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"A REVIEW ON TRIBOLOGICAL BEHAVIOUR OF METAL MATRIX COMPOSITES"

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ABSTRACT

Nickel metal matrix composites are potential materials for different applications because of their great physical and mechanical properties. The expansion of reinforcements into the metallic composites enhances the solidness, explicit quality, wear, creep and weakness properties contrasted with the regular designing materials. This paper exhibits the review of the impact of expansion on various reinforcements in nickel composite featuring their benefits and bad marks. Significant issues like agglomerating marvel, fiber-lattice holding and the issues identified with dispersion of particles are talked about in this paper. Impact of various reinforcements on AMCs on the mechanical properties like elasticity, strain, hardness, wear and weariness is likewise talked about in detail. Real uses of various Nickel MMCs are likewise featured in this work.

Key Words: *Nickel, Metal matrix composites, Solidness, Wear, Creep, Fiber lattice.*

I. INTRODUCTION

MMC (Metal matrix composites) are structures reinforced with other metal, ceramic or organic compounds. They are made by dispersing the second phase particles in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. Nickel and its alloys have attracted most attention as base metal in metal matrix composites. Nickel MMCs are widely used in aerospace, automobiles and various other fields. The reinforcements should be stable in the given working temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC). SiC reinforcement increases the tensile strength, hardness, density and wear resistance of Nickel and its alloys. The particle distribution plays a very vital role in the properties of The Nickel MMC and is improved by intensive shearing. Furthermore, Aluminium is also an excellent working metal to be added with second phase particles. Oxygen when added with Al has good compressive strength and wear resistance. Boron Carbide is one of hardest known elements. It has high elastic modulus and fracture toughness. The addition of Boron Carbide (B4C) in Al matrix increases the hardness, but does not improve the wear resistance significantly. Fibres are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Zirconia is usually used as hybrid reinforcement. It increases the wear resistance significantly. In the last decade, the use of fly ash reinforcements has been increased due to their low cost and availability as waste by-product in thermal power plants. It increases the electromagnetic shielding effect of the Al MMC. Based on the stated potential benefits of MMCs, his paper examine the various factors like (a) effect of various reinforcement (b) mechanical behaviour like strength, wear, fatigue behaviour, etc. (c) processing methodology and its effects.

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II. Titanium Alloy MMC

Titanium alloys are used in aerospace and automotive applications because of its high specific strength, stiffness and good machinability but its wear resistance is inadequate. To eliminate this property lag K. Soorya Prakash et al used Boron Carbide (B4C) ceramic particles reinforced with Ti-6Al-4V through powder metallurgy route (PM). Reinforcement particles are mixed with base alloy for the weight percentage of 0, 5 and 10 so as to analyse the effect of reinforcements on mechanical, corrosion and wear properties. This research outcome corresponds to decreased density, increased hardness and corrosion resistance capability for significant increase in B4C content of the newer composite developed and tested. Applied load signify higher effect on wear performance of the composite specimens followed by B4C addition percentage. Scanning Electron Microscope results reveal that B4C reinforced Ti-6Al-4V composite comprise for higher wear resistance and illustrate mild worn surface when compared to that of unreinforced Ti alloy.

III. Magnesium MMC

Azzat Essam et al studied the wear and mechanical responses of pure magnesium-graphite (Mg–Gr) composites aiming to get the optimum composition of reinforcement. The composite materials were fabricated by mechanical alloying. The percentage of graphite reinforcement was chosen as 3, 5, 7 and 10 wt.% to identify its potential for self-lubricating property under dry sliding conditions. The mechanical properties including hardness, tensile strength and flexural strength of the composites and the base material were tested. The wear tests were conducted by using a pin-on-disc tribometer. The results show that the mechanical properties decrease with increasing graphite content as compared to that of the base material. The wear rate and average coefficient of friction decrease with the addition of graphite and was found to be minimum at 5 wt.% graphite reinforcement. The addition of 5 wt.% graphite in the composite exhibits superior wear properties as compared to that of the matrix material and other compositions of the Mg–Gr composites.

IV. Nickel Based MMC

Ashraf Bakkar and Mohammad M. Z. Investigated Titanium carbide/Inconel 625 (nickel alloy) metal matrix composites (MMCs) developed for the combination of the super mechanical and corrosion properties of nickel alloy matrix and the high hardness of reinforcing titanium carbide particles (TiCp). The microstructure, hardness, wear, and corrosion behaviour of MMCs with different volume contents of TiCp (25, 50 and 70 vol.%) were investigated. The effect of increasing TiCp on the intermetallic sand precipitates formed was examined using SEM/EDS and XRD analyses. The tribological behaviour of the MMCs was investigated using wear testing with a pin-on-disk machine. The corrosion behaviour was examined using potentiodynamic polarization experiments in3% (w/v) NaCl solution. The results showed that the addition of TiCp into the Inconel 625alloy resulted in formation of several intermetallics such as MoNi4, Cr2Ni3and MoCr, in addition to molybdenum and chromium carbides in the matrix alloy. A great improvement in the hardness was resulted with addition of 25 vol.% TiCp and consequently the wear resistance was also improved. Further increase of TiCp from 50 to 70 vol.% did not result inmore improvement of both hardness and wear resistance. The corrosion resistance of TiCp(25 vol.%) composite was comparable to that of monolithic Inconel 625 matrix alloy, while clear reduction in the corrosion resistance was found in the 50 and 70 vol.% composites.

V. MMC Through Powder Metallurgy

Venkatesh et al studied the wear and corrosion behaviour in marine applications, especially when it comes to structural support components like bearings, bushes and blocks. The copper hybrid metal matrix components are the new avenues explored in this front. A novel combination of alumina and graphite were considered as the reinforcements in a copper base for the development of a metal matrix composite. Power metallurgical techniques were used for the development of the MMC. The Vickers's hardness value of 64.9Hv has been observed by increasing the volume of alumina. Thermogravimetric analyses were carried out on material samples to estimate the exact sintering temperature and identified that 450 e700 _C would be conducive. The TGA curves shows two step decomposition exists between 4300Ce

460 _C. FT-IR analysis was done to confirm the peak values of the materials. FTIR exposed the peak value of 1600 cm_1 for alumina where as for Copper and graphite peak values have been 2840 cm_1 and 17260 cm_1 respectively.

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The potentio dynamic analysis was done to estimate the rate of corrosion on the samples. The sample with nano and micro reinforcements offered intensive resistance to corrosion. The presence of graphite minimized the weight loss of the samples during the corrosion test. Finally the wear rates of the samples were estimated using the Pin On Disc experimental setup. The samples with nano material reinforcement and with a maximum proportion of graphite exhibited a better wear rate of 1.52 _ 10_12m2/kg under maximum load conditions.

Halil Karakoc et al investigates the production of various reinforced and non-reinforced composite materials using powder metallurgy (PM). It presents the new approach into optimize the mechanical properties of hybrid composites (Al-SiC-B4C) produced with powder extrusion process. A16061 powders are used as the matrix material and B4C and SiC powders are used as the reinforcement materials. Matrix and reinforcement materials are mixed in a three-dimensional mixer. The mixtures are then subjected to cold pressing to form metal block samples. Block samples are subjected to hot extrusion in an extrusion mold after being subjected to a sintering process. This produces samples with a cross-sectional area of 25 × 30 mm2. These extruded samples were subjected to T6 heat treatment. The composite materials produced are examined in terms of density, hardness, transverse rupture strength, tensile strength, and wear resistance. Furthermore, optical microscopy, scanning electron microscopy, energy-dispersive X-ray spectroscopy and XRD are performed to examine the microstructure, surface fractures, and surface abrasion. In this study, high densityAl6061/B4C/SiC hybrid composite materials were successfully produced. After extrusion, some micro particles were found to crack. The highest hardness occurred in 12%B4C rein-forced composites. The lowest hardness was obtained in Al6061 alloy without reinforcement. The highest tensile strength occurred in 12%SiC particle reinforced composite material. The highest wear resistance was obtained for 9%B4C+3%SiC samples due to the hardness of B4C and the good adhesion properties of the matrix and SiC.

VI. SILICON CARBIDE, ALUMINA & OTHER MMC

Tamer Ozbenet al. investigated the mechanical and machinability properties of SiC particle reinforced Ni-MMC. With the increase in reinforcement ratio, tensile strength, hardness and density of Ni-MMC material increased, but impact toughness decreased. Sedat Ozdenet al. investigated the impact behaviour of Nickel and SiC particle reinforced with MMC under different temperature conditions. The impact behaviour of composites was affected by clustering of particles, particle cracking and weak matrix-reinforcement bonding. The effects of the test temperature on the impact behaviour of all materials were not very significant. Srivatsan et al. conducted a study of the high cycle fatigue and investigated the fracture behaviour of 7034/SiC/15p- UA and 7034/SiC/15p-PAmetalmatrix composites. The modulus, strength and the ductility of the two composite microstructures decreased with an increase in temperature. The degradation in cyclic fatigue life was more pronounced for the under-aged microstructure than the peak-aged microstructure Also, for a given ageing condition, increasing the load ratio resulted in higher fatigue strength. Maik Thunemann et al. studied the properties of performs. Polymethylsiloxane (PMS) was used as a binder. Apolymer content of 1.25 wt.% conferred sufficient stability to the pre forms to enable composite processing. It is thus shown that the PMS derived binder confers the desired strength to the SiC preforms without impairing the mechanical properties of the resulting Al/SiC composites. Sujan et al. studied the performance of stir cast Al2O3 and SiC reinforced metal matrix composite material. The result showed that the composite materials exhibit improved physical and mechanical properties, such as low coefficient of thermal expansion as low as 4.6x10-6/ C, high ultimate tensile strength up to 23.68%, high impact strength and hardness. The composite materials can be applied as potential light weight materials in automobile components. Experimentally it is found that with addition of Al- SiC reinforcement particles, the composite exhibited lower wear rate compared toAl-Al2O3 composites. Zhang Peng et al. studied the Effects of Particle Clustering on the flow behaviour of SiC particle reinforced Al MMCs. The results revealed that during the tensile deformation, the particle clustering has greater effects on the mechanical response of the matrix than the elastic response and also the plastic deformation is affected very much. The particle clustering microstructure will experience higher percentage of particle fracture than particle random distribution. Balasivanandha Prabhuet al. analysed the influence of stirring speed and stirring time on distribution of particles in SiC AMC. The studywas about high silicon content aluminium alrial, with 10% SiC synthesized using different stirring speeds and stirring times. The analysis revealed that at lower stirring speed and time, the particle clustering was more at some places, by increasing themthe

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distribution resulted better and also it had its effect on hardness of the composite. Uniform hardness values were achieved at 600 rpm with 10 min stirring. Tzamtzis et al. suggested processing Al/ SiC particulate MMCs under intensive shearing by novel Rheo-process. The current processing methods such as conventional stir casting technique often produce agglomerated particles in the ductile matrix and as a result these composites exhibit extremely low ductility. whereas the Rheo-process significantly improved the distribution of the reinforcement in the matrix by allowing the application of sufficient shear stress (s) on particulate clusters embedded in liquid metal to overcome the average cohesive force or the tensile strength of the cluster. Valencia Garcia et al. suggested an alternate technique of compo forging of Al-Si Metal Matrix Composites reinforced with SiC. This method of preparation increased the mechanical resistance to elongation. This method proves to be more economical as it reduces production stages, as well as time and energy consumption. Narayana Murty et al. Al2O3 particulate reinforced metal matrix composites. They proposed from productivity viewpoint that a high strain rate region in which high values of mass and efficiency are present should be selected for bulk working operations and the lower strain rate regions for secondary metal working operations. Palani kumar and Karthikeyan and assessed the factors influencing surface roughness on the machining of Al/SiC particulate composites. The parameters like feed rate, cutting speed, %volume fraction of SiC were optimized to attain minimum surface roughness using response graph, response table, normal probability plot, interaction graphs and analysis of variance (ANOVA) technique. Feed rate is the factor, which has greater influence on surface roughness, followed by cutting speed and %volume fraction of SiC. The recommended machining conditions are low cutting speed with high feed rate and depth of cut for rough and medium turning process.

Park et al. investigated the effect of Al2O3 in Aluminium for volume fractions varying from5-30% and found that the increase in volume fraction of Al2O3 decreased the fracture toughness of the MMC. This is due to decrease in inter-particle spacing between nucleated micro voids. Park et al. investigated the high cycle fatigue behaviour of 6061 Al-Mg-Si alloy reinforced Al2O3 microspheres with the varying volume fraction ranging between 5%and 30%. They found that the fatigue strength of the powder metallurgy processed composite was higher than that of the unreinforced alloy and liquid metallurgy processed composite. Tjong et al. compared the properties of two aluminium metal matrix Al2O3 system. It was found that the reactive hot pressing of the composites resulted in the formation of ceramic Al2O3 and TiB2 particulates as well as coarse intermetallic Al2O3 had higherAl3Ti content and showed high tensile strength, but low 2O3 2 had more fatigue 2. Kok fabricated the Al2O3 particle reinforced 2024 Al alloy composites by vortex method and studied their mechanical properties and found the optimum conditions of the production process with a pouring temperature of 700 C, pre heated mould temperature of 550 C, stirring speed of 900 rev/min, particle addition rate of 5 g/ min, stirring time of min and with a applied pressure of 6MPa. The wettability and the bonding between Al alloy/Al2O3 particles were improved by applied pressure but porosity will be decreased by this pressure. Abhishek Kumar et al. experimentally investigated the characterization ofA359/Al2O3MMC using electromagnetic stir casting method. They found that the hardness and tensile strength of MMC increases and electromagnetic stirring action produces MMC with smaller grain size and good particulate matrix interface bonding. Abouelmagd studied the hot deformation and wear resistance of powder metallurgy aluminium metal matrix composites. It was found that the addition ofAl2O3 andAl4C3 increases the hardness and compressive strength. The addition ofAl4C3 improved the wear resistance of the MMC. Kannan and Kishawy conducted orthogonal cutting tests to study the effect of cutting parameters and particulate properties on the micro-hardness variations on the machined Al2O3 particulate reinforced AMC. They found that the micro- hardness is higher near the machined surface layer. Micro-hardness variations were higher for low volume fraction and coarse particles.

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