International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 2 Feb 2022, pp: 1611-1615 www.ijaem.net ISSN: 2395-5252

Mechanical properties and Microstructure Characterization of SiC, TiC and B_4Creinforced Al-7075 Metal Matrix Composite: A review

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Submitted: 15-02-2022 Revised: 25-02-2022 Accepted: 28-02-2022

ABSTRACT
This paper represents the complete review of SiC, TiC and B_4C reinforced Aluminium-7075 Metal Matrix Composite(MMC's). The present review focuses on Al7075-SiC, Al7075-TiC and Al7075-$B_4C$of metal matrix compositesare considered in thisstudy.New materials revolution has brought this era of rapidly advancing in aerospace technology.Due to their good mechanical properties, high strength to density ratio and low density these are commonly uses in the field of aircraft and space industriesas an application. SiC, TiC and B_4C particles reinforced aluminum composites are preferable because of its decreased cost, uniform properties and various fabrication techniques. Through mixing, compacting and sintering processes Al/SiC, Al/TiC and Al/B_4C composites are produced. The Scanning Electron Microscope images revealed a uniform distribution of SiC, TiC and B_4C particles with fewer pores in Al7075. The composites haverecorded higher mechanical properties, hardness, toughness and flexural strength because of uniformity in distribution of reinforcement particles in matrix material.

Keywords: Al-7075, wear characterization andSiC, TiC, B_4C and metal matrix composites

I. INTRODUCTION

Al7075 is the most popular high strength aluminum alloy based on Al-Zn-Mg system. It is widely employed in automotive, defense, and aerospace industries owing to its high strength to weight ratio, low density, good thermal conductivity and high specific energy absorption capability [1]. MMC unify a continuous metallic matrix and a judiciously chosen ceramic reinforcements typically in the form of fibers or particles.In 1990's cold war forces development of MMC for military aircrafts and missile guidance system [2].A MMC is a material with atleast two constituent parts one being a metal necessarily. The other materials may be a different metal or another material such as a ceramicsor organic compounds.The reinforcement materials used in MMC are Alumina, SiC, Zirconia, TiC, B_4C etc.Matrix materials are Aluminium, steel, Magnesium, cobalt and Nickeletc[3].

Reinforcement is defined as a consequence that follows an operant response that increase (or attempts to increase) the likelihood of that response occurring in the future.Reinforcement material was added to the matrix material to enhance the physical properties of the final composite material [4-5]. Two kind of reinforcement material was used mostly by the researcher's, namely synthetic fiber and natural fiber. Secondary reinforcement was added to the composite material to further enhance the properties of the composite. When two or more reinforcement material were added to the matrix material, then this kind of composite was called as hybrid composite [6].

Al7075 has extensivevarieties of applications since this isessential for reinforcement. The Al alloy is used ascontinues phase and formed with various properties by adding needed single and multiple reinforcementparticulates likeSiC, TiC and B_4C as composites,itrecords higher strength than the parent alloy material.This improvement in alloy material were requires further rapid upgrading technologies in many fields of applications [7]. Therecent interests in research are the MMCs ability in changingmechanical

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properties (compressive behavior and tensile), physical properties (density thermal and expansion), tribologicalproperties, etc. by altering filler material phase constituent.In case of MMCs material system, combining or mixingprocess for more than two micro, macro or nano constituentsseparating and interface them shows various forms of chemical composition [8-9]. Also, constituent separating and interface materials are essentiallyunsolvable in phase material. MMCs showedsuitable in different engineering applications as well as functional and structural applications due to variation or changing in mechanicalbehavior depending upon the composition of matrix material and percentage variation of reinforcement [10].

II. MATERIALS AND METHODOLOGY

Matrix materials – Al7075

The primary alloying element of Aluminium alloy is zinc as shown in the Table.1. It exhibits good and excellent mechanical properties.7000 series aluniniumis one of themembers of AA, it is available strongest alloy when comparable to steel. Al7075 is selected and reinforced with various reinforcements.It has excellent mechanical properties,high strength,toughness andgood ductility. Al7075 is widely used for construction of aircraft structures, such as fuselages and wings. Its light weight and strength are also looked-for in other fields.

Table :1 composition of Al-7075

Elements	Zn	Mg	Cu	Mn	Fe	Si	Al
Chemical composition (wt%)	5.6	2.5	1.5	0.04	0.3	0.08	Bal

Reinforcements

1. Silicon carbides (SiC).
2. Titanium carbides (TiC).
3. Boron carbides (B_4C).

1. Silicon carbides (SiC):

SiC is selected due to its outstanding oxidation resistance and ability to improve hardness and strength ofaluminium matrix.It is composed of carbon atoms and tetrahedra of silicon and hadCristal lattice strong bonds.From decades SiC has been utilized and studied in nuclear systems. In accumulation to being strong enough to endure the pressure buildup from the division product, this SiC layer also sustain chemical outbreak from metallic separation products such as mechanical loads resulting from induced dimensional changes.Added recent applications of SiCcontain its use as structural composites for high-temperature.

2. Titanium carbides(TiC)

TiC is similar to tungsten carbide extremely tough refractory ceramic material. It had anadvent of black powder with the sodium chloride crystal structure.It has high hardness, good chemical stability with high melting point. TiC is used widely for cutting tools for its combination of high hardness and wear resistance.It is used in the Military aviation materials, spray coating materials, Welding materials.

For preparationof cermetsTitanium carbide uses, which are normally used at high cutting speed to machine steel materials. Titanium carbide also used as surface coating as an abrasion-resistant on metal portions, such as watch mechanisms and tool bits . For atmospheric re-entry of spacecraft it is used as a heat shield coating. Titanium carbide prepared products weighs one third as much Al7075 aluminium alloy but it is almost as strong as steel.

3. Boron carbides (B_4C):

Boron carbide is one of the hardest ceramic materials known, falling just short of cubic boron nitride and diamond, It has develop the material of excellent for body armour systems because of its low density. Boron carbide is a covalently bonded solid with a high melting point with2427°C, good mechanical properties, outstanding hardnessand low specific gravity. For lightweight armours making it ideally uses. The minimal boron carbide stoichiometric formulation is B_4C. The boron carbide desirable the hot press intocompact shapes by means offine powders and pure.At high temperature orvacuum undergoes inert atmosphere. B_4C can also be formed using pressure less sintering at very high temperature very close to the melting point.

Powder metallurgy Methodology:

Initially formation of metallic powder, blending of powders thencompacting/compressing themetallic powders.Sintering the compacted article in a controlled furnace atmosphere.Subjecting the sintered article to secondary process.Analysis of mechanical properties Induced in the article by using Material

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testing machines.Finally,absorbingitsmetallographic structure using metallurgical microscope.The same methodology is followed for making Al7075/SiC, Al7075/TiC and Al7075/ B_4CMMC to this research.

The ball milling operation is used to making metallic powders to this research.In blending operation both the metal matrix and reinforcement metal powders are mixed together in the proportion ratios.In this process both the matrix metal powder and reinforcement metal powders are compressed together by using compacting machine to make a solid composite metal.

Sintering, which is also called frittage, is the process of forming a solid mass of material through heat and pressure without melting to the point of liquefaction.It is heat treatment process to achieve desired mechanical properties of the metal matrix composite.

III. RESULTS ACHIEVED BY METAL MATRIX COMPOSITES

1. Al-7075 and silicon carbide (SiC) metal matrix composites

Through powder metallurgy route the Al7075/SiC composition of SiCwith 15% processed successfully. The uniform distribution of SiC particlesreveals by microstructure with fewer pores 15% SiCin the Aluminium matrix as shown in fig:1.The density composites exhibit better mechanical propertiesbecause of uniform distribution of SiC in the matrix material.

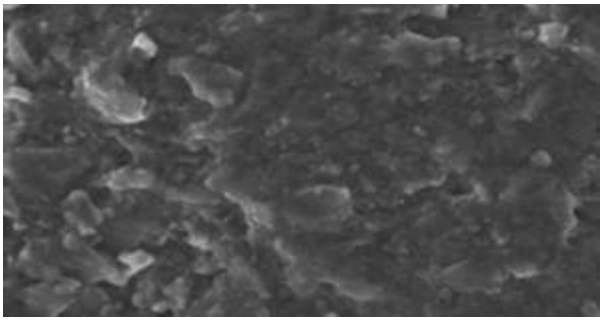

Fig:1 Microstructure of Al7075/SiC

2.Al7075 and Titanium Carbides (TiC) metal matrix composite

The work on Aluminium reinforced process to enhance the mechanical properties with 5% and 10% of TiC particle composite via powder metallurgy has led to following constituents.Powder metallurgy was successfully used to produce Al 7075/TiCmetal matrix composite.Through sintering process below 600°c temperature the interfacial reaction between Al 7075/TiCis good.In fig:2 microstructure shown the good interfacial reaction of reinforcement powder particles and the matrix.By adding of Titanium carbide to Al7075 will increase the strength and hardness.

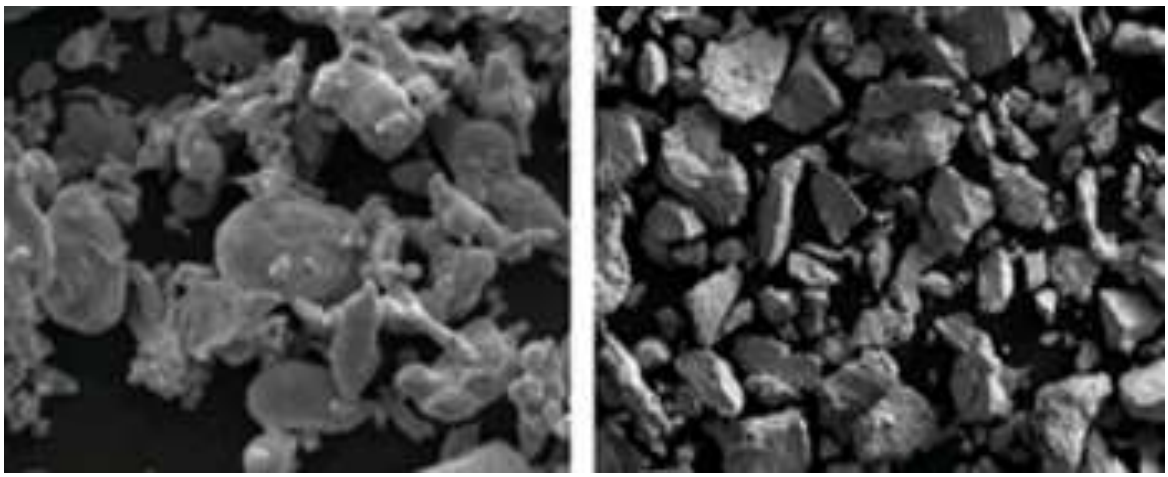

Fig:2 Powder particles of Al7075/TiC

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3. Al7075 and Boron carbide (B_4C) metal matrix composite

In compacting of Al7075/B_4C particles were uniformly distributed with in Al7075 particles.The highest hardness of HV was accomplished when large reinforcement particles wear added to small matrix particles.It achieved that there is a decrease in the density of the Al7075 by adding of B_4C. It exhibits highest compressive strength.B4C experiences high strain rate with a significant rise in disintegration when exposed to high-speed impacts.

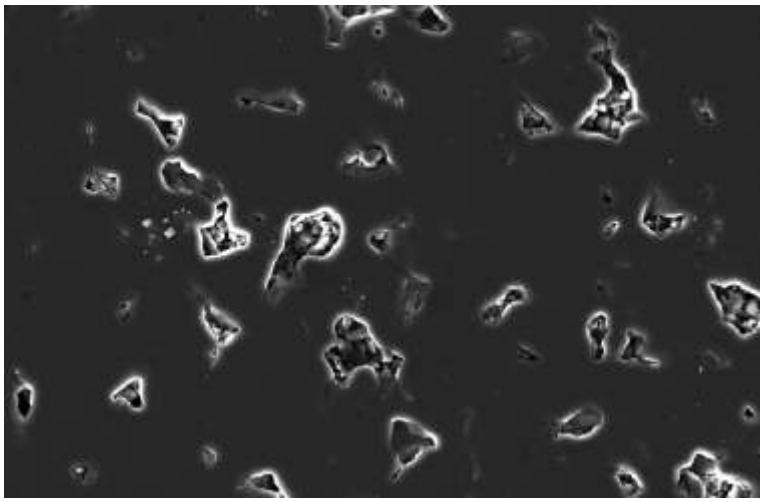

Fig:3Microstructure of Al7075/ B_4C

IV. CONCLUSIONS

The Al7075/SiC metal matrix composite will exhibit a reasonable density with flexural strength,wear resistance, high strength and hardness. The bond between reinforcement and matrix metal is good.Powder metallurgy technique is one of the best suited techniques for the fabrication of Al7075/SiC composites. Addition of SiC particulates reveal that composites reinforced with SiC was found to be the hardest.The hardness value is significantly increased by increasing the percentage of Al7075/TiC reinforcement. The compressive strength of Al7075/TiCcomposites has been increased due to the effect of harder reinforcement incurred in it.Al7075/TiCcomposition hardness of composites is higher than that of Al7075 alloy. The Al7075/B_4C exhibits high compressive strength, good abrasive resistance and lower density.As amount of B_4C increases hardness increases. This can be attributed to dispersion strengthening of alloy matrix.

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