

## Evaluation of Coefficient of Thermal Expansion of Ti-6Al-4V Alloy By Ansys

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### Abstract

Various materials are used to achieve a good “Thermal Control System” (TCS) of spacecraft. The need for lightweight, dimensionally stable materials for critical aerospace applications opened new frontiers in the development of advanced materials. Powder metallurgy technique was used to fabricate the Titanium-6Al-4V alloy. Coefficient of thermal expansion of composites must be known for design purposes. The heat flow response is recorded as a function of actual sample temperature range from 0<sup>o</sup> C to 100<sup>o</sup> C. FEA was performed to determine thermal expansion. Three-dimensional shapes were modelled with two-dimensional axisymmetric elements in ANSYS was used.

**Keywords:** Composites, Coefficient of thermal expansion, FEA, ANSYS.

### Introduction

An increase in demand of Ti-6Al-4V alloy due to the increased efficiency and higher operating temperatures of aero-gas turbine engines. Titanium and its alloys have excellent combinations of structural properties such as high strength to weight ratio, high rigidity, high elevated temperature properties and good corrosion resistance [1,2]. Powder metallurgical (P/M) processing using blended elemental (BE) powder [3] is promising for making low-cost titanium components because the process utilizes titanium powder in the form of inexpensive sponge fines and is capable of near-net shape forming. The initial BE titanium components, however, have found only limited applications because of serious drawbacks in mechanical properties caused by residual pores and residual chlorine when using high chlorine-containing titanium sponge fines as starting powder [4-6]. The BE process has also been adapted to develop titanium metal matrix composites reinforced with particulate materials to achieve enhanced wear properties and elastic modulus [6 –9]. The process consists of mixing titanium powder with reinforcing powders SiCp compacting the mixture,

vacuum sintering to produce fully dense products with superior mechanical properties. It is very difficult to machine titanium alloys [10] with traditional mechanical cutting. The diamonds are bound by compression derived from shrinkage upon sintering, and the compressive stress arises from differences between the coefficients of thermal expansion (CTEs) of diamonds and metal matrix augmented by any volume change [11]. The thermal expansion mismatch between diamonds and metal matrix induces residual stress at the interface, which is responsible for retention capability [12]. In this work the alloys Ti-6Al-4V alloy were prepared by cold pressing. The CTEs of Ti-6Al-4V alloy were simulated by finite element analysis (FEA). A computational strategy was developed to forecast the coefficient of thermal expansion between the Ti-6Al-4V with different thermal expansion properties.

## **Experimental Procedure**

### **Specimen Fabrication and Test Methods**

Titanium powder 90% weight, Aluminium powder 6% weight and Vanadium 4% weight were used for mechanical alloying to make Ti-6Al-4V alloy. 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 die.

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 sintered in 1200°C with high Temperature Tubular furnace with argon atmosphere was used for sintering holding time of 2 hrs and followed by cooling to room temperature in the furnace itself. Compression test specimen of size (10mm×10mm) was obtained from sintered specimen by wire-cut. The mechanical test was performed on a MTS servo-hydraulic test machine in compression.

### **Finite Element Modelling**

FEA was performed to determine Heat flux in each Ti-6Al-4V particle after the cooling stage of the sintering process. Symmetric conditions were used for embedded in the matrices. Three-dimensional shapes were modelled with two-dimensional axisymmetric elements, and ANSYS element Solid 8node77 and reduced integration points was used. The solid particles were assumed to be isotropic linear elastic with Young's modulus  $E=114\text{GPa}$  and Poisson's ratio  $\mu=0.33$ . Simulation was performed for the CTEs of solid circular at different temperatures in figures and those of the three matrices were experimentally obtained.

CTEs were determined from 0°C temperature to 100°C using a high-precision thermal mechanical analyser (TMA) at a cooling rate of 25°C. Data were collected in terms of linear change (LC) with respect to temperature.

## Results and Discussion

### Influence Ti-6Al-4V alloy on LC and CTE

The experimentally obtained LCs of the three matrices are shown in Fig. 1. The LCs of all matrices increase with increased temperature, and the LCs of the heat flux are higher than that of the matrix without reinforcement.

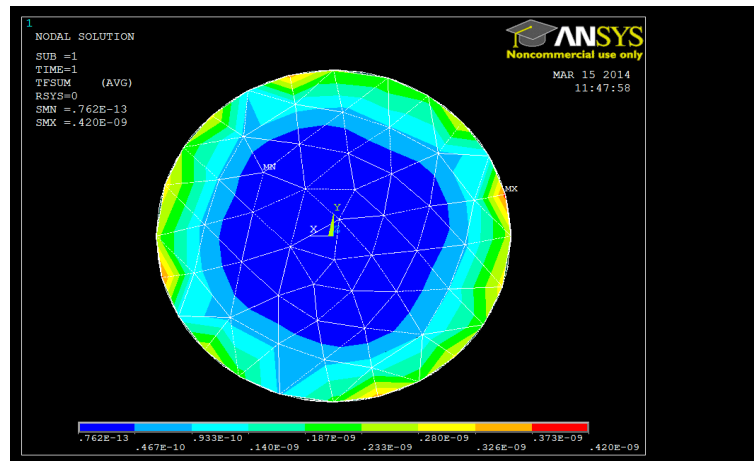


Figure 1:

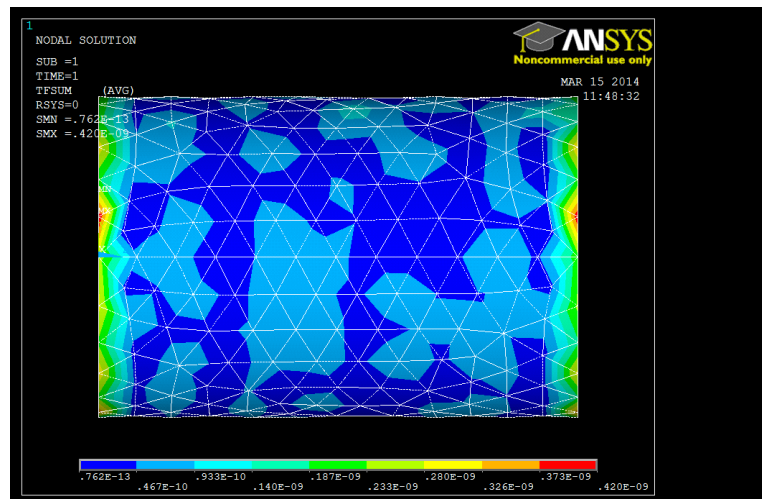
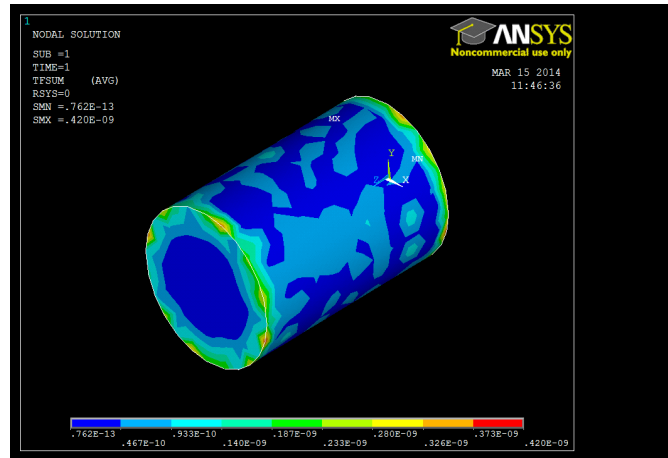


Figure 2:

### Influence of Different Heat Flux In The Cylinder

The FEA results of the thermal stress fields of the node matrices are shown in Figs. 2 and 3. Two kinds of heat flux distribution exist after cooling. The definite heat flux are quite inferior when change temperature. Here we can able to determine the coefficient of thermal expansion.



**Figure 3:**

## Conclusions

The CTEs and heat flux of Ti-6Al-4V alloy studied by experimental and FEA. The CTEs of matrices with increased with increased temperature. The CTEs of the Ti-6Al-4V is high in the temperature range 75°C to 100°C.

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