CHARACTERIZATION OF B_4C REINFORCEMENT ON TI-6AL-4VSINTERED COMPOSITE PREPARED BY SOLID-STATE AND POWDER PROCESSING TECHNIQUE METHOD

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ABSTRACT-In this study Titanium, Aluminum, Vanadium and boron carbide powders were milled separately in plantery ball mill for various milling time period. The properties of reinforcement particle size and weight percentage on plastic deformation behavior of composite powders were investigated. For every 1h the samples morphology was tested by using Scanning electron microscopefinally the individual powders were mixed with weight basis to produce novel Ti-6Al-4V-B_4C composites. These composites were examined by again Scanning electron microscope to found the uniform distribution of the particles. The FT-IR spectra was used to confirm the presence of boron carbide particles in the base material. From the observation milling time period, reinforcement size and reinforcement content were strongly affecting the particle size and micro hardness of the composite powders.

***KEYWORDS*-Ti-6Al-4V, Boron carbide, SEM, FT-IR, Hardness.**

INTRODUCTION

The improvement of metal matrix composites (MMCs) is the result of emerging interest to scientific and industrial societies, due to their attractive physical and mechanical properties [1-3]. Particularly, particle incorporated titanium matrix composites have attracted significantconsideration, because of their high strength and good corrosion resistance. One of the major alloys Ti-6Al-4V has been used in aircraft, turbines and surgical implants due to its heat treatment ability, adequate mechanical strengthand good corrosion resistance. For these kinds of applications mechanical and tribological properties such as hardness and wear need to be balanced sensibly along with low density and homogeneous microstructure almost free of porous.Presence of Al as an alloying element improves the grain refinement efficiency of B_4C particles via improving the wettability. Presence of V as an alloying element improves the rust resistance.The proposed secondary particle boron carbide has attractive properties like high strength, low density, extremely high hardness, good wear resistance and good chemical stability. In the case of metal matrix nano composites, incorporation of small volume percentage of boron carbide particles leads to a much greater increase in strength than with micron sized additions [4-6]. Moreover the properties of the particle dispersed alloys, the nano sized B_4C particles should be incorporated homogeneously in the titanium matrix composites where the constructive effect of the particle dispersion becomes more substantial with decrease in particle size. The distribution of the secondary particles depends on the processing route and also as well as the size of the matrix particles in relation to that of the reinforcement particles [7-10]. Among the various processing techniques, a mechanical ball-mill technique is simple and cost- effective method to produce fine and homogeneous powders. A decrease in secondary particle size has increase in both mechanical strength and wear resistance of the composites. Therefore an appropriate selection of particle size may enrich the homogeneity in particle distribution.

The P/M method is most suitable technique to distribute the secondary particle in even manner and also that to avoid the interfacial reaction between matrix and reinforcement, to chance of adding higher amounts of reinforcement and controlling microstructure of the phases are the most advantages of P/M method. However, reinforcement agglomerates were formed in the combined composite material, particularly in the case of small size reinforcement particles. Mechanical alloying is one of the P/M techniques that produce uniform dispersion of the secondary particles in the matrix material [11, 12]. This process consists of repeated grinding of a mixture of powder particles in a high-energy ball mill. Increasing attention has recently focused on the nanostructured metal matrix composites due to superior properties in comparison to the conventional micro structured composites.

The present study deals with investigate the effect of particle size and reinforcement content on properties, morphology of nano crystalline Ti-6Al-4V-B_4Ccomposite powders and to observe the effect of ball milling time on the particle size and micro hardness of the milled powders for different milling time period.

EXPERIMENTAL PROCEDURE

The Titanium, Aluminum and Vanadium powders were purchased in 99.95 % Purity from M/s. Alfa Aesar, United States and the boron carbide particles were purchased in 99.9% purity from M/s. Sigma Aldrich, Germany. These powders purity were confirmed by test certificate provided by company itself. Fig.1-4. shows the SEM image of the as received powders and corresponding FT-IR spectra. The FT-IR peak has obtained in the region 1071.50 and 1548.84 for B_4C. These 1071.50 peak were

B=O and 1548.84 peak were B=OH peak, irrespective of born carbide. For pure metals there has no peaks were found, because of IR spectrum was analyzed the C=C band has present in the material.

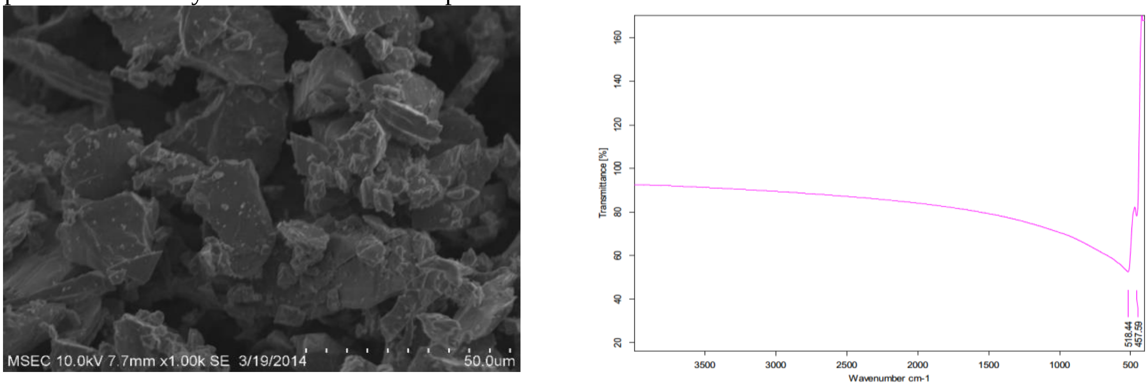

Fig 1: (a) SEM image of as receivedtitanium (b) FT-IR spectra of titanium

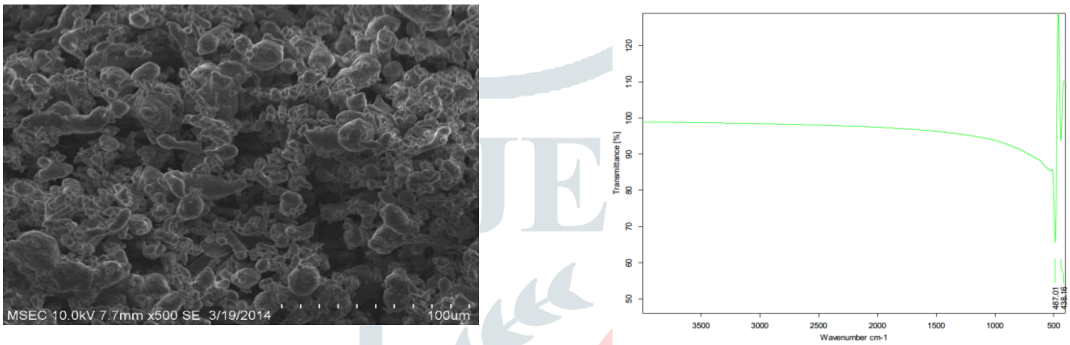

Fig 2: (a) SEM image of as receivedaluminum (b) FT-IR spectra of Aluminum

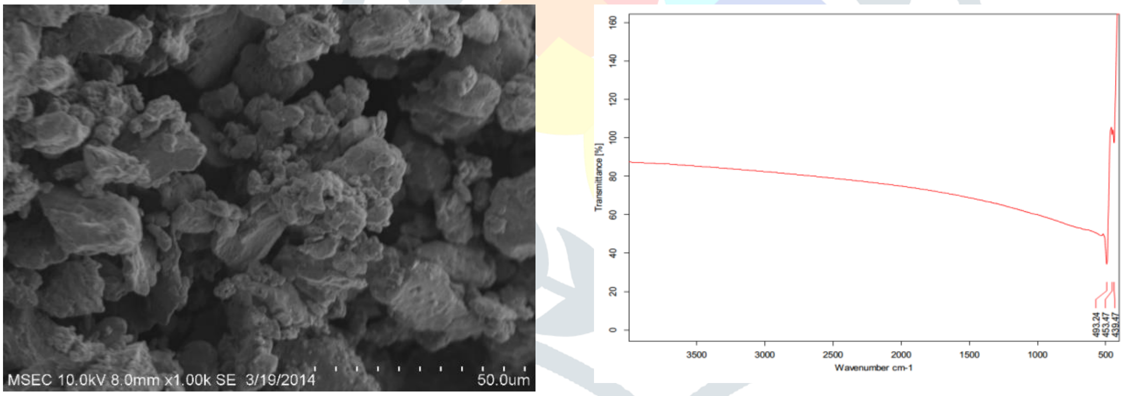

Fig 3: (a) SEM image of as receivedvanadium (b) FT-IR spectra of vanadium

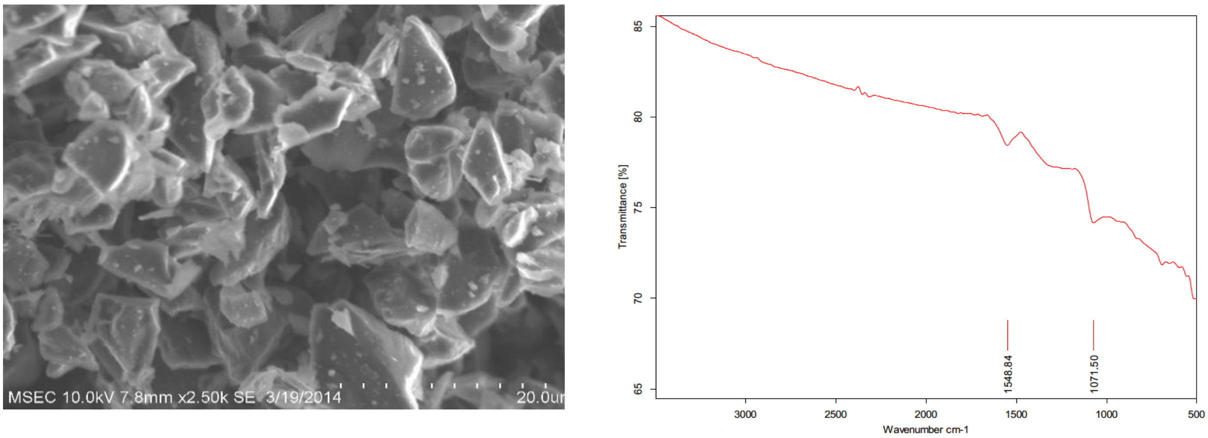

Fig4: (a) SEM image of as receivedboron carbide (b) FT-IR spectra of Boron carbide

RESULT AND DISCUSSION

EFFECT OF POWDER MORPHOLOGY EVALUATION ON VARIOUS MILLING TIME PERIOD

The various milling time period of Titanium, Aluminum, Vanadium and Boron carbide particles are shown in Fig. 5. While the time period is increasing the crystalline size of the particles decreases. The powders were milled separately in the tungsten carbide vial and tungsten carbide balls having 10 mm diameter in size. Tungsten carbide has more abrasion resistant than the milling powders, and hence is not mingled with any of the milled constituents. The ball to powder ratio is taken as 1:20. All the milling process was done in wet medium and inert atmosphere to avoid oxidation [13]. The organic element toluene (C_6H_5-CH_3) are filled in the WC vial at adequate quantity and its level is frequently checked in each interval. The milling time period were interrupted at a regular interval 0.25 h for Cooling. For every 1 h the samples has taken out and test its microstructure and crystalline size of the particles. Fig. 6-9 (a-d) shows the SEM microstructure of titanium, aluminum, vanadium and boron carbide particles for prolonging of time period. From the SEM image it can clearly visualized the microstructure changes of the particles. Fig.6 (a-d) shows the microstructure changes of the titanium particles. Initially the titanium has hexagonal closed pack structure. During milling the hexagonal closed pack structure has transformed to flattened shape. Titanium has milled for 30 h and its size is reduced to $\leq$ 400 nm. Fig.7 (a-d) shows the microstructure changes of the aluminum particles. Initially the titanium has spherical in shape. During milling the spherical shape has transformed to sharp flattened shape. Aluminum has milled for 50 h and its size is reduced to $\leq$ 400 nm. Fig.8 (a-d) shows the microstructure changes of the vanadium particles. Initially the vanadium has body centered cubic structure. During milling the body centered cubic structure has transformed to hexagonal shape. Vanadium has milled for 40 h and its size is reduced to $\leq$ 400 nm. Fig.9 (a-d) shows the microstructure changes of the boron carbide particles. Initially the boron carbide has rhombohedral structure. During milling the rhombohedral structure has transformed to agglomerated spherical shape. Boron carbide has milled for 60 h and its size is reduced to $\leq$ 125 nm.

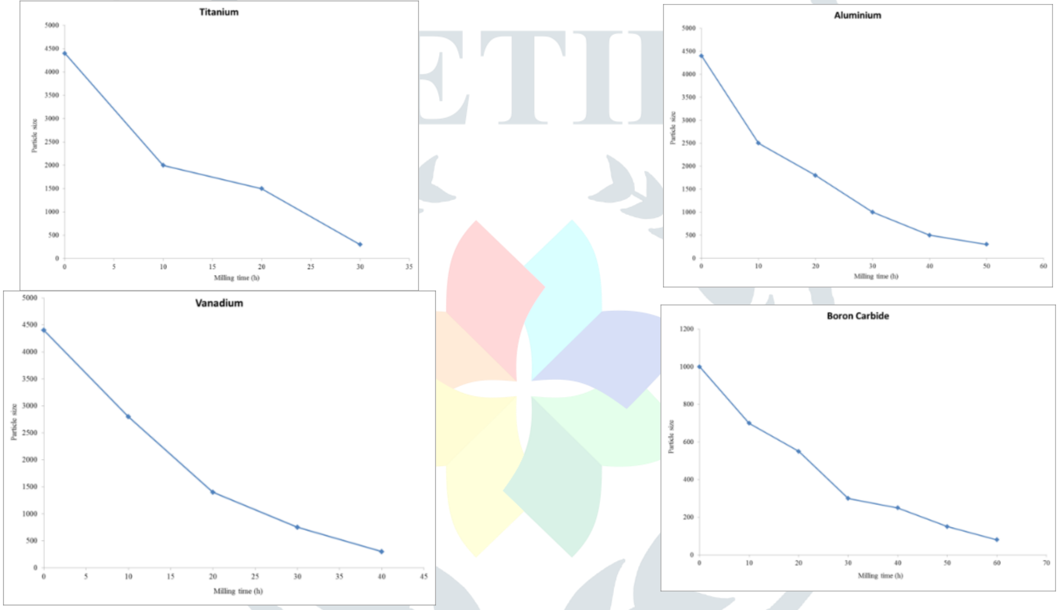

Fig 5: crystalline size of the particles depending on the various milling time period (a) titanium, (b) aluminum, (c) vanadium and (d) boron carbide

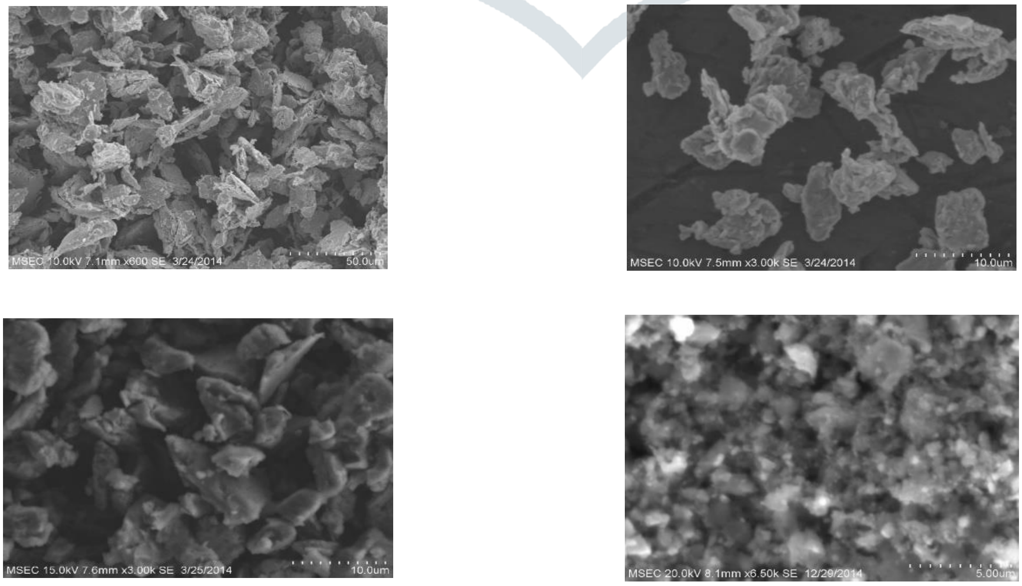

Fig 6: SEM micrograph of various time period of titanium (a) 5 h, (b) 10 h, (c) 20 h and (d)30h

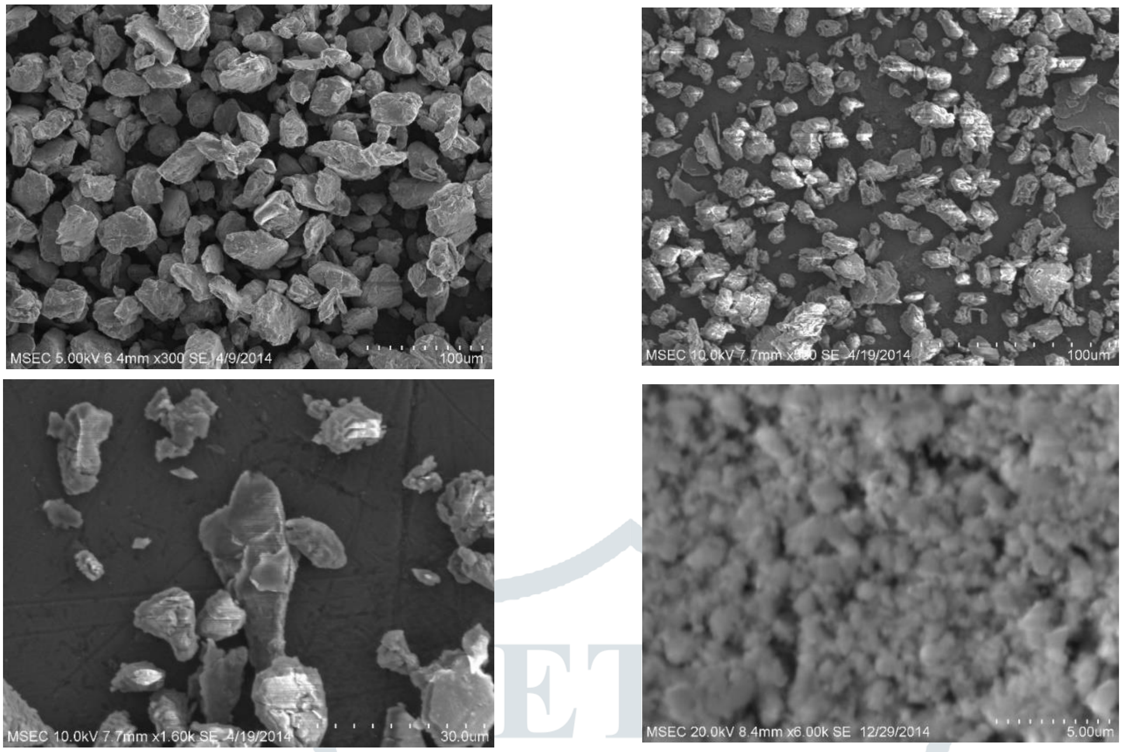

Fig 7: SEM micrograph of various time period of aluminum (a)10 h, (b)20 h, (c) 30 h and(d) 50h

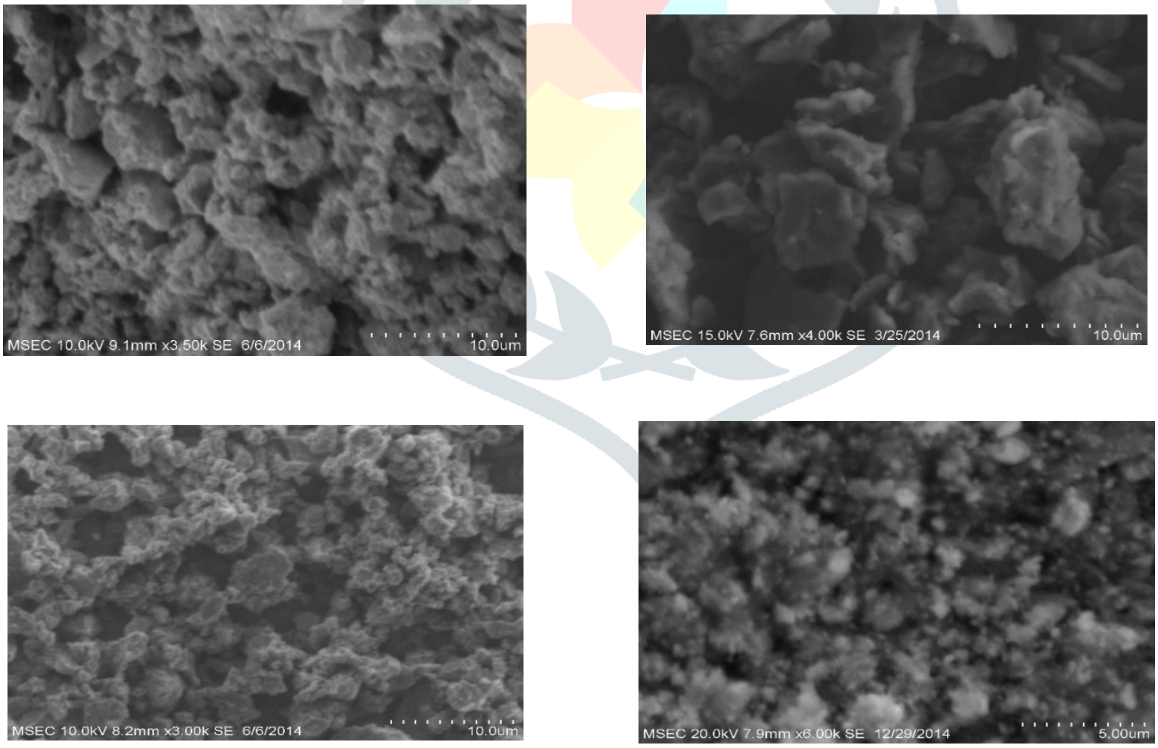

Fig 8: SEM micrograph of various time period of vanadium (a)10 h, (b) 20 h, (c)30h and (d)40h

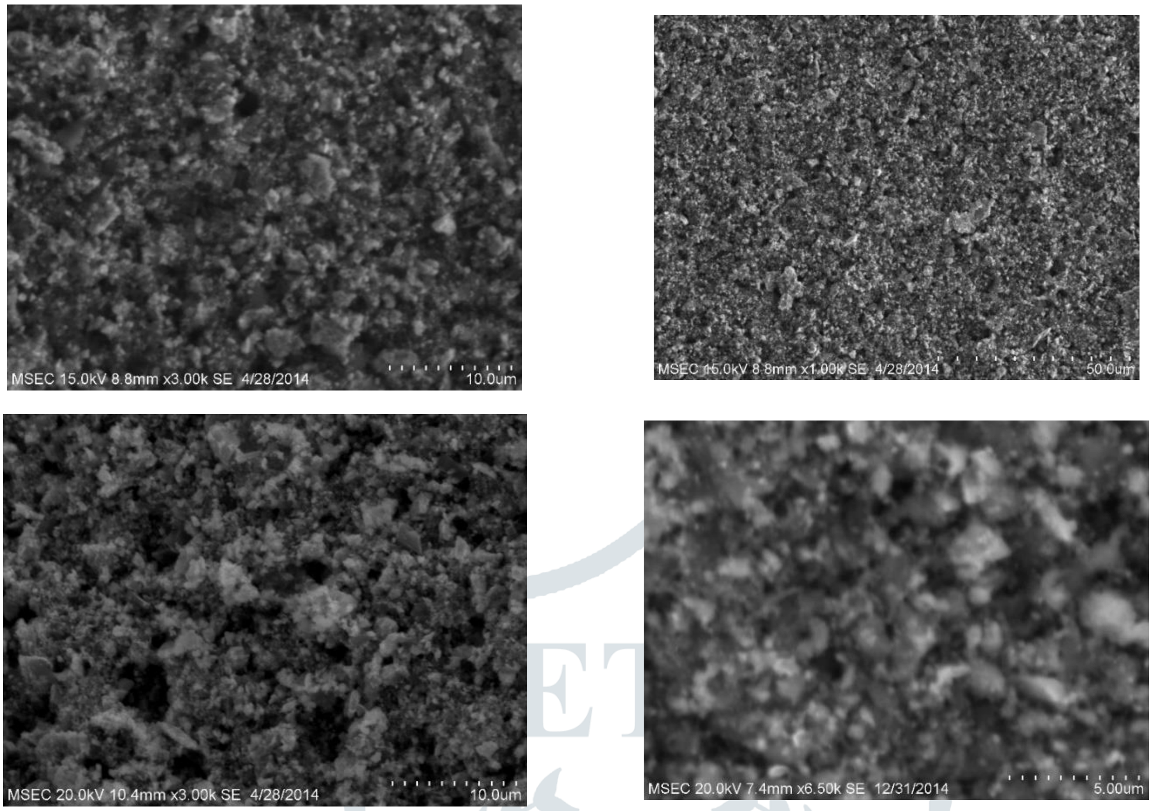

Fig 9: SEM micrograph of various time period of boron carbide (a) 10 h, (b) 30 h, (c) 40 h and (d) 60 h

MICRO HARDNESS

The micro hardness of the milled powders as a function of milling time of B_4C content is shown in Fig. 10. The strain and work hardening of the powders were increased with increasing the milling time period. From the fig. it shows that there was a continuous increase in micro hardness of all the composite powders with increasing the milling time period of B_4C content [14-18]. The maximummicro hardness was attained at Ti-6Al-4V-15B_4C composites. The main reason was affecting the micro hardness of powders was strain and work hardening of powders and also that the particle size of the secondary powders has a substantial effect on the powder micro hardness. The various milling parameters of the as received powders are shown in table 1.

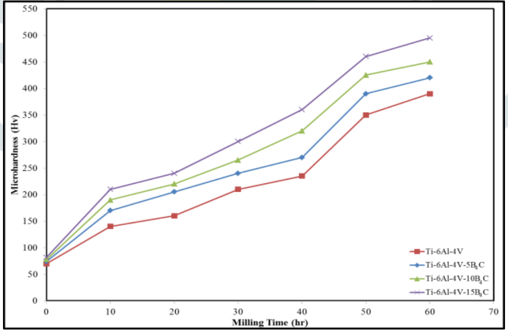

Fig 10:Micro hardness of the various composites as function of milling time period

Table 1. The properties of as received powders and various milling parameters

Sl.No	Material	Wt.% of B_4C	B_4C Particle size(μm)	Milling Speed rpm	BPR	Milling Time (h)
1.	Ti-6Al-4V	0	10	300	1:20	50
2.	Ti-6Al-4V-5%B_4C	5	10	300	1:20	50
3.	Ti-6Al-4V-10%B_4C	10	10	300	1:20	50
4.	Ti-6Al-4V-15%B_4C	15	10	300	1:20	50

CONCLUSION

In the present work the particle size of the Ti-6Al-4V-B_4C were reduced by using plantery ball mill. Based on the experimental work the following conclusions can be drawn:

- The SEM images were confirms that particle size and particle distribution of the samples which has all the particles are in nano scale.
- The particle size of B_4C composite powders decreased with increase the milling time period. After 55 h milling the average particle size of the B_4C powder was reduced to ≤ 50 nm.

- Ti-6Al-4V-15B_4C micro hardness was enriched when compare to the Ti-6Al-4V composite, because of the presence of milled B_4C particles.

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