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# Effect of Powder Size on Titanium Mechanical Properties

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***Abstract –*** Titanium and its alloys are increasingly used in aerospace, automotive and biomedical industries because of their high strength, excellent corrosion, wear resistance and a wide range of mechanical properties. Materials with superior properties are needed in many industries and composite materials also meet this need because of their extraordinary properties. In the production of composite materials with powder metallurgy, the powder size is very important. In this work, we investigated the effect of titanium powder size on mechanical properties. In experimental studies steps are as follows: different size of titanium powders (≤150µm, ≤43 µm, ≤30 µm) were compacted and then sintered at 1100$^0$C for 120 min. Compared the other size of powder, the highest Vickers hardness (420 HV) and ultimate compressive strength (920 MPa) test results were obtained with ≤30 micron size of pure titanium.

*Keywords – Titanium, powder metallurgy, hardness, compressive strength*

## I. Introduction

Nowadays Titanium and titanium alloys are recently being used in many areas, due to high strength and high corrosion resistance. It is used not only in the aviation industry but also in the medical, energy, marine and biomaterial industries. Ti-based materials have a high biocompatibility and elastic modulus which is similar to the characteristics of bone. This feature is very good for biomedical applications. Titanium and titanium alloy are also use as a matrix materials in metal matrix composite because of in the field of using [1-2].

Generally, titanium matrix composite can be produced with various methods such as powder metallurgy (PM), melting, and squeeze casting. PM is the most preferred method because of it is applicable for the production of large-scale and complex-shaped parts [3-4].

In the production of composite materials, the particle size is very important in order to make the structure more dense and have good mechanical properties. For this reason, titanium particle size is very important in titanium matrix composite production to develop mechanical properties [5].

In this work, investigated the effect of various powders size (≤150µm, ≤43 µm, ≤30 µm) on titanium mechanical properties. PM method was used and Vickers hardness and compressive strength tests were performed for this purpose.

## II. Materials and Method

In this work, different particle sizes of Ti powder (particle size of (≤150µm, ≤43 µm, ≤30 µm and density of 4.5 g/cm$^3$) were used as a matrix material with a purity of 99.8% [6]. Different size of Titanium powders were fabricated by PM as given in Fig. 1. As seen in Fig. 1, firstly, each mixture was blended in ethanol medium with ultrasonic mixer approximately and then the mixed powders were ground with a ball mill. Then, the mixed powders were shaped in a 10-mm diameter stainless steel mold at 900 MPa. After shaping titanium samples were heated with tube furnace under vacuum at 1100$^0$C for 120 min. Then the production of titanium samples mechanical tests were done. Then the obtained titanium samples mechanical tests were performed.

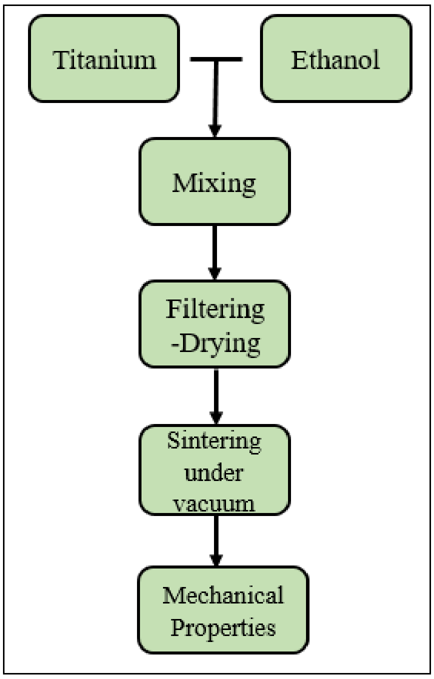



Fig.1.Schematic diagram of titanium fabrication by using PM method

## III. Results

Micro vickers hardness tester (HV 1000B) was performed under a load of 500 g (HV 0.5) and waiting time of 15 s. The measurement was done six times and averaged for each sintered sample at different parts on the surface of the polished samples. From the mechanical tests after sintering at 1100°C for 120min. Samples have been labeled in this study as follows: the ≤30 μm powder size of titanium samples labeled as P30 and in the same manner, successively. (Table1).

Table 1. Codes of samples

| Titanium Powder Size (μm) | Samples Code |
|---|---|
| ≤30 | P30 |
| ≤43 | P43 |
| ≤150 | P150 |

As shown in Fig. 2, the highest hardness (420HV) was obtained with P30. The hardness value of the P150 is reduced. As shown in Fig. 3, the greatest ultimate compressive strength result was obtained for P30 (920MPa) when compared to other size of titanium P43 and P150 (826MPa and 659 MPa).

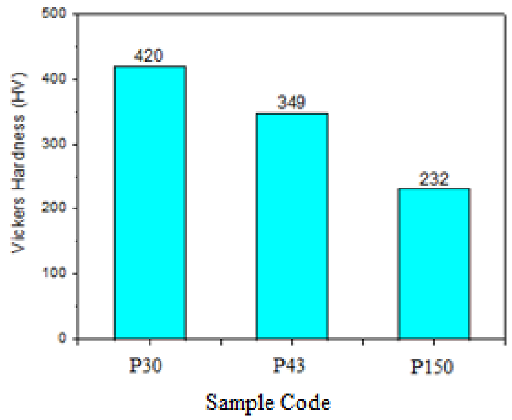
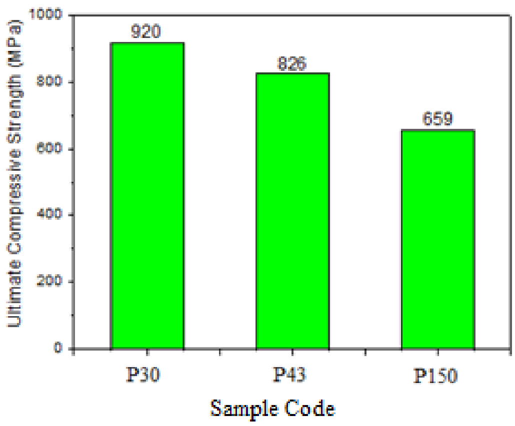



Fig.2.Vickers hardness test results of different powder size of titanium




Figue 3. Ultimate Compressive Strength (UCS) test results of titanium powder

## IV. DISCUSSION

The highest hardness (420HV) and also ultimate compressive strength (920MPa) results were obtained with P30. This is because, strong neckings are formed between powder particles during sintering and then the grains are formed. More grain boundaries are occured in small grain size (≤30 μm) materials than large size (≤150 μm). When the material is deformed, dislocations encounter more grain boundaries. Therefore, it is necessary to apply more force to deform the material. In addition, when working with a small size of powder (≤30 μm), a more dense structure is obtained during pressing and sintering process in powder metallurgy method.

In the production of composite materials, P43 can be preferred as a matrix material. Because of its Vickers hardness (349HV) and UCS test (826MPa) results were good. Since it is a very small powder size of P30, it can tend to flake while the composite material is being produced.

## V. CONCLUSION

Different particle size (P30, P43, P150) titanium powders were successfully fabricated by PM method. Effect of powders size on titanium mechanical properties were studied.

The greatest hardness (420 HV) and compressive strength (920MPa) were performed at 1100$^0$C for 120 min. for the size of ≤30 μm titanium. At the sintering process between contacting parts, a neck is occured. Titanium particles interface interaction decreased the pore size so we obtained a more dense structure. This study shows how important the powder size of the matrix material is in the production of composite materials. In addition, further studies can show that working with P30 can produce better results.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