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SIMULATION OF HEAT CAPACITIES OF Ti-6Al-4V ALLOY/ NANO SiCP COMPOSITES BASED ON ANSYS

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ABSTRACT

The high strength, low weight ratio and outstanding corrosion resistance inherent to titanium and its alloys has led to a wide and diversified range of successful applications which demand high levels of reliable performance in aerospace, automotive, chemical plant, power generation, oil and gas extraction, sports, and other major industries.Ti-6Al-4V alloy was used as a matrix and SiC_p was used as Reinforcement. Ti-6Al-4V alloy with different percentage of (10%, 15%, 20%) nano SiC_pComposites were fabricated through Powder mettalurgy route.To cater the needs of various requirements in aspacecraft making, a wide variety of materials are used. Besides, the indigenization efforts and development of new materials for space-use emphasizes the measurement of Cp before their actual use. Specific heat measurement must be also known for design purposes. Thermal calculation using finite element method is employed to solve the temperature dependent specific heat capacity via ANSYS and the three dimensional transient heat transfer problem was solved. In this study, the specific heat capacity of the Ti6Al4V alloy and Ti6Al4V/Nano-SiCp composites in the temperature range of 173K to 648K are determined.

Keywords: Composites, Heat capacity, FEA, ANSYS

1. INTRODUCTION

An increase in demand of Ti-6Al-4V alloy is 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 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 –8]. The process consists of mixing of titanium powder with reinforcment, vacuum sintering to produce fully dense products with superior mechanical properties. A simulation of a system is the operation of a model of the system. The model can be reconfigured and experimented with; usually, this is impossible, too expensive or impractical to do in the system it represents. The operation of the model can be studied, and hence, properties concerning the behavior of the actual system or its subsystem can be inferred. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time.[9]

2. EXPERIMENTAL PROCEDURE

2.1. Specimen fabrication and test methods

Ti-6Al-4V alloy with different percentage of (10%, 15%, 20%) nano SiCp Composites were fabricated through Powder mettalurgy route. Titanium powder 90% weight, Aluminium powder 6% weight and Vanadium 4% weight were mechanical alloyed to make Ti-6Al-4V alloy. All the powders were mixed in a high energy ball mill (Fritsch-Pulverisette-6) to obtain homogeneous alloy. Silicon carbide powder (SiC) was pulverized in a high energy ball mill to make nano size.

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.The powders were compacted by using suitable punch and die.

The green compacts are sintered in the high Temperature Tubular furnace with argon atmosphere. Choking time of 2 hrs was maintained and followed by cooling to room temperature in the furnace itself. The cylindrical specimens of dimensions 3 ± 0.1in diameter and 2.5 ± 0.1mm in length[10] were machined from the hot extruded rods with the help of wire cutting machine for the specific heat [C_p] test in the differential scanning calorimeter [DSC].

2.2. Finite element modelling.

The specific heat capacity of Ti6Al4V alloy analytically determined based on time-varying surface temperature and its temperature-dependent thermal conductivity using thermal analysis approach. The measurement of heat capacity (Cp) has been generally regarded as ultimate test for characterizing a material, as it is a bulk property that gives more information for thermodynamic studies. [11] Three dimensional transient heat transfer analysis was solved by ANSYS (Element Tet 10node87). Thermal calculation using finite element method is employed to solve the temperature dependent specific heat capacity via ANSYS. In this study, the alloy and composites were chosen for the ANSYS APDL analysis in temperature range between 173K and 648 K with heating rate 293.15 degree Kelvin per minute raise. The diameter of the specimen (D) = 3 mm and length of the specimen (L) = 2.5 mm and the considered material properties are shown in the Table.1.

Table.1. Materials properties of Ti6Al4V alloy and Ti6Al4V/ Nano - SiCp

Materials	Modulus of elasticity(Ex) GPa	Density, g/cc	Poisons ratio(μ)	Thermal conductivity (K),w/m-k
Ti6Al4V Alloy	113.00	4.43	0.300	6.70
Ti6Al4V/10%Nano-SiCp Composites	143.00	4.29	0.321	18.00
Ti6Al4V/15%Nano-SiCp Composites	158.23	4.23	0.321	24.40
Ti6Al4V/20%Nano-SiCp Composites	173.04	4.164	0.3016	30.36

3. RESULTS AND DISCUSSION

Cylinder was taken for the nodal solution of the specimen with minimum result value on plot (SMN) as 173K and maximum value on the plot (SMX) as 648K. The specific heat value predictions compared with each other, with the available experimental data and with the finite element results of Ti6Al4V alloy and Ti6Al4 /Nano-SiCp composites and are shown in Figures 1-4

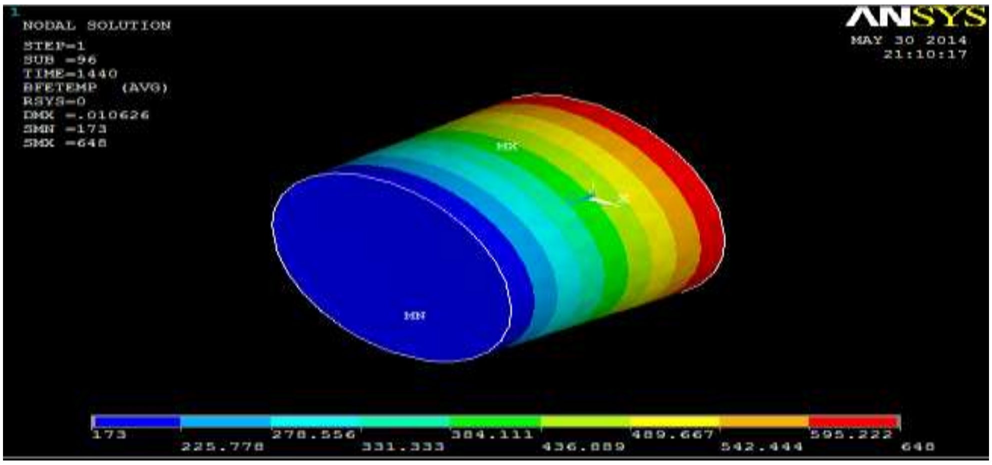

Fig 1. FEM model of Ti6Al4V alloy specific heat capacity

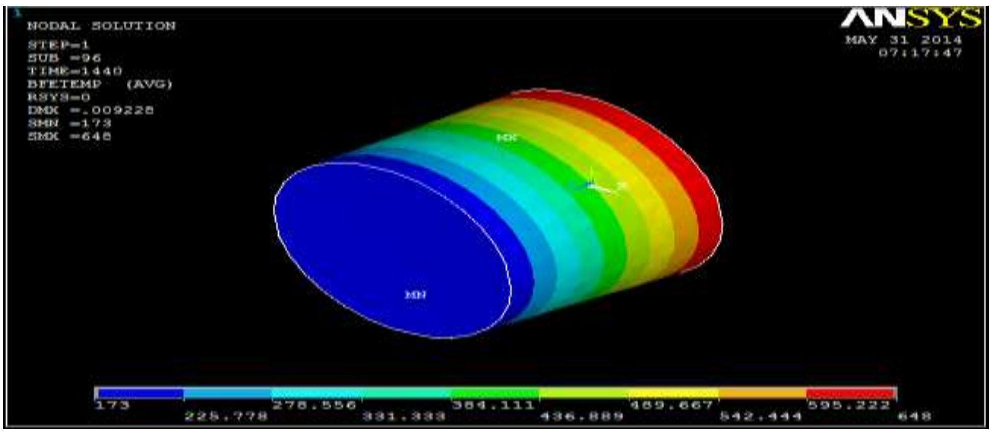

Fig.2. FEM model of Ti6Al4V/10% Nano-SiCp specific heat capacity

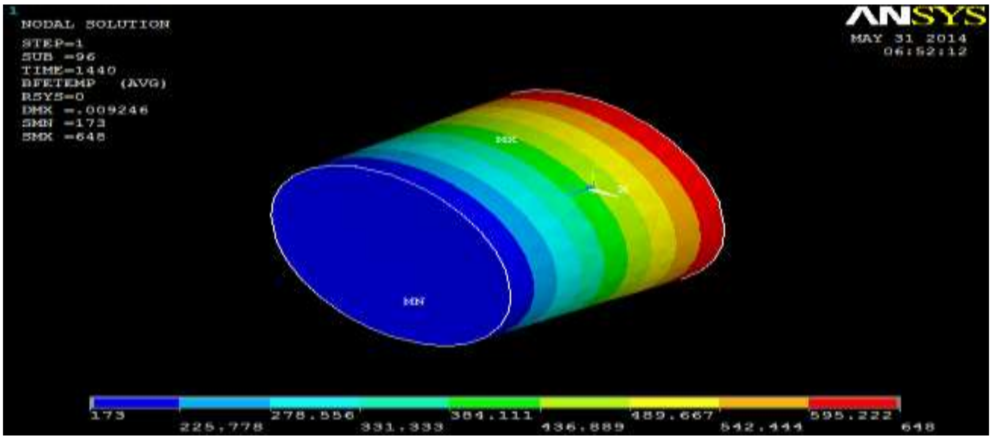

Fig.3 FEM model of Ti6Al4V/15% Nano-SiCp specific heat capacity

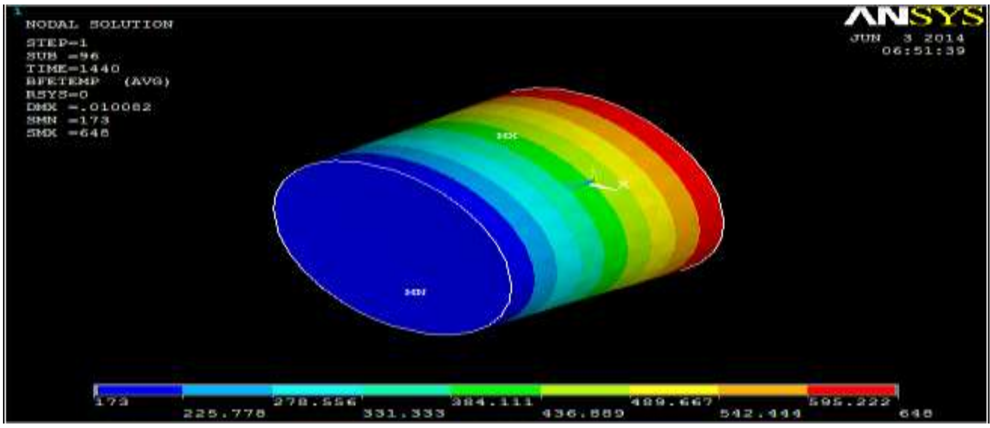

Fig.4 FEM model of Ti6Al4V/20% Nano-SiCp specific heat capacity

Heat capacity predictions compared with the available experimental data and with the finite element results of Ti6Al4V alloy and Ti6Al4V / Nano-SiCp composites. The comparisons of these model predictions with experimental data hold good agreement with each other and minor discrepancies are also notified. The heat capacity predictions using FEM is shown in Table.2.

Table. 2. Model prediction deflection values (Cp)

Material	**Ti6Al4V Alloy**	**Ti6Al4V/10% Nano-SiCp**	**Ti6Al4V/15% Nano-SiCp**	**Ti6Al4V/20% Nano-SiCp**
Deflection	0.010626	0.009228	0.009246	0.010082

It is observed that the Cp values of alloy and composites increases with increase of reinforcement particles as observed from the experimental values. The experimental heat capacity value of Ti6Al4V/10%Nano-SiCp Composite has good agreement with model prediction data. The Cp values of Ti6Al4V/ 10%Nano-SiCp composite is low when comparing with alloy and other composites. For a good heat material, it is desirable to have low Cp property [10].

Conclusions

A FEA model has been developed by ANSYS to analyze the temperature distribution and deflection in Ti-6Al-4V alloy and Ti-6Al-4V/ nano SiCp Composites. The temperature range from 173K and 648 K was taken for analysis and simulated by the ansys. The heat capacities of matrices are increased with increase of temperature. Ti-6Al-4V / nano 10% SiCp Composites shows the lower deflection when compared to Alloy and other Ti-6Al-4V/ SiCp Composites.

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