STUDY ON THE LATEST RESEARCH AND DEVELOPMENT OF NITRIDE BASED PARTICULATE REINFORCED COMPOSITE – A REVIEW

A. Shanmugasundaram[1], Dr. V.C. Uvaraj[2], C. Arunkumar[3], S. Ramu[4]

[1]*Assistant Professor, Department of Mechanical Engineering, KGiSL Institute of Technology, Coimbatore.*
[2] *Associate Professor, Department of Mechanical Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode.*
[3]*Assistant Professor, Department of Mechanical Engineering, Sri Krishna College of Engineering and Technology, Coimbatore.*
[4]*Lecturer, Department of Mechanical Engineering, Debre Tabor University, Ethiopia.*

ABSTRACT

At the present modern world, the industries are seeking for the high performed materials at low cost. Day by day the high performed materials have been developed and further the research is taking places to have a multi-functional property in one material at low cost. Among these categories of materials, the composite material is performing excellent and replacing most of conventional and superior alloy materials. The composite is tailoring of different property materials to have a better life than the individual material or other conventional materials. By seeing the latest research and development on composite, a lot of researches have been carried out on addition of carbides, oxide and boron based particulate reinforcement. With respect to nitride based particulate reinforcement composite no much research has taken place. Hence, there is a great scope for the research and to develop multi based properties composite. And also no much research has been found on the reinforced coated composite materials. In the view of the above, this review study has focused on the latest research and development taken place on nitride based particulate reinforcement composite and its application.

Keywords: *Composite; Aluminium alloy; Nitrides; Oxide; Boron.*

1. Introduction

Among the engineering materials, the composite plays important role in engineering development and replaces most of the materials due to the superior properties. At the present manufacturing sector needs materials with high strength to weight ratio, high hardness at surface and core level, better corrosion resistance, good weldability and machinability properties. This study has given the overall latest research and development taken place in nitride based reinforced composite.

1.1 Composite Material

The composite material is made up of matrix materials and reinforcement material. There are different types of composite material based on type of matrix been employed and reinforcement type. The generally based on matrix based, there are three types METAL MATRIX COMPOSITE (MMCs), POLYMER MATRIX COMPOSITE (PMCs) AND CERAMIX MATRIX COMPOSITE (CMCs). Other classification schemes based on a matrix/fibre notation, such as Al/SiC and 6061/SiC/40p-T6 for aluminium reinforced with silicon carbide and boron- and carbon-fibre reinforced polymers (BFRP or CFRP), are also being used. The recognition of the three basic types of composites is based on the nature of the matrix material. Each of these types may make use of particle or either discontinuous (short fibre) or continuous fibre reinforcement for property enhancement. It must be realized that systems reinforced with particulate, discontinuous and continuous fibres give rise to different physical and mechanical properties, and that they must be utilized accordingly.

Lakhwinder Sing et.al[2012] has classified the particulate-reinforced systems into two categories: dispersion-strengthened, and particle strengthened or particle-reinforced systems. In dispersion strengthened systems, small particles (Φ between 0.01 and 0.1 μm) are dispersed in the matrix that acts as the major load-bearing constituent. In particle-strengthened composites, larger particles (Φ> 0.1 μm) are incorporated in the matrix and the load is shared by the matrix and the particles. To determine the physical and mechanical properties of composites, use is made of expressions known as mixture rules. The density ρm of a composite, for example, consisting of particles evenly dispersed in a matrix, is given by $\rho m = f1\rho1 + f2\rho2 + f3\rho3 + ...fi\rho i$. Where, ρi refers to the density and fi to the volume fraction of the individual components i. In these systems, the reinforcing particles actually impede slip, thus increasing resistance to plastic deformation of the matrix, which is the main load carrying constituent. Mixture rules for the dispersed phases of spherical particles can be applied even to irregularly shaped or plate like particles, provided the orientation is completely random and the aspect ratio (length to width) is relatively low.

2. Review of Literature Survey

2.1 *Mechanical Properties*

K.Gajalakshm, et.al.2014 has investigated on Microstructure and Mechanical Properties of Silicon Nitride Reinforced Aluminium matrix composites (AMCs) by Using Stir Casting Method. The authors has concluded that by addition of silicon nitride in aluminium matrix the hardness value is increased and tensile strength has been decreased Also reveals that this combination composite has lower surface roughness value.

Aleksandra Dubiel et.al[2016] has investigated on Mechanical properties of hot-pressed Si3N4-TiN grain composites. The author has stated the properties improvement by addition of silicon nitride and titanium nitride. The dense Si3N4-TiN grain composites were sintered from commercial powders. About the silicon nitride, it's a common structural ceramic material for wear and high temperature application. Its good mechanical properties, wear resistance and reliability at room and high temperature enable several applications for example cutting tools, engineering components, crucibles for molten metal, ball bearings.

To improve mechanical properties of Si3N4 based materials some other ceramic phase can be added to silicon nitride matrix. Titanium nitride and silicon carbide are most often used for this application. Moreover addition of a conductive phase may enable EDM machining, which is great alternative in case of hard, difficult to machine materials. Hot pressing seems to be very effective way to achieve dense silicon nitride based composites with good mechanical properties. Addition of rather coarse TiN (3 to 6 μm) is reported to increase fracture toughness of Si3N4-TiN composites, but to decrease flexural strength. Addition of fine titanium nitride to silicon nitride lowers friction coefficient and wear rate Usage of fine TiN powder resulted in increase in flexural strength of composites. Fracture toughness of composites was lower than fracture toughness of reference sample.

Pardeep Sharma et.al.2015 has investigated on "Production and some properties of Si3N4reinforced aluminium alloy composites". The composite was manufactured by using stir casting technique with varying volume fraction of particles reinforcement. The interesting outcomes are the density and porosity of composite is increased 3 to 4% by varying the particulate reinforcement of silicon nitride from 0% to 12%. Also the hardness value of composite has increased nearly 50%. The other mechanical properties like tensile strength is increased 20% with 0% to 12% of reinforcement but the ductility is reduced nearly 50% of original value. Therefore, the final conclusion is by addition of Silicon nitride reinforcement the tensile strength and hardness value is increased.

Jayashree et al. [2013], carried out the literature survey and concluded that there is further study scope to determine and compare the properties of welded joint in untreated and heat treated condition to improve the quality of welded joint and highlighted on the behavior of SiC particles in metal matrix composites during welding by microstructure examination and improvement in mechanical and physical properties after precipitation hardening process.

Achutha Kini et al [2015] studied the Characterization of Aluminium 6061 Hybrid Composite. The specimens are successfully cast by stir casting method and subjected to age hardening treatment. It's observed that the lower the aging temperature, higher is the peak hardness value. Higher the aging temperature, shorter is the peak aging duration for the peak hardness. Higher the weight percent of the alumina, higher is the peak hardness value. Lower the weight percent of alumina longer is the peak aging duration. Wear resistance of the composite is better when aged at lower temperature. Both wear resistance and hardness are better in heat treated condition compared to as cast condition. Microstructure recorded shows good dispersion of reinforcements in the matrix without agglomeration and porosity.

Motohiro Yamada et.al[2006] has fabricated Aluminium Nitride based composite by Coatings through Reactive RF Plasma Spraying method. The formation of Al interlayer between AlN layer and carbon steel substrate improve the adhesion according to alleviation of thermal stress. However, it was difficult to enhance the nitriding reaction with maintain the Al layer. The Author has stated that the fabrication onto Al alloy or low melting point materials is difficult due to melt the substrate during spraying. It should be selected the substrate materials with much higher melting point than aluminium. It was possible to fabricate almost completely AlN coating using quartz substrate. Low thermal expansion coefficient and high melting point were very important factors for the substrate material.

Baskaran.G et.al [2015] has carried out the research and development on Aluminium with TIC and TIO2 reinforced composite. The Al-TiC-TiO2 composite material was fabricated and the study effects of TiC and TiO2 was studied on the mechanical properties of composite material such as wear for all loads, sliding velocity and sliding distance, hardness, and density was studied by conducting experimental tests. Hardness, density and wear rate was increased with the increases in TiC and TiO2 content in Al composite material.

Rabinskiy et.al[2016] has developed silicon nitride reinforced composite materials by using binder jetting and reaction sintering technology. The other information stated in this research are silicon nitride ceramics have excellent mechanical, thermal and dielectric properties. Silicon nitride parts are widely used in different technical fields, particularly in jet engine structural components, in the fuel systems, in the braking system components. The conclusion is the development of silicon nitride ceramic additive fabrication using binder jetting and reaction sintering technology was carried out. The control system of binder jetting three-dimensional printing process was developed. The method of silicon powder preparation was offered. Two types of binders based on acrylic acid with polyurethane and based on modified starch were used. Optimal parameters of silicon powder preparation were determined. Porous silicon nitride samples, for which the composition and microstructure parameters were examined, were fabricated resulting from the reaction sintering of the obtained preforms. It was found that the material consists mostly of α-Si3N4 fibers with particle inclusions of 1-20 μm. Silicon oxynitride and silicon carbide with total volume content of not more than 20% are also present in the material composition.

3. Future Scope and Conclusion

The above literature survey indicates very clearly that no much research has taken place on nitride reinforced composite materials with respect to mechanical and tribological proper improvement.

From a few researchers has investigated that the addition of silicon nitride in aluminum alloys matrix which shows better properties as compared to other reinforcement. Other observation from this study is application of developed composites to moderate temperature application only.

The following are scope has been identified for further study,

a) Design and development of aluminium based composite with nitride reinforcement for high temperature application.
b) Effect of nitrides and with combination of oxides particulate reinforcement on tribological and mechanical properties of Aluminum based composite.
c) Utilization of advanced characterization techniques for the material characterization study purpose. The most of researchers have used only Classical Diffraction, Spectroscopic and Microscopical techniques for characterization study. But not been used advanced state-of-the-art techniques such as positron annihilation spectroscopy (PAS), small-angle neutron scattering (SANS), small-angle X-ray scattering (SAXS) and others.

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