Synthesis and Characterization of Ti6Al4V Alloy by Powder Metallurgy

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Abstract

Experimental investigations were undertaken in order to understand the densification behavior and mechanical characterization of Ti6Al4V alloy by cold compaction operation. The preforms were prepared out of mixed elemental powders of Ti (90%), Al (6%), and V (4%) and compacted by 100 Ton hydraulic pressing machine with several designated loads of 22.5,28,30 and 32.5 tons, and the densities were calculated. Then the green compact having maximum density was immediately sintered in1800 c capacity High Temperature Tubular furnace with argon atmosphere up to 1250c with choking time of 2 hrs and followed by cooling to room temperature in the furnace itself. Alloy powder was characterized by scanning Electron Microscope and XRD and sintered Ti6Al4V was characterized by uniaxial compression test.

Keywords: *Cold Compaction, Sintering, Scanning Electron Microscope, XRD, Compression test*

I. INTRODUCTION

Ti–6Al–4V widely used as medical implants because of their excellent surface oxide biocompatibility, corrosion resistance and strength [1]. The high stiffness of the implant can however cause stress shielding, leading to deterioration of the bone [2].

Titanium alloys possess a unique combination of high strength, low density and good corrosion resistance which makes them very attractive for many structural applications. However, the cost of titanium produced by conventional ingot technology is high compared to steel and aluminum, thus limiting their use in automotive applications [3]. A powder metallurgy approach is a viable and promising route for cost effective fabrication of titanium alloys [4-7] A blended elemental (BE) method is potentially the lowest-cost titanium components manufacturing process for the titanium-aluminium- vanadium alloy Ti-6Al-4V, The most cost-effective PM processes are based on the use of low-cost blended elemental (BE) technology where alloying elements are added to titanium as elemental or master alloy powders [8, 9].

2. EXPERIMENTAL STUDY

In this study Titanium powder 99% purity was supplied by Kemphasol, Mumbai, Aluminium fine powder was supplied by Lobachemi, Mumbai and Vanadium was supplied by Aesar Alfa. Titanium powder 90% weight, Aluminium powder 6% weight and Vanadium 4% weight were used for mechanical alloying of Ti6Al4V. All the powders were mixed in a high energy ball mill (Fritsch-Pulverisette-6) to obtain homogeneous alloy.

The powders were compacted by using suitable punch and dies set assembly [Fig1] and 100 Ton hydraulic pressing machine [Fig2] at several designated loads: 22.5,28,30 and 32.5 tons to make cylindrical specimens with 31mm diameter and average height of 22.85 mm [Fig3]. Densities of the specimens were recorded at each step by measuring the weight and the volumes of specimens, [Table1]. As titanium is very active and easy to be polluted, no lubricant or binder was added into the powder. But before powder filling, the die wall was lubricated with zinc stearate dissolved in acetone to facilitate the ejection of the samples.

Then the green compact having maximum density was immediately sintered in1800 c capacity High Temperature Tubular furnace [Fig4] with argon atmosphere up to 1200c with choking time of 2 hrs and followed by cooling to room temperature in the furnace itself. Compression test specimen of size (10mmX10mm) [Fig5] was then obtained from sintered specimen by wire-cut EDM. The mechanical test was performed on a MTS servo-hydraulic test machine in compression.

[Fig1] Die and Punch assembly

[Fig2] 100 Ton Hydraulic Press

[Fig3] Ti6Al4V Green compacts

Table (1) Densities obtained for various compaction loads

Specimen no.	Load in tons	Density Grms/cc	Density %
A	22.5	2.52	55.55
B	28.0	3.20	71.11
C	30.0	3.80	80.00
D	32.5	4.20	93.33

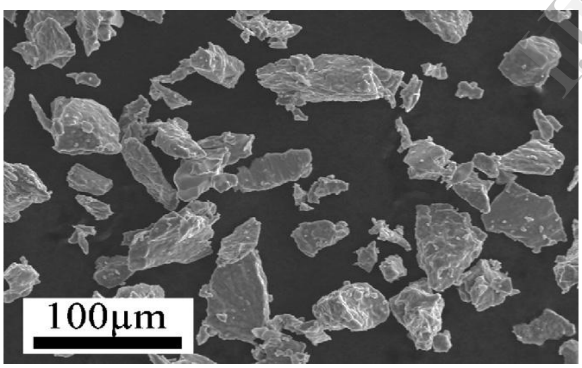
[Fig4] 1800c Capacity Tubular Sintering Furnace

[Fig5] 10mmX10mm Compression Testing Specimen.

3. RESULTS AND DISCUSSION

3.1 Powder characterization

Scanning electron microscopy of photomicrograph of Ti64 alloy powder is illustrated in Fig5, the powder has angular shape.



[Fig6] SEM image of Ti6Al4V Alloy Powder

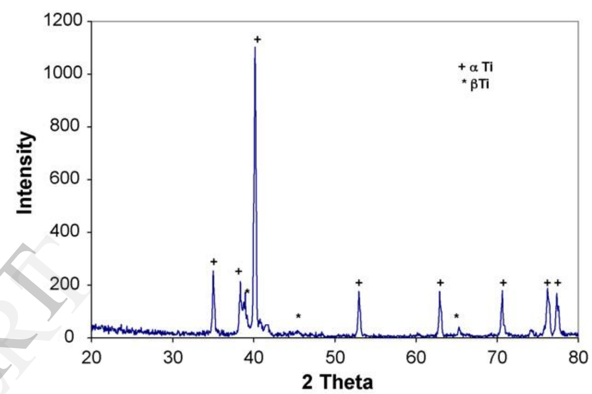
3.2 Density and compaction load relationship

Density of die-pressed Ti64 alloy increase monotonically with increasing load, the densities obtained from various aspect ratios are shown in table.1

3.3 Sintered specimen characterization

3.3.1 X-ray diffraction analysis

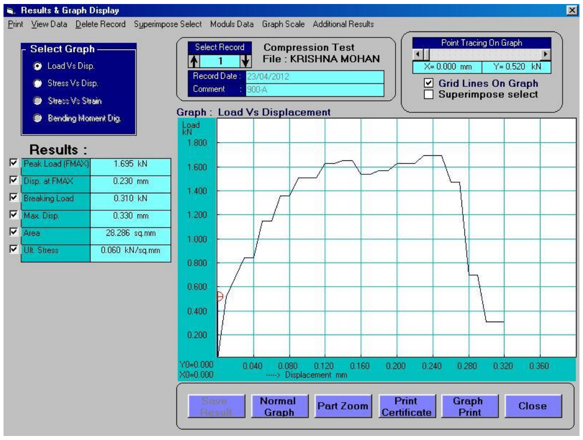
Fig. 6 shows XRD pattern of Ti–6Al–4V sample after sintering at 1250 ◦C for 2 h. It can be seen that the only phases identified are α and βTi. There were no other phases identified by XRD, i.e. the space-holder was removed completely and there was no any chemical reaction or contamination during decomposition of sintering cycle.



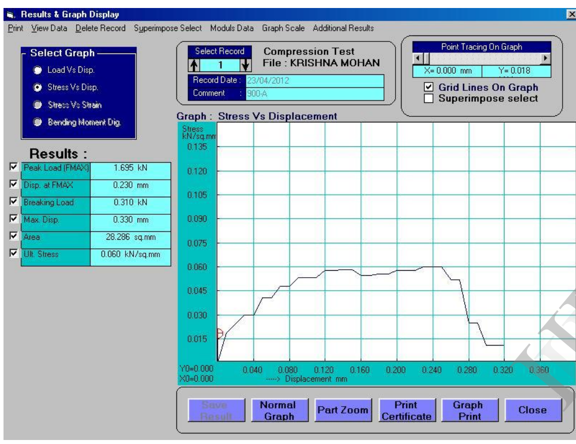
[Fig6] XRD pattern for Ti–6Al–4V sintered at 1250 ◦C for 2 h.

3.3.2 Compression test analysis

The results of compression experiments are shown in Fig [7] and Fig [8] the graph plotted Load Vs Displacement and stress Vs Displacement. The results obtained for sintered Ti6Al4V are peak load as 1.695KN, breaking load as 0.310KN and ultimate stress as 0.060KN/sq.mm.



[Fig7] Compression test Result (Load Vs Displacement)



[Fig8] Compression test Result (Stress Vs Displacement)

4. CONCLUSIONS

The study has been carried for Ti6Al4V alloy by cold compaction powder metallurgy route. The basic conclusions that can be drawn from the present investigation are as follows:

1. Titanium alloy successfully compacted and sintered
2. Titanium alloy powder was characterized by scanning electron microscope
3. Lower aspect ratio exhibits improved density when compared to that of higher aspect ratio performs.
4. Cold compaction parameters were arrived
5. Sintered Titanium alloy was characterized by XRD
6. The compression test results obtained for sintered Ti6Al4V are peak load as 1.695KN, breaking load as 0.310KN and ultimate stress as 0.060KN/sq.mm.

5. ACKNOWLEDGEMENTS

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