THE EFFECT OF COMPACTION PRESSURE AND SINTERING TIME ON MECHANICAL PROPERTIES OF A WASTE METAL POWDER

AHMAD SYAZWAN BIN MOHAMMAD

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ABSTRACT

Waste metal powder usually obtains by metal cutting process and this metal powder commonly disposes. This research proposes a technique or method to reuse this metal powder. However, there are many challenges in using this waste metal powder which are the waste metal powder mix with oil and it is needed to obtained small size of metal powder. This challenge can be solve by pyrometallurgy and filtering process. This research use powder metallurgy process in order to reuse this metal powder. Compaction pressure and sintering are an important in powder metallurgy process, which affects the final performance of the part. This study investigates the compaction pressure and sintering on mechanical properties of waste metal powder which get from cutting the metal. The correlation between the density and mechanical properties of the fabricated porous parts are intensively studied. It is found that the compaction pressure and sintering time will affect the mechanical properties of the waste metal powder.

ABSTRAK

Sisa serbuk logam biasanya mendapat melalui proses pemotongan logam dan serbuk logam biasa melupuskan. Kajian ini mencadangkan satu teknik atau kaedah untuk menggunakan semula ini serbuk logam. Walau bagaimanapun, terdapat banyak cabaran yang menggunakan serbuk sisa logam ini adalah campuran logam sisa serbuk dengan minyak dan ia diperlukan untuk saiz yang diperolehi kecil serbuk logam. Cabaran ini boleh diselesaikan oleh pyrometallurgy dan proses penapisan. Kajian ini menggunakan proses metalurgi serbuk untuk menggunakan semula ini serbuk logam. Tekanan pemadatan dan pensinteran yang penting dalam proses metalurgi serbuk, yang akan menjejaskan prestasi akhir bahagian. Kajian ini menyiasat tekanan pemadatan dan pensinteran pada sifat-sifat mekanik serbuk logam sisa yang dapat daripada pemotongan logam. Korelasi antara ketumpatan dan sifat-sifat mekanik bahagian fabrikasi berliang intensif dikaji. Ia didapati bahawa tekanan pemadatan dan masa pensinteran akan mempengaruhi sifat mekanik serbuk logam sisa.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Metals are important and reusable resources. Although the ultimate supply of metal is fixed by nature, human ingenuity helps to determine the quantity of supply available for use at any point in time by developing economic processes for the recovery of primary metal (from the Earth) and secondary metal (recycled from the use/process stream). The reusable nature of metals contributes to the sustainability of their use. So that, recycling are a significant factor in the supply of many of the metals used in our society, provides environmental benefits in terms of energy savings, reduced volumes of waste, and reduced emissions associated with energy savings. Waste metal powder can be obtained by metal cutting process. These metal powders usually dispose. In Malaysia, mild steel are the most steel that been used. In this project, the waste metal powder obtained from mild steel. The waste metal powder was disposed because it makes the factory environment messy and risk to worker health. Because the waste metal powder is very small, it is easily spread by the wind. So, the powder could harm to the workers. Other than that, the waste metal powder becomes useless when it mixes with the oil. Therefore, this project will study the possibility at using this metal powder to become a product. This project also will reduce the disposal metal powder to the environment and at the same time make a product from this waste metal powder. Figure 1.1 shows the data of waste metal powder in Intergate Steel Mill Sdn Bhd.

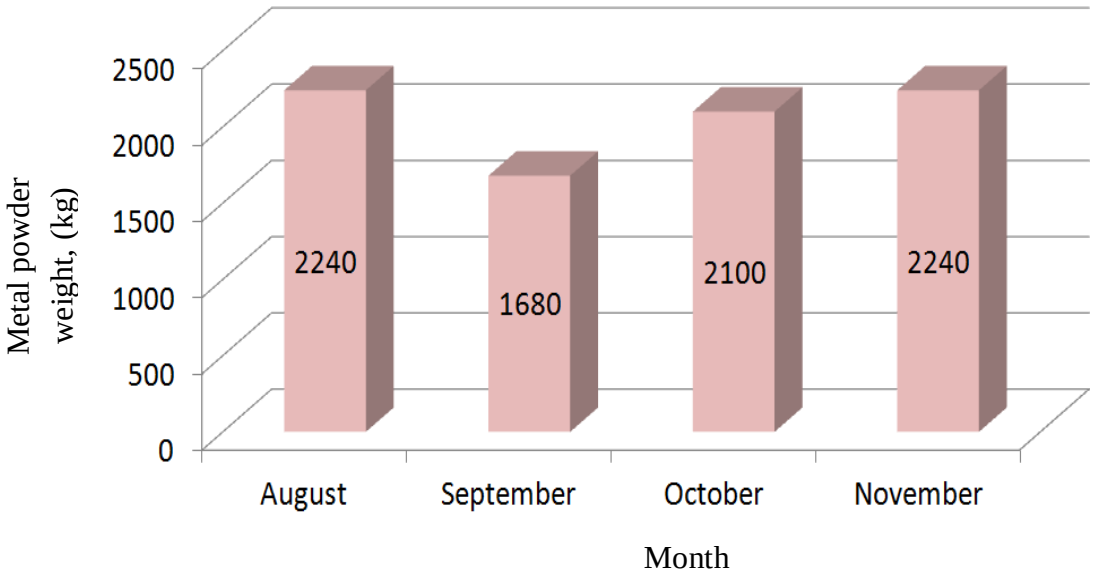

Figure 1.1: Waste Metal Powder at Intergate Steel Mill Sdn Bhd.

(Source: Intergate Steel Mill Sdn Bhd)

1.2 Problem Statement

Mostly, current methods for powder metallurgy process start by using a new powder by mixing with chemical composition. This kind of method produces higher cost in production of new material. Many studies have been done in analyzing the waste metal powder that not been use in producing a product. Usually, the waste metal powder from factories has been mix with oil. Therefore, the process to utilize the metal powder needs to be investigated and implemented. Besides that, the process that wants to treat in this project are also investigated and implemented.

1.3 Objective

The objectives of this project are:

i. To implement the technique how to remove the oil from waste metal powder.
ii. To investigate the effect of different compact pressure and sintering time on mechanical properties of waste metal powder.

1.4 Project Scope

The project scopes of this project are:

i. Waste metal powder that has been used in this project is obtained from cutting process of mild steel.
ii. The result of mechanical properties will be obtained using hardness test and compression test.

CHAPTER 2

LITERATURE REVIEW

2.1 Pyrometallurgy process

Processes which means to separate the metal from the impurities. Separations are carried out based on differences in chemical properties such as size, shape, mass, or chemical affinity between the constituents of a mixture, and are often classified according to the particular differences they use to achieve separation.

Pyrometallurgy, or the use of heat for the treatment. It involves heating in a blast furnace at certain temperature to convert waste to a form that can be determined. In this case, this experiment wants to separate the waste metal powder with the oil. The boiling point for engine oil is in the range 250 ^{o}C – 370 ^{o}C during 10 and 20 min at boiling time. When the engine oil has arrived at boiling point, it will vaporize.

2.2 Lathe machine

Lathe machine tool that performs turning operations in which unwanted material is removed from a work piece rotated against a cutting tool. The lathe is one of the oldest and most important machine tools. The rotating horizontal spindle to which the work holding device is attached is usually power driven at speeds that can be varied (SeropeKalpakjian, 1971).

Lathes are used in woodturning, metalworking and metal spinning. The function of this lathe machine is to create a mold. Figure 2.1 shows that the lathe machine that will be use in creating the mold.

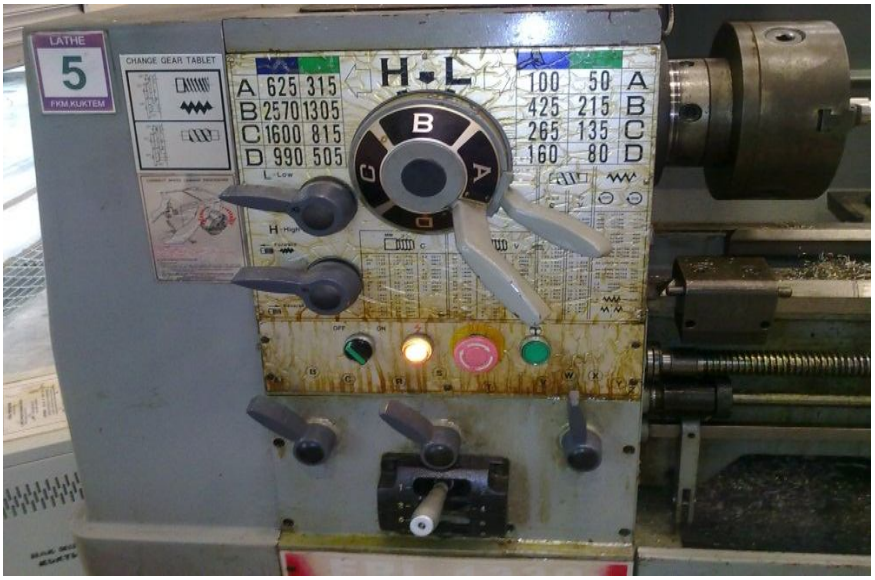

Figure 2.1: Lathe machine

2.3 Powder metallurgy process

Powder metallurgy is a metal working processes for forming precision metal components and shapes from metal powder. One accepted definition describes powder metallurgy as the material forming technique used to consolidate particulate matter, both metals and nonmetals, into discrete shapes.

Modern powder metallurgy began in the early 1900's when incandescent lamp filaments were fabricated from tungsten powder - the same way they are made today. Other important products followed, such as cemented carbide cutting tools, friction materials and self lubricating bearings. Today structural powder metallurgy parts are used widely in automobiles; fan machinery, home appliances, power tools, air craft engines and wherever small mass produced metal components can be utilized (Antes, 1973).

Powder metallurgy has been one of the fastest growing metal fabrication processes. The principal reason is that powder metallurgy process is an economical, high-volume production method for making parts exactly to final dimensions and finishing them with fewer or no machining operations. As illustrated in Figure 2.2, there is flow chart of steps in the most widely used conventional powder metallurgy process.

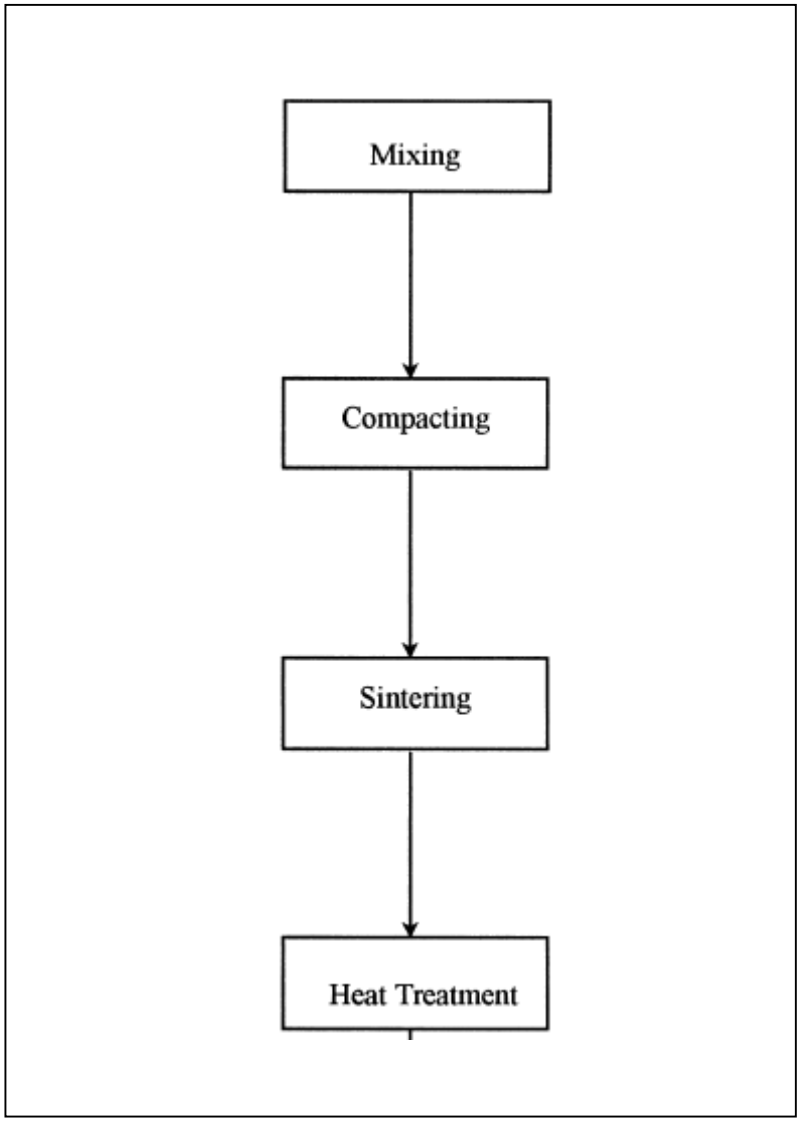

Figure 2.2: Flow chart of powder metallurgy

2.3.1 Mixing process

Elemental metal powders or alloy powders are mixed together with lubricants or other alloy additions to produce a homogeneous mix of ingredients. The term mixing refers to the mix at the metal powder with other addition to make the bonding each metal powder strong. The main purpose of mixing process is to blend the metal powder with epoxy to form a homogenous mixture of ingredients to increase the bonding at green compact while compaction process.

2.3.2 Compaction Process

The strength properties of sintered components increase with increasing density but their main reason to increase the yield strength is start with compaction process. Thus, it is most desirable, for both economic and technical reasons, to achieve the highest possible compact density at the lowest possible pressure. It is well known that the efficiency of compaction is heavily dependent on the morphology and hardness of powder particles. The irregular morphology and high hardness of powders contribute to low green densities. In fact, poor packing behavior of powders with irregular morphologies causes a broad pore size distribution that can inhibit sintering progress. Table 2.1 shows the parameter that will be use in compaction process.

Table 2.1: Compaction process of powder metallurgy

Application	Tons	Mpa
Porous metal and filter	3 – 5	40 – 70
Refractory metal and carbides	5 – 15	70 -200
Porous bearing	10 – 25	146 – 350
Machine part (medium-density iron and steel)	20 – 50	275 – 690
High density iron and steel parts	18 – 20	250 – 275
High density iron and steel parts	50 -120	690 - 1650

2.3.3 Sintering process

Sintering is a thermal treatment, below the melting temperature of the main constituent material, which transforms a powder compact into a bulk material containing, in most cases, residual porosity. The process of sintering brings about certain physical as well as chemical changes in the material. The chemical changes can be illustrated as:

i) Change in composition or decomposition
ii) New phase formation or decomposition followed by phase change
iii) New phase formation due to chemical changes

Furnace is use in this process. Furnace means device for heating process. The heat energy to fuel a furnace may be supplied directly by fuel combustion, by electricity such as the electric arc furnace, or through induction heating in induction furnaces. The temperature of heating can be setting at temperature that wants to use.

The implementation of high temperature sintering in the manufacture of ferrous powder metal alloys enhances the functional properties of parts, including tensile strength, ductility, and hardness test. High temperature sintering is arbitrarily defined as processing above 1150° C (2100° F), since this is the practical limit for metal wire belts that are used to convey product in continuous sintering furnaces. Table 2.2 shows that the parameters are use in sintering process.

Table 2.2: Sintering temperature and time for various metal.

Metal powder	**Sintering temp (^{o}C)**	**Sintering time (min)**
Brass	850 – 900	10 – 45
Bronze	750 – 880	10 – 20
Copper	850 – 900	10 – 45
Iron	1000 – 1150	10 – 45
Nickel	1000 – 1150	30 – 45
Stainless steel	1100 - 1300	30 - 60

In this experiment, the sintering process that will use is at 750 ^{o}C and different sintering time. The different sintering times are 15 min, 30 minutes, 45 min and 60 min.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology can be defined as a sort of management and project planning from the beginning until the final stage of the project. To avoid delay of works and clash activities a well planned methodology must be performed. It can also accomplish the procedure which satisfied the project objectives on time when it being followed. The designing and analysis process will be discussed in this chapter.

3.2 Flow Chart

To achieve the objective of this project, a methodology flow chart has been constructed like Figure 3.1. The methodology flow chart purpose is to give guidelines and directions to successfully accomplish the main goal of this project. By following the flow chart, the experiment will go smoothly even if some problem may occur during the experiment.

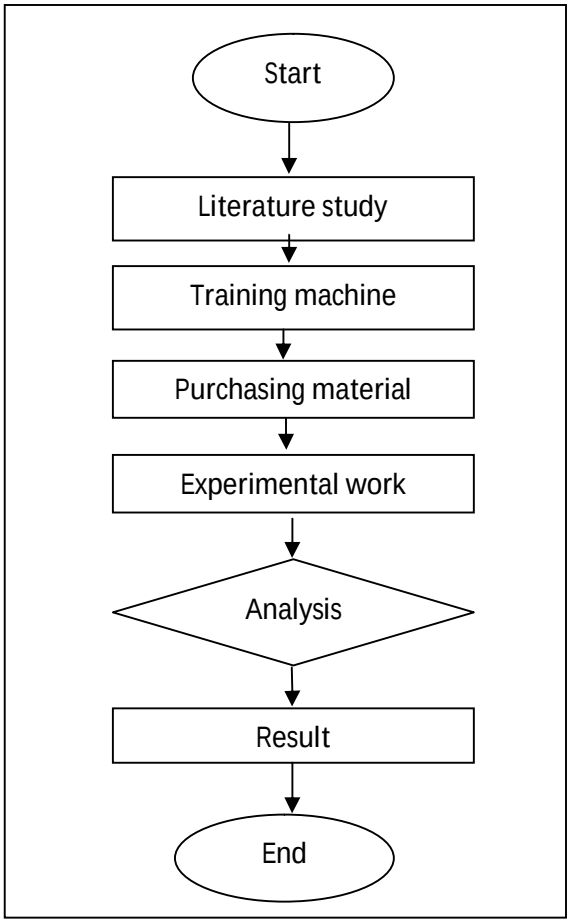

Figure 3.1: Project flow chart

Figure 3.1 shows the research methodology which investigates the effect of compact pressure and sintering time on mechanical properties of waste metal powder. The first step is to gather information about the project objectives. Then the suitable experiment will be designed according to the objectives. The waste metal powder will be prepared by obtain from steel factory. Next, the oil that mixes with the waste metal powder will be separated by pyrometallurgy process. Then, compaction and sintering process worked to get the result on mechanical properties. It will be analysis by Rockwell hardness test and compression test.

3.3 Experimental Work

The first process is filtering process. This process is about filtering the waste metal powder into a small size. Figure 3.2 show that how filtering process was done.

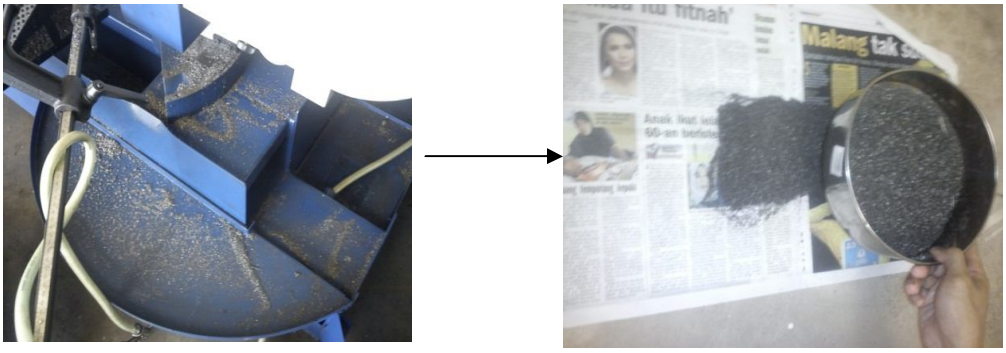

Figure 3.2: Filtering process.

Next, pyrometallurgy process and powder metallurgy process will be done. The waste metal powder usually mixes with the engine oil. The function of pyrometallurgy process is to remove the oil from waste metal powder. The waste metal powders are heated at 250 ^{o}C, 300 ^{o}C, 350 ^{o}C, 400 ^{o}C and 450 ^{o}C in 10 min and 20 min. The waste metal powder will be heated in the furnace. The oil will vaporize through chimney and the mass of waste metal powder before and after heated will be measured. Figure 3.3 shows the furnace for pyrometallurgy process. Figure 3.4 shows that the metal powder before and after pyrometallurgy process.

Figure 3.3: Furnace for pyrometallurgy process

In this furnace the waste metal powder is heated at certain temperature in different time.Figure 3.4 shows that the metal powder before and after pyrometallurgy process.

Figure 3.4: Metal powder in pyrometallurgy process