FABRICATION OF TITANIUM FOAM BY USING COMPACTION METHOD

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ABSTRACT

Metal foam is a new material that is less used in engineering. Metal foam is widely used in bio-medical fields to produce artificial human bones. Metal foam made of a porous structure that provides the physical and mechanical properties of both as low specific weight and high thermal fluidity. In this study, the selected metal to be foamed is a titanium metal powder. In general, titanium is very light weight compared to other metals. Special properties of the titanium encourage more study implemented on titanium foam. Preferred methods for producing titanium foam is via powder metallurgy or Fraunhofer process. Foaming agent used is urea or carbamide which is widely used as crop fertilizer. Powder metallurgy process needs to go through the mixing, pressing, sintering and analysis. The composition of titanium was fixed at 75%, 80% and 85% while the remaining percentage is the composition of the urea. The selected sintering temperature is 1200 ° C, 1250 ° C and 1300 ° C. Sintering process was conducted in the tube furnace in the argon gas atmosphere. After sintering process carried out, analysis of the density and porosity was carried out on all samples. Density test shows the increasing density of the particles of titanium when added up to 85% for all sintering temperatures. For porosity tests, it is found that the percentage of porosity decreases when the titanium particles increased up to 85%.

KEYWORDS; Porous structure; powder metallurgy; sintering; porosity; density.

INTRODUCTION

Metal foam is a new material that could be said is a stranger in the world of engineering. To date, studies of metal foam are continuing to search for the best method for producing metal foam features that are required. Due to imperfections in the classification and control parameters are involved, and then there is variety of foaming properties of different metals (Ashby et. al, 2000). Introduction to the metal foam provides greater benefits to human life today. This is because the metal foam is widely used in the field of energy absorption and noise, the automotive sector and also in other fields (Ashby et. al, 2000). In this study, the production of titanium foam is expected to provide favorable results of the discovery of the physical characteristics of mechanical or better than metal foams that available.

Metal foam is a hard metal that has a cellular structure and a large fraction of the surface of the filled pores. As is well known, metal foam has the strength to weight ratio is high, which makes it very light compared to solid metal. Metal foams can be divided into two types. It depends on the pattern of the resulting pores. Pores can be sealed (closed cell foam) or can form a network of pores (open cell foam). Figure 1 shows the open cell foam and closed cell foam for aluminum. For Figure 1 (a) and Figure 1 (b) shows the closed cell foam to aluminum occur as a result of gas bubbles from aluminum metal. Figure 1 (c) or foam is open cell, such as name, too, has an open cell walls. This type of foam has wrinkles, leaving the ligaments strong. This is a solid metal ligament, which consist of structural foam. Difference in size of the foam is determined by the parameters set as the quantity of foaming agent used and sintering temperature during the sintering process carried out.

Therefore, in this research it is determined to achieve:

a) The fabrication of titanium foam with 20-30% of porosity
b) To perform tests of porosity and density on sample after sintering process

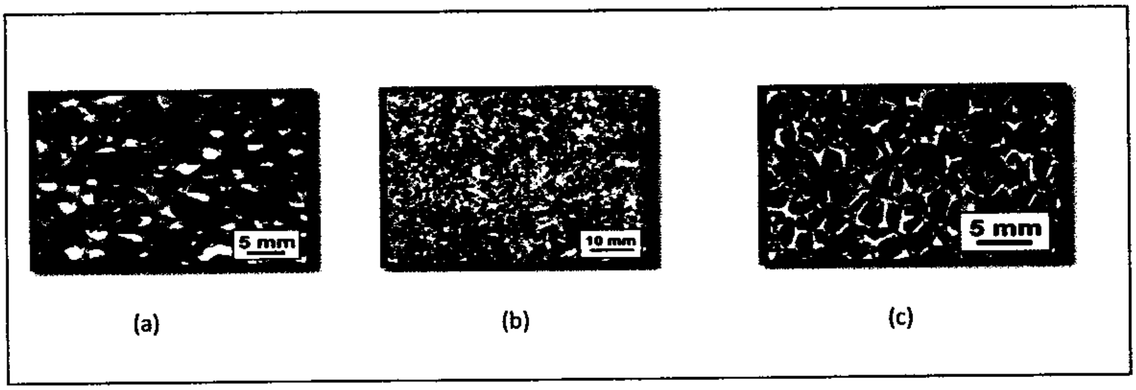

Figure 1: Foam structure: (a) a large closed cell foam (b) small-sized closed cell foam (c) the foam is open cell (Shinko Wire Company, 2005)

MATERIALS AND METHOD

The methodology for this research is based on the powder metallurgy method. The most fundamental step begins with the mixture of the metal powder together with foaming agent. Then, the mixture is compacted adequately; so that it is strong enough to be hold. Next, the ready sample is sintered in tube furnace. After that, the sample is tested by three kinds of testing. The more clear view of this research is represented by the flow chart in Figure 2.

The target composition for titanium are 75%, 80% and 85% while the remaining percentage filled by theirs foaming agent (urea). The mixing process is done by ball milling machine. Carver Hand Press machine is applied to perform compaction. Pressure applied is 8 tons which according to Azar (2003) who managed to fabricate aluminum foam by using this pressure. Via compaction, a sample is obtained and that it can be hold for the next stage. At this stage, sample is sintered in a tube furnace in three sintering temperatures which are 1200°C, 1250°C and 1300°C. The argon gas is used during the sintering in order to avoid oxidation from occur onto the sample. After the sintering process, the sample is tested by using three kinds of tests which are porosity test, density and also Scanning Electron Microscopy (SEM).

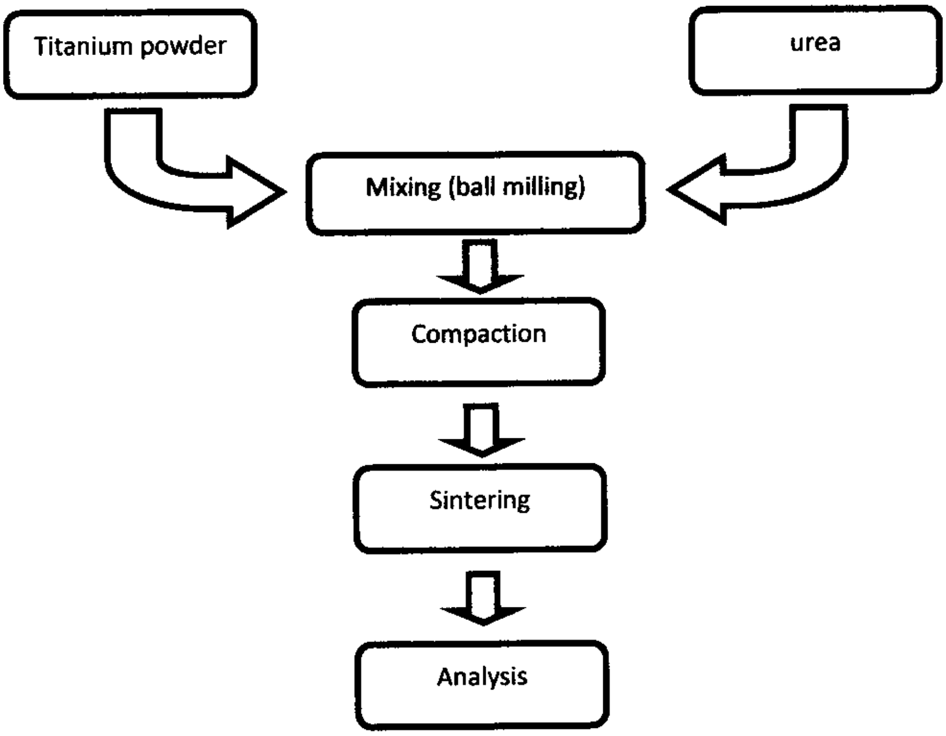

Figure 2: The flow chart for the sample preparation of titanium foam

RESULTS AND ANALYSIS

Figure 3 shows the microstructure of the sample after sintering at 1250°C in the tube furnace. This figure has shown the pores and strut of the sample. After the testing, the results of porosity percentage, density and shrinkage are obtained. The Graph for porosity and density verses composition of titanium shown in Figure 4 and Figure 5. From Figure 4, when titanium particle added until up to 85%, the porosity for all sintering temperatures was decrease. It because more particle was replace the pore in this sample (sufizar ahmad 2010). When the sintering temperature increases so the percentage of porosity was decrease. This because during the sintering process, the neck grow at the particle contact (German 1996). This causes the elimination of pores and increase in density (S. Ahmad 2010). From Figure 5, as more titanium particle added until up to 85%, the density for all samples was increase for all sintering temperatures. At this stage, the densification process occurs (German 1996, sufizar ahmad 2010). However, the changes are not too obvious. When more particles of titanium are present in the sample, the porosity of the sample decreased and thus the density of the sample would increase (Yan et al. 2008, Li et al. 2005). The density and porosity can affect the mechanical properties of the samples.

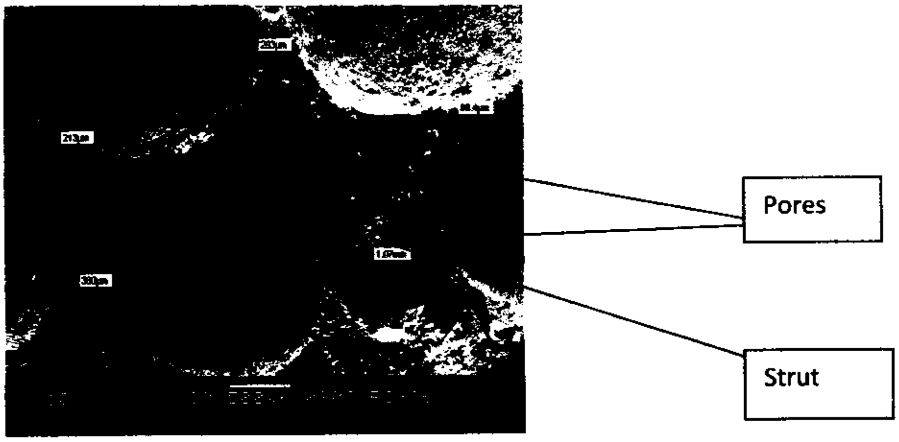

Figure 3: SEM micrographs of pure Titanium foam sintered in the tube furnace. The magnification for the sample is 30X

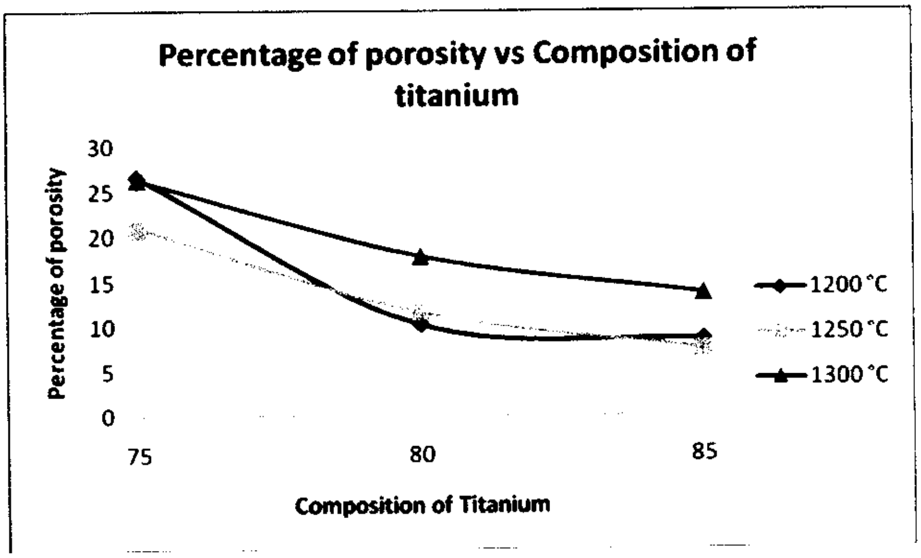

Figure 4: The effect of pure titanium foam content and sintering temperature on the percentage of porosity for the titanium foams

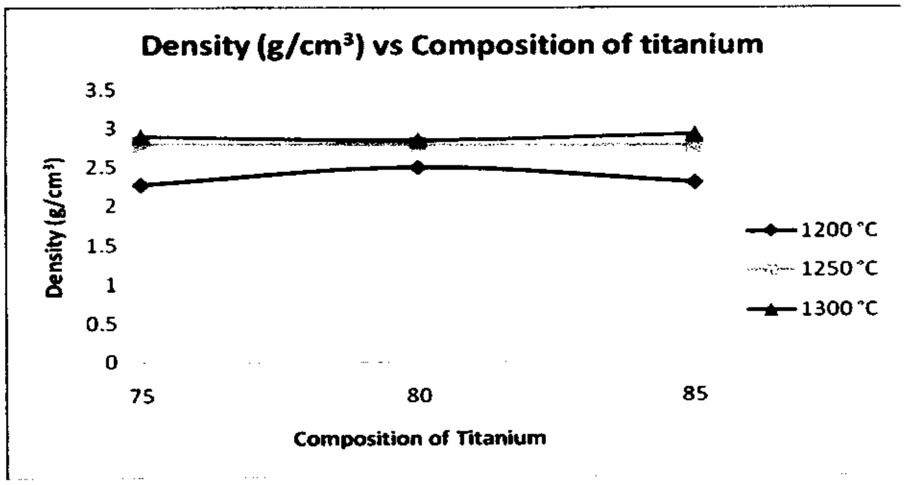

Figure 5: The effect of pure titanium content and sintering temperature on the density of the titanium foams

CONCLUSION

Pure titanium foam was successfully produced by compaction method. From the results gained, not all samples achieved the porosity of 20-30% except for the composition titanium of 75% in all sintering temperatures. The result for density test also did not follow the research before but it still acceptable because this is primarily test for this method. The sintering parameter also plays a critical factor to produce the best pure titanium foams. For further research, the compressive strength of these samples will be investigated.

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