powder.

1.6 Outline of Report

In this final project writings, there are 5 chapters of the writings :

Chapter 1. Introduction. This chapter describes about the background of the writings, problem statement, the objectives of the research, benefits, scopes, and the outline of the research.

Chapter 2. Literature Review. This chapter review about the literature of this writings which contains the review about biomaterials, types of biomaterials, Stainless Steel as Implant material, Hydroxyapatite and Coating methods of biomaterials.

Chapter 3. Methodology of Research. This chapter contains of research flowchart and the procedure of the research

Chapter 4. Result and Analysis. This chapter describes the result of the research and analyse the Hydroxyapatite on mould, Surface Morphology on Coated Material, Implant Composition, Coating Thickness and Hardness Number of the Implant Material.

Chapter 5. Conclusion. This chapter contains of conclusion and advises for the next similar research.

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