CHAPTER ONE

INTRODUCTION

1.1 Background of study

In powder metallurgy (P/M) practice, sintering is the process of heating of the compacted powder specimen in a controlled atmosphere so that the powder particles are welded together and a strong finished part is produced. The sintering of mechanical parts is usually done in a continuous belt furnace; in special cases a vacuum furnace is used. For this particular study, microwave is used as a means of sintering. Microwave energy has been in use for a variety of applications for over 50 years. Some of the early applications include communication, navigation and drying of food items. At present, industrial uses of microwaves include wood processing, vulcanization of rubber, meat tempering, and medical therapy. In the past two decades, the remarkable success of domestic microwave ovens has revolutionized home cooking. However, the use of microwave heating in sintering of metallic compacted specimen is relatively new.

Microwave heating and sintering is fundamentally different from the conventional sintering. Conventional sintering involves radiant or resistance heating followed by transfer of thermal energy via conduction to the inside of the body being processed. Microwave heating is a volumetric heating involving conversion of

electromagnetic energy into thermal energy, which is localized, instantaneous, rapid and highly efficient.

The microwave part of the electromagnetic spectrum corresponds to frequencies between 300 MHz and 300 GHz. However, most research and industrial activities involve microwaves only at 2.45 GHz and 915 MHz frequencies. Based on their microwave interaction, most materials can be classified into one of three categories - opaque, transparent and absorbers. Bulk metals are opaque to microwave and are good reflectors. This property is used in radar detection. However, powdered metals are very good absorbers of microwaves and heat up effectively, with heating rates as high as 100°C min^{-1}. Most other materials are either transparent or absorb microwaves to varying degrees at ambient temperature. The degree of microwave absorption, and consequently of heating, changes dramatically with temperature.

Until recently, microwave heating has been applied to sinter only oxide ceramics and semi-metals like carbides and nitrides. However, recent research reveals that in powdered form, virtually all metals, alloys, and intermetallics will couple and heat efficiently and effectively in a microwave field, and their green parts will produce highly sintered bodies with improved mechanical properties. Specimens in this study are made of tin base alloys. One of the most important properties of tin is the ease with which it alloys or mixes with the majority of other metals, and thus chosen for this study. It also has low melting point and relatively low sintering temperature. Therefore, it is thought that the commercial microwave furnace can be modified to study the behavior of microwave heating, when metallic powder compacts are sintered.

1.2 Objectives of study

The purposes of this study are:

a) To modify a domestic microwave oven for sintering low melting temperature tin base alloys.

b) To determine the influence of microwave sintering on the tin base alloys density, porosity, dimensional changes, hardness and microstructure.

c) To determine the optimum conditions of highest density, porosity, hardness and best dimensional accuracy.

d) To compare the microwave sintered properties of tin base alloy with conventionally sintered tin base alloys.

1.3 Scope of study

This study will cover the areas of

a) Powder metallurgy process

b) Microwave heating mechanism

c) Modifying a domestic microwave oven for sintering

d) Effects of microwave sintering on the physical and mechanical properties of tin base alloys

e) Microstructure studies

1.4 Approach of study

This study follows the following phases;

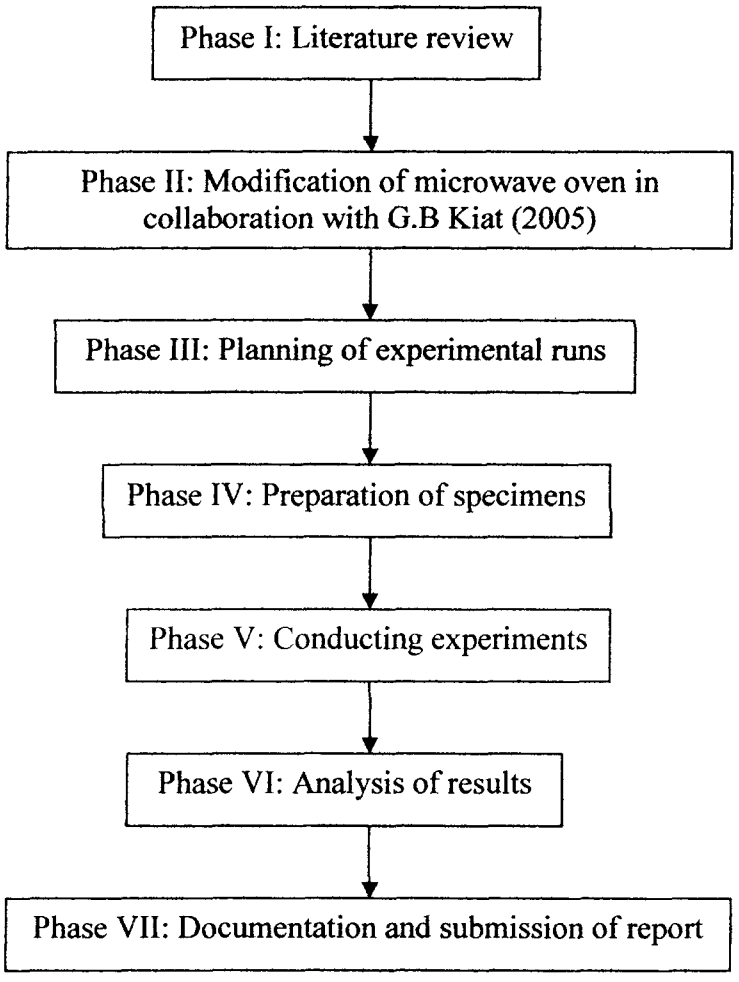

Figure 1.4 Phases of study

Phase I: Literature Review

Literature is reviewed on the microwave sintering of different materials and the sintering of tin base alloys. Information is gathered from books, journals, internet and other written works on microwave heating mechanism, sintering and powder metallurgy process and the characteristics of tin base alloys.

Phase II: Modification of microwave oven

A domestic microwave oven is purchased. The operation of the microwave oven is studied to come up with a design that suits the requirement of the experiment. After discussion with the supervisor, the modification of the furnace according to the proposed design and installation of thermocouple as temperature controller was assigned to a professional vendor. The fabrication was done under the supervisor.

Phase III: Planning of experimental runs

Taguchi Parametric Robust Design, based on orthogonal array (L_8) has been used to plan the experiments. The control factors and noise factors are identified. The levels of different factors were decided.

Phase IV: Preparation of specimens

Tin, copper and antimony were blended in the planned properties. Then the mixture was compacted to produce the green compact under different pressure. At this stage, the specimens were ready for sintering.

Phase V: Conducting experiments

After testing the modified microwave oven, the specimens were sintered according to the conditions planned. Data were collected from the experiment results.

Phase VI: Analysis of result

Analysis of the data was done in a systematic fashion. The results were analyzed graphically as well as statistically to simplify the process of discussion, conclusion and recommendation making. Comparison was made with results of other works.

Phase VII: Documentation and submission of report.

The thesis report written for submission and final presentation is prepared.