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Studyof Wear Behaviour of Titanium Metal Matrix Composite Reinforced With High Entropy Alloy

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ABSTRACT

In the present work, we want to increase the existing higher specific strength of the material made of Titanium and its alloys by adding the secondary phase reinforcement in the form of metal matrix composite. Here, we will be preparing the Titanium Metal Matrix Composite with High Entropy Alloy [$(AlSi)_{0.5}CrCoNi$] as reinforcement by powder metallurgy route with a uniaxial compaction. The MMC samples are heat treated for 1 and 2 hours at different temperatures under vacuum of 10^{-5} milli bar. The effect of soaking time and the sintering temperature on wear behaviour of MMCs must study. The increase in secondary phase (HEA) volume percentage must study the wear resistance of the Ti-MMC. The coefficient of friction (COF) slightly decreases with increasing temperature. The XRD show the presence of new phase/compound when the MMC is heat treated at 900 ℃ and considerable rise in the hardness values. The MMC samples are further characterized for density by Archimedes principle. The microstructure analyzed by Scanning Electron Microscope.Due to the lighter weight high strength materials, titanium metal matrix composite is used in aerospace applications. Introduction of titanium MMC into high performance engine applications overcomes the problem of high material and implementation cost of composite rotor fabrication.

KEYWORDS:High entropy alloy, Metal Matrix Composite, Vacuum Heat treatment.e

1. INTRODUCTION

Composite:

Composite is a multiphase material from a combination of materials, differing in composition or form, which remain bonded together, but retain their identities and properties. The components do not dissolve or completely merge instead maintain an interface between each other and act in coherent to provide improved, specific, or synergetic characteristics not obtainable by any of the original components acting singly. Different materials are combined to create a composite with superior properties. In this sense, metal matrix composites seek to combine the high strength and stiffness of a ceramic with the damage tolerance and toughness provided by the metal.

Metal matrix composites:

Metal matrix composites consist of a metal or an alloy as the continuous matrix and a reinforcement that can be particle, short fiber or whisker, or continuous fibre. Metal matrix composite can be defined as the materials having a microstructure of continuous metallic phase into which second phase is introduced with a purpose of enhancing the matrix phase properties. Applications in various fields due to high specific strength, better wear properties, improved stiffness etc. Normally the matrix material used are Aluminium, titanium and other alloys owing to high strength to weight ratio.

Based on the form of the reinforcements used, there are three kinds of metal matrix composites (MMC):
• Particle reinforced MMCs
• Short fiber or whisker reinforced MMCs
• Continuous fiber or sheet reinforced MMCs

Table 1. provides examples of some important reinforcements used in metal matrix composites and their aspect (length/diameter) ratios and diameters. Particle or discontinuously reinforced MMCs have become very important because they are inexpensive than continuous fiber reinforced composites and they have relatively isotropic properties compared to fiber reinforced composites.

Table 1: shows the typical reinforcement in metal matrix composite.

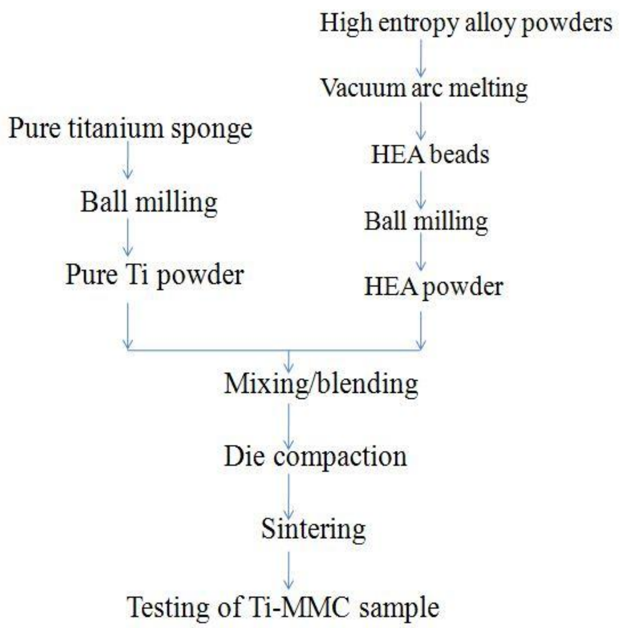
Type	Aspect ratio	Diameter (μm)	Examples
Particle	~1–4	1–25	SiC, Al_2O_3, WC, TiC, BN, B_4C
Short fiber or whisker	~10–1,000	0.1–25	SiC, Al_2O_3, Al_2O_3 + SiO_2, C
Continuous fiber	>1,000	3–150	SiC, Al_2O_3, Al_2O_3 + SiO_2, C, B, W, NbTi, Nb_3Sn

Generally used powder particle reinforcement in Ti-MMC includes TiC, TiN, TiB, TiB_2, TiO_2, Si_3N_4, SiC, oxides, rare Earth oxides & intermetallic compounds.

2. EXPERIMENTAL PROCEDURE

The Manufacturing of metal matrix composite is of many ways based on the chemical and physical properties of matrix and the reinforcement. In this process commonly used as matrix as Titanium and reinforcement as High Entropy Alloy.

Before going to the preparation of high entropy alloy, we need to know how much weight % of elemental metals are required for the process. To take the required quantities, first we need to calculate the weight% for 100 grams of the HEA. As the capacity of each crucible is 30 grams in Vacuum Arc melting furnace, further we need to calculate for 30 grams.



Flow chart for Synthesis of HEA reinforced Ti-MMC.

Initially the amounts of metals to be taken for making high entropy alloy is calculated and tabulated as

Table 2. The composition of the High Entropy Alloy.

Sl.No.	Element	Atomic Weight (amu)	Atomic%	Weight%
1	Al	26.98	12.5	6.70
2	Si	28.09	12.5	6.98
3	Cr	51.99	25	26.90
4	Co	58.93	25	29.29
5	Ni	59.68	25	29.18

Secondly, the metals that are used in making the high entropy alloy is taken in the form of the blocks, granules and melted in the Vacuum Arc Melting Furnace.
NOTE: Make sure that all the metals are not in the form of powder as this leads to the spilling of metals during melting with the help of vacuum arc melting furnace.

A pure titanium sponge (99.99 %) powder is used as matrix for the composite. The sponge is crushed and ball milled for 6 hours with a ball to powder ratio 5:1. The purpose of this milling is to reduce the size of titanium powder. The reinforcement is powder particle of high entropy alloy of the composition shown in the Table 2. The alloy is prepared by arc melting in a laboratory arc melting furnace. The alloy is melted 6 times by flipping the alloy each time after melting to get uniform composition. The melted high entropy alloy is crushed manually and then ball milled with a ball milled with balls to powder ratio of 6:1 for 7 hours to get uniform powder particle. After power production done, titanium powder is mixed with HEA powder in the volume ratios of 10%, 15%, 20%. Mixing is done in the ball mill without any balls for 60 minutes to get homogenous mixing of HEA powder and matrix powder. 0.3 wt% Abron binder is added to get green strength for handling the compacts before heat treatment. The mixed powder along with the binder is compacted by uniaxial compaction at 900 to 1000 MPa. The pressed samples are heat treaded for 1 to 2 hours at 700,800, 900° C in the tabular under the vacuum of 10^{-5}millibar. The heat-treated samples are polished and etched with reagent. The MMC samples are microstructure characterization is analyzed by SEM. The Heat-treated samples are analyzed by XRD to identify any new phases found. Hardness of the samples is carried out using Vickers hardness tester, density by Archimedes principle and Wear testing by using pin on disc.

3. CONCLUSIONS

To study the wear properties of Ti metal matrix composite with HEA. To study the friction behavior of Ti metal matrix composite with HEA at high temperature. To study the effect of Heat treatment on the microstructure of the HEA reinforced Ti MMC. The increase in volume % of HEA to Titanium the properties of Ti have to increases or decreases will be study. Find the microstructure and phases present in the HEA reinforced Ti MMC by the XRD and SEM equipment.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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