

Wear Behaviour of Aluminium-Diamond Composite Material by Powder Metallurgy

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ABSTRACT: Al based materials including Al-Nanodiamonds and Al-Al₂O₃ processed by explosive compaction are considered in this paper. Improvements of composite properties were obtained by the introduction of diamond and ceramic Nanoparticles (10 wt% of each) into the mixture of aluminium Nanopowder. Various schemes and conditions, including a theoretical calculation of the explosion process, were suggested and discussed. Physical and mechanical properties of composites reinforced with Nanoparticles are determined and discussed with special consideration paid to process conditions. The results show an increase in the hardness, compressive strength and elastic modulus of the composites after explosive compaction with the introduction of Nanoparticles into the powder mixture. Improvement of mechanical properties of composites compared to pure aluminium is determined by dispersion strengthening, small material grain size and internal compressive stresses caused by dynamic shock-wave compaction processing.

KEYWORDS: Aluminium, Nanoparticles, Explosive compaction, Composite, Mechanical properties, Diamond powder.

I. INTRODUCTION

In the recent years, cast aluminium alloys are widely used in automobile and other engineering applications as cylinder blocks, piston, piston ring, brake disc and drum, due to light weight, corrosion resistance, high thermal conductivity, fatigue strength and workability. However the applications of aluminium alloys are limited due to poor wear and seizure resistance at room and elevated temperatures. The demand for light weight, inexpensive and energy efficient Aluminium Metal Matrix Composites (AMCs) has been increasing with multifunctional properties for automobiles, aircraft and other applications

The AMCs is an attractive material due to its low density, high hardness, strength, stiffness, good corrosion resistance and high thermal conductivity. Recent studies have used micro-sized particles to improve the mechanical properties of AMCs. However, the poor ductility and reduced fracture toughness have limited the application of micro-sized ceramic particle-reinforced AMCs (Dongshuai Zhou et al. 2014). The use of Nanosized particles to improve the mechanical properties of the AMCs is attractive because it improves ductility, high temperature creep resistance, fatigue life, wear resistance and fracture toughness. The Nano particle content increases the mechanical and wears resistance of the aluminium metal matrix Nanocomposites (AMNCs). The fabrication of AMNCs by ultrasonic cavitation-based solidification processing is attractive due to better matrixparticle bonding. easier control of matrix structure, simplicity, inexpensive processing, flexibility, applicability to bulk production and complex shape.

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II. MATERIAL AND METHOD

METAL MATRIX COMPOSITE

A metal matrix composite is composite material consisting of two or more where tailored properties are achieved by systematic combination of different constituents. One is a metal and the other material can be different metal or other materials such as a ceramic and organic compound. Metal matrix composites reinforced with ceramic particulate offer significant advantages over pure metals and alloys. The metal matrix composites offer several advantages when compared with conventional material. A few such advantages include the combination of high strength, high elastic modulus, high toughness and impact resistance, thermal stability and thermal shock resistance, high surface durability, high hardness, high thermal and electrical conductivity, improved wear resistance, minimum exposure to the potential problem of moisture absorption resulting in environmental degradation, and improved fabric ability with conventional metal working equipment.

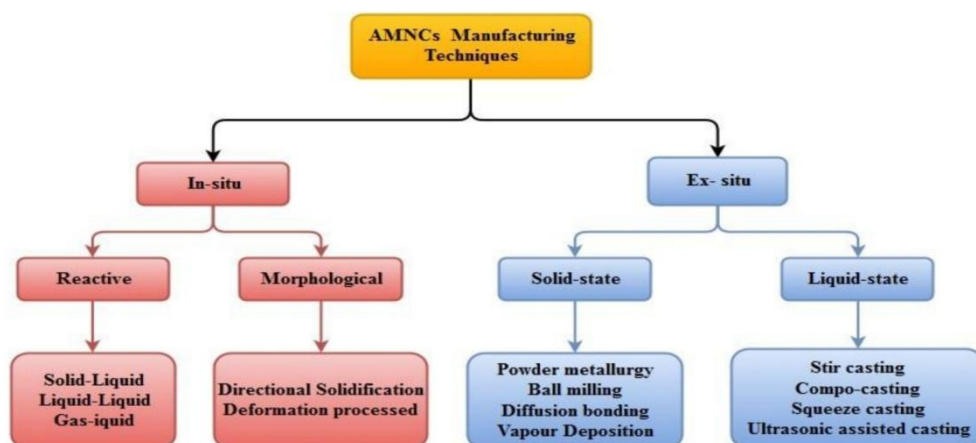


Fig1: Classification of AMNC

POWDER METALLURGY

Powder metallurgy is the process of blending fine matrix and reinforcement powders followed by pressing into a desired shape and then heating the compressed material in a controlled atmosphere to bond the material. The powder metallurgy process generally consists of four basic steps: (1) powder manufacture, (2) powder mixing and blending, (3) compacting, (4) sintering. A schematic of a typical powder metallurgy process is shown in Figure 1.3. Recent developments have made it possible to use rapid manufacturing techniques which use the Nano powders for the Nanocomposite products.

The advantages of the powder metallurgy process are flexibility, near-net shape products, production of complex shapes to very close dimensional tolerances, with minimum scrap loss and fewer secondary machining operations. Physical and mechanical properties of Nanocomposite can be tailored through close control of starting materials and process parameters. Particular properties of the Nanocomposites can be improved through secondary processing operations such as hot or cold extrusion. The advantages of this processing method include the capability of incorporating a relatively high volume fraction of Nanoparticles and fabrication of Nanocomposites with matrix alloy. However, this method requires alloy powders that are generally more expensive than bulk material, and involves complicated processes during the fabrication of Nanocomposites. The powder metallurgy may not be an ideal processing technique for mass production of MMNCs.

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BALL MILLING

Ball milling is a grinding method that grinds Nanotubes into extremely fine powders. During the ball milling process, the collision between the tiny rigid balls in a concealed container will generate localized high pressure. Usually, ceramic, flint pebbles and stainless steel are used. In order to further improve the quality of dispersion and introduce functional groups onto the Nanotube surface, selected chemicals can be included in the container during the process. The factors that affect the quality of dispersion include the milling time, rotational speed, size of balls and balls/ Nanotube amount ratio. Under certain processing conditions, the particles can be ground to as small as 100 nm. This process has been employed to transform carbon Nanotubes into smaller Nanoparticles, to generate highly curved or closed shell carbon Nanostructures from graphite, to enhance the saturation of lithium composition in SWCNTs, to modify the morphologies of cup-stacked carbon Nanotubes and to generate different carbon Nanoparticles from graphitic carbon for hydrogenstorage application. Even though ball milling is easy to operate and suitable for powder polymers or monomers, process-induced damage on the Nanotubes can occur.

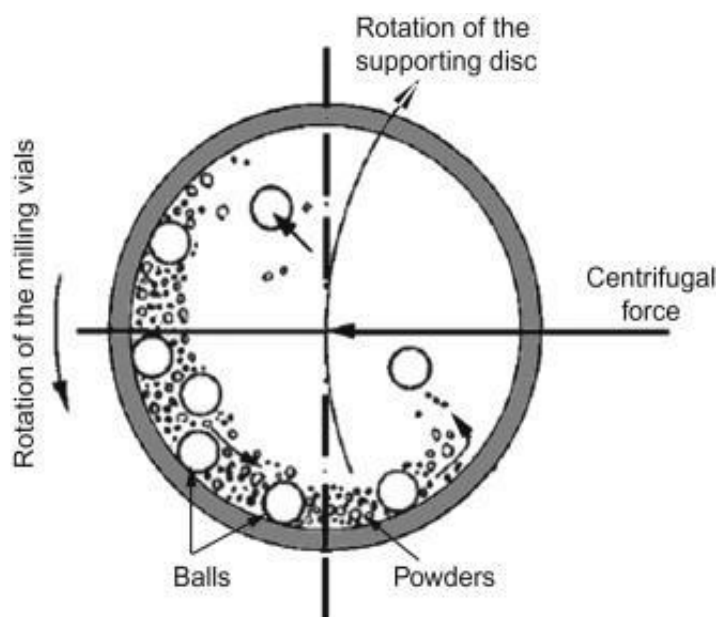


Fig 2: Ballmilling

III. MECHANICAL PROPERTIES OF THE ALUMINIUM/DIAMOND METAL MATRIX NANOCOMPOSITES

PIN ON DISC WEAR TESTER

Friction and wear (typically wear rates and wear resistance) characterization of materials is typically performed using various types of tribometers, while pin on disk test being probably one of the most common. The popularity of the method is due to its relative simplicity and abundance of the tribological contacts that can be well described by the a simple pin on disk motion. from dry contacts of bolt screws 1. To rail wheels to rail contact. 2. And to lubricated contact of biological implants. Further information on the tribology testing standards can be found here.

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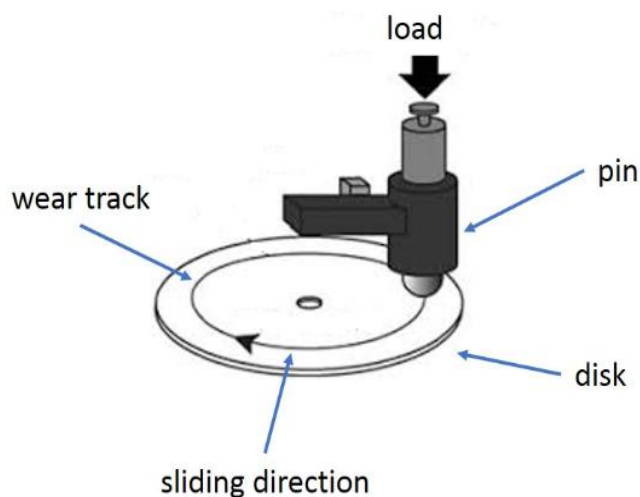


Fig 3: Pin disc on Wear tester

ABRASIVE WEAR TESTING

When screening materials, laboratory abrasive wear testing is a quick and inexpensive way of obtaining large quantities on information on wear rates and wear mechanisms. Typical laboratory abrasive wear tests approximate two- and three-body abrasion. The Albany Research Center, however, uses a suite of four laboratory abrasion, gouging- abrasion, and impact- gouging abrasion wear tests to rank materials for wear applications in the mining and minerals processing industries.

Keywords: Dry-sand rubber-wheel; Pin-on-drum; Impeller-in-drum; Jaw crusher; Abrasion; Ferrous alloys and composite.

DRY-SAND, RUBBER-WHEEL WEAR TEST

The dry-sand, rubber-wheel _DSRW. abrasion test apparatus simulates low-stress, three-body abrasive wear w3x. This type of wear occurs in the mining industry in linkages, pivot pins, and wire ropes, which suffer slow wear from the sliding and rolling action of abrasive fragments of rock and ore trapped between metal surfaces. Because this type of wear is slow, field trials alone would be too slow for evaluating new materials.

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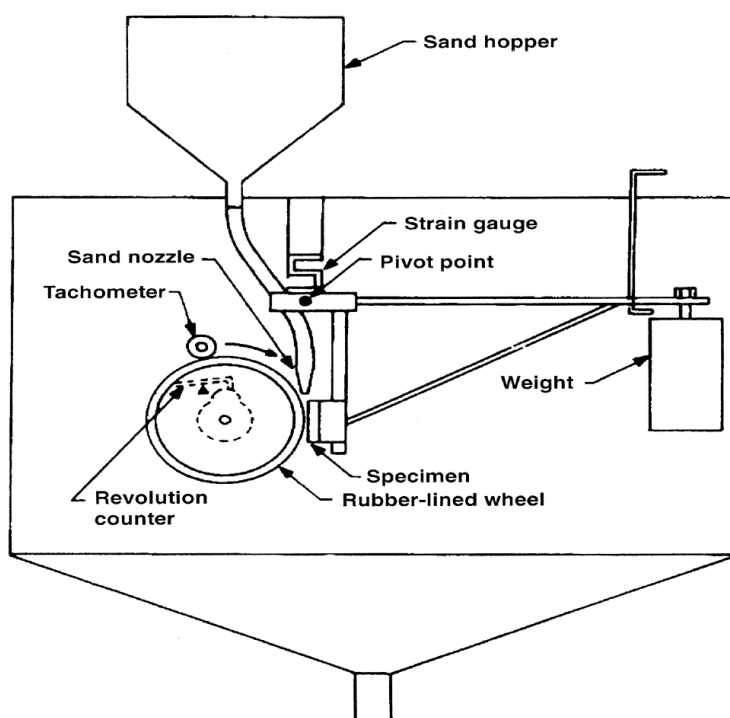


Fig4: Dry sand rubber wheel tester

IV. CONCLUSION

AL 6063 alloy matrix composites reinforced with Zircon Sand particles can be successfully synthesized by the ball milling method. For successful synthesis of composite by stir casting process, stirrer design and position. This process has been employed to transform carbon Nanotubes into smaller Nanoparticles, to generate highly curved or closed shell carbon Nanostructures from graphite, to enhance the saturation of lithium composition in SWCNTs, to modify the morphologies of cup-stacked carbon Nanotubes and to generate different carbon Nanoparticles from graphitic carbon for hydrogen storage application. Wear behaviour of Al6063 /Zircon Sand MMCs is tested by Pin on disk method and found increasing in the percentage of Zircon Sand particles will reduce the wear rate where the composite having 8wt% ZrSiO₄ having the higher wear resistance rate.

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