CHAPTER 1 INTRODUCTION

1.1 Background and Rationale

Presently, both ferrous and non-ferrous metal industries are key drivers of Thailand's economic growth. Metals are used to make alloys, castings, forgings, extrusions, wires, cables, pipes, etc., which are used in power plants, construction, machinery, jewelry, marine applications, and vehicles industries [1]. However, because the production capacity has increased gradually, the amount of waste or scrap produced is accordingly high. The scrap from both commercially pure (CP) titanium and titanium-based alloys is one of the most expensive industrial scraps, and it is likely that the amount of Ti metal Scrap, which is generated from the melting, forging, casting and fabrication of titanium components, will increase in the future. Ti scrap produced in the fields of dentistry and jewelry is very clean because this metal is melted in a controlled environment. Since the year 2000, recycled metals have become increasingly important as the industry need to conserve materials and protect the environment [2]. Bauer et al. [3] reported that recycling, which is a significant supply for many of the metals used in society today, provides environmental benefits in terms of energy savings, reduced volumes of waste, and reduced emissions, all of which are associated with the energy savings.

Titanium is used in many fields such as aerospace, marine, and automobile industries. Ti is also used in chemical plants materials, medical equipment, buildings, and several consumer products (spectacle frames, golf clubs, etc.). Ti has such diverse uses because of its high strength, light weight, high-temperature performance, excellent flexibility, extraordinary corrosion-resistance, and biocompatibility characteristics. Moreover, Ti can be mixed with other metals to synthesize new materials. Intermetallic compounds of Ti are some of the most interesting materials for engineering applications because of their favorable properties make them suitable for various services in the industries mentioned above. For example, the titanium aluminides (TiAl) are intermetallics synthesized from titanium and aluminum. They are promising candidates as advanced structural materials for high-temperature applications because of their attractive combination of low density (approximately 3.8 g/cm^3), high modulus and strength at elevated temperatures (approximately within the 550-750^{o}C service range), high melting temperature, good corrosion and burn resistance, and good creep properties [4]. Because TiAl-based alloys are a prospective light-weight material for high-temperature structural applications, which include automotive and aerospace engine components, they have been investigated extensively over the last decade [4]. Gamma titanium aluminides are a class of TiAl suitable for use in high temperature services. These materials are favorable for high-temperature service because they possess the properties of a high melting point, low density, high specific strengths and moduli, low diffusivity, good structural stability, good resistance against oxidation and corrosion, and high ignition resistance (when compared with the conventional titanium alloys) [5]. Two phase-based alloys of gamma TiAl (based on TiAl with the $L1_o$ structure and P4/mmm symmetry) and α_2 (based on Ti_3Al with the DO_{19} structure and $P6_3$/mmc symmetry) [6] are optimized structure for gamma titanium aluminides and can be classified broadly by their microstructures into either fully lamellar or duplex structures with equiaxed γ and lamellar components [7].

CP titanium scrap is of interest as starting raw material for the synthesis of titanium aluminides as this would decrease the costs while creating local knowledge. Typical production processes for manufacturing TiAl alloys require specialized equipment, including the vacuum arc melting furnace, induction skull melting (ISM) or plasma melting. These processes must be carried out under an argon atmosphere to prevent the formation of Ti_2O[4,5]. TiAl alloys properties can be improved by the addition of alloying elements and heat treatment. Alloying elements that can be used are numerous including V, Cr, Mn, Fe, Co, Ni, Y, Zr, Nb, Mo, Hf, Ta, W, Ga, Ge, In or Sb[8,9]. The most frequently used alloying elements are Nb, Mo, and Cr, which have significant effects on microstructure and mechanical properties of the resulting TiAl[4,5].

1.2 Objectives of the Study

The objectives of this study are:

1) To synthesize titanium aluminides from locally available raw materials
2) To investigate the influence of alloying elements on crystal structure and microstructures of titanium aluminides
3) To investigate the influence of alloying elements on properties of titanium aluminides
4) To investigate the effects of heat treatment and cooling rate on crystal structure and microstructures of titanium aluminides
5) To investigate the effects of heat treatment and cooling rate on the properties of titanium aluminides.

1.3 Scope of the work

1.3.1 Chemical compositions

The alloys investigated in this research are listed to followings:

Ti-46Al, Ti-48Al, Ti-46Al-5Nb, Ti-48Al-5Nb, Ti-46Al-10Nb, Ti-48Al-10N b, Ti-46Al-2Mo, Ti-46Al-2Cr, Ti-46Al-4Nb-2Mo, and Ti-46Al-4Nb-2Cr.

1.3.2 Heat treatment and cooling rate

The heat treatment in this study is solution treatment which is carried out at 1,400^{o}C for 30 minutes, followed by cooling in air. All specimens were then treated in a high-temperature furnace at a temperature of 1,350°C for 60 minutes and cooled by various paths; water quenching (WQ), oil quenching (OQ), air cooling (AC), and furnace cooling (FC).

1.3.3 Property and structures

The property of interest in this work is microhardness. The structures investigated include macro and microstructures, crystal structures, and phase orientation.