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MILLING OF STIR CAST ALUMINIUM BORON CARBIDE METAL MATRIX COMPOSITE-A LITERATURE REVIEW

S. Mohamed Hussain, P. Muruganantham, R. Rekha
Department of Mechanical Engineering,
Saranathan College of Engineering,
Trichy.

Abstract

In this study, machining parameters were evaluated and optimized with Genetic Algorithm in milling Al-B_4C (with weight composition of Al-85%, B_4C-15%) reinforced metal matrix composites (MMCs) produced by stir casting. we found B_4C with less composition (10-15%) gives best result. Carbide tools were used under dry cutting conditions for milling. The milling parameters such as feed rate, spindle speed, and depth of cut were optimized based on multiple performance characteristics including MRR, cutting force, and surface roughness. Furthermore, average surface roughness of milled face is good at high cutting speed, low feed rate and high depth of cut. MRR increases with feed rate and depth of cut. Cutting force is optimum at medium factor level.

Introduction

Manufacturing of engineering materials which are light and durable yet strong has been one of the most interesting topics in both academic and industry in the last three decades. Compared with conventional, unreinforced alloys, composite materials usually exhibit higher strength, both at ambient and elevated temperatures, as well as good fatigue strength and wear resistance. There has been a great interest in aluminium reinforced ceramic composites due to their low density and excellent wear resistance. Aluminium is lighter weight which is first requirement of a composite. Its strength, hardness and thermal expansion coefficient of Al matrix composites can be adjusted by adding boron carbide by stir casting method. Stir casting is an economical process for the fabrication of aluminium matrix composites. Main objective of this research is developing lightweight Aluminium metal matrix composites and analyze the influence of Boron Carbide reinforcements in machinability study.

Literature survey

Kesha singh et al. (2017) Prepared by stir casting. Preheating of reinforcement Boron Carbide B_4C at 350°C was done by using muffle furnace. mechanical stirring is carried out for a period of 12 min. Composites prepared were in three different compositions i.e. LM24

+ 3% B_4C, LM24 + 5% B_4C, LM24 + 7% B_4C. The Ultimate tensile strength of composites increases with increases weight % of B_4C particles up to 7%. Impact strength of the alloy increases 52.94 % on reinforcing it with 7% of Boron Carbide [1].

T. Rajmohan et al. (2012) The aluminum alloy was melted in an electric muffle furnace with crucible. Mica and SiC preheated at about 620 °C were added to the molten metal at 750 °C and stirred continuously. The drill size was 6 mm in diameter and its helix angle was 30°, the point angle used was 118°. The drills used were carbide, TiN coated carbide and polycrystalline diamond. The mechanism of drilling depends on the content of reinforcement particles embedded in the matrix, type of drill used, cutting conditions used, etc. The recommended levels of drilling parameters for minimizing thrust force, surface roughness, tool wear and burr height (exit) simultaneously are the content of mica at level 2 (3%), drill type at level 3 (PCD), spindle speed at level 1 (1000 r/min) [2].

B. Manjunatha et al. (2015) Samples were prepared from both the as-cast and extruded samples for hardness measurements. primary processing of Al-6061- (1.5- 10 wt. %) B_4C composite by 'stir casting' technique and subjecting the matrix and its composites to T6-heat treatment (Thermal loading) as well as to extrusion process (Mechanical loading); study of the effect of mechanical loading and thermal loading of the cast composite on the tensile strength and hardness. The melt was allowed to attain constant, uniform temperature of 680°C.The mixing of slurry was performed at speed of 400 RPM for 10minutes to obtain uniform distribution of ceramic particles in the melt. After ensuring the proper mixing of the ceramic particles with melt, the mixture was poured into preheated (400 Celsius) [3].

B. Ravia et al. (2015) The fabrication of AA 6061-B_4C composite using a Stir Casting method. In this, firstly AA6061 alloy in the form of 25 mm diameter rods cut into 75mm length was placed in a clay graphite crucible. It was then melted in a resistance heated muffle furnace to the desired temperature of 850C. The mixture was stirred continuously by using mechanical stirrer for about 10-15 minutes at an impeller speed of 400 rpm. The melt temperature was maintained at 800C during addition of the particles. The molten metal was then poured into the preheated die to cast plates of 100mmx100mmx10mm size. The microhardness of the composites increased from 62 HV to 68 HV with incremental weight percentage of B4C particles. The B4C reinforcement has enhanced the tensile strength of Aluminium Matrix Composites (AMCs) from 117 MPa to 145 MPa [4].

Sener Karabulut et al. (2016) The B4C particles were injected into molten aluminum using a powder injection technique and compositions were homogenized to obtain a uniform microstructure at the elevated temperatures for 48 h. Then, resulting specimens were quenched in warm water and aged in the range of 25-400°C for 10 h, at each temperature. The use of orthogonal arrays can decrease the time and cost of experiments by reducing the number of experiments. The optical and SEM micrographs show that B_4C particles are homogeneously distributed in all composite specimens and achieved good interfacial bonding with the matrix [5].

Bhaskar Chandra Kandpala et al. (2017) It was found that stir casting is an economical method to fabricate AMMC. The objectives of this research work are the fabrication and characterization of AA 6061/ Al2O3 AMMC which was fabricated using stir casting process. The reinforcement of Al203 particles improved the micro hardness and ultimate tensile strength of AMMCAA 6061/ Al2O3 reveal reasonable increase in hardness and decrease of ductility with increasing aluminium oxide content. The increase in Al2O3 content shifted the fracture mode from ductile to brittle [6].

B. Vijaya Ramnath et al. (2014) This paper deals with the fabrication and mechanical investigation of aluminium alloy, alumina (Al2O3) and boron carbide metal matrix composites. Aluminium is the matrix metal having properties like light weight, high strength and ease of machinability. After solidification, the samples are prepared and tested to find the various mechanical properties like tensile, flexural, impact and hardness. The microstructure is also a very important parameter which influences the properties of the composite. It has been inferred that the tensile strength of sample 3 is marginally higher than other two samples because of its aluminium content. But, the sample 1 has higher tensile strength (54.60 MPa) than sample 2 (51.75 MPa). Considering the results of the impact test, the impact value of sample 1 (2.18 J) is lower than the impact value of sample 2 (2.42 J), but higher than that of sample 3 (2 J) [7].

K. Shirvanimoghaddam et al. (2016) This paper investigates the manufacturing of aluminium-boron carbide composites using the stir casting method. Mechanical and physical properties tests to obtain hardness, ultimate tensile strength (UTS) and density are performed after solidification of specimens. There has been a great interest in aluminium reinforced ceramic composites due to their low density and excellent wear resistance. Wettability and mechanical properties are increased with increasing processing temperature from 800°C to 1000°C. Temperature, surface treatment of particles, stirring speed and stirring time, affects the wettability, agglomeration and dispersion of B_4C particles. Shorter stirring times cause the non-uniform dispersion and higher stirring time cause agglomeration, floating and running of particles to the edge of the crucible which consequently affects the mechanical properties of MMCs [8].

Hao Guo et al. (2017) Boron-carbide-reinforced aluminum matrix composites are widely used as various function materials. This paper aims at reviewing theoretical and experimental background related to boron-carbide reinforced aluminum matrix composites. The formation of interface between boron carbide and matrix and strengthening mechanisms of the boron-carbide-reinforced aluminum matrix composites are discussed [9].

K. Rajkumar et al. (2014) This paper deals with the comparison studies on mechanical properties for cleaner energy like microwave heat treatment and conventional heat treatment of Al (6061) -B_4C composite. Machinability characteristics of microwave heat treated and non-heat treated composites were evaluated using a lathe tool dynamometer. At high cutting speed, machining will minimize chip tool contact length & build-up edge formation, which reduces the cutting force. Microwave heat treated composites exhibited finer microstructure in machining compared with non-heat treated composite material [10].

I. Sudhakar et al. (2015) High strength-to-weight ratio of non-ferrous alloys, such as aluminium, magnesium and titanium alloys, are considered to be possible replacement of widely accepted steels in transportation and automobile sectors. Ballistic performance testing as per the military standard (JIS.0108.01) was carried out. In the present work, an analytical method of predicting the ballistic behavior of surface composites was developed. For the first time, the present work demonstrated successfully that the friction stir processing route is an effective strategy for enhancement of ballistic performance of AA7075 aluminium alloy which finds wider range of defense applications [11].

Andy Nieto et al. (2017) In this study, the effect of B_4C reinforcement particle size on the abrasive wear behavior of Al-B_4C composites was investigated. Composites with a homogenous dispersion of micrometric-B_4C, submicron-B_4C, and nano-B_4C in a nanostructured Al alloy 5083 (AA5083) matrix were fabricated using cryogenic mechanical alloying and dual mode dynamic forging. The Al-nanoB_4C composite has superior wear resistance due its high hardness and greater interfacial area, which hindered pull-out of nano-B_4C particles. The more ductile AA5083 material benefitted from embedding of hard silica particles/debris during the abrasive wear test, which partially compensates for the absence of a hard reinforcement phase. The Al-nB_4C composite exhibited improved abrasive wear resistance over AA5083 and the composites with larger B_4C particles because of the higher hardness obtained and the higher surface area of the nanoparticles that led to more particle-matrix interfaces [12].

Ravinder Kumar et al. (2015) This paper presents an experimental investigation on Over-Cut in Drilling of aluminum hybrid metal matrix composite (Al-15%B_4C). The parameters used for drilling here was Depth of Cut, Spindle Speed, and Drill Diameter. Taguchi's L27 orthogonal array experimentation was used to optimize the parameters of Al-B_4C MMC. The effect of drilling parameters on Over-Cut is studied and presented. The experiments were conducted on a vertical milling machine for the machining of Al/B_4Cp. The tool used for the drilling operation is a High-Speed Steel. The research findings of the present study are based on Taguchi optimization, and can be used effectively in drilling of Al-B_4Cp, in order to obtain best drill hole [13].

J. Udaya Prakash et al. (2015) The present investigation focuses on finding the optimal machining parameters setting in drilling of aluminium metal matrix composites using the signal to noise ratio analysis. The Taguchi method of experimental design is a widely accepted technique used for producing high quality products at low cost, therefore a L27 orthogonal array is used for the experiments. Experimental results have shown that the required performance characteristics in the drilling process are improved by using this approach. The confirmation experiments show that error associated with thrust force is negligible [14].

S. Kannan et al. (2007) In this paper, tool wear, surface integrity and chip formation are studied under both dry and wet cutting conditions. The turning results showed that the influence of coolant on tool life was more pronounced at higher cutting speeds than at lower cutting speeds. The microhardness measurements on the aluminium matrix beneath the machined layer showed higher values when cutting under wet conditions. The microhardness measured beneath the machined layer in the aluminium matrix was slightly higher under wet cutting conditions at lower cutting speed [15].

Isil Kerti et al. (2008) The present work introduces a cost-effective and reliable casting technique to overcome the wetting problem between B_4C and liquid aluminium metal as well as the formation of undesirable phases at the interface using K2TiF6 flux. For this aim, experimental work was carried out using B4C powders with different particle sizes to reinforce commercially available aluminium using casting technique. It is possible to produce Al–B_4C composites with homogenous microstructure using K2TiF6 flux by casting method [16].

Ahmet Taskesen et al. (2013) In this study, machining parameters were evaluated and optimized with grey relational analysis in drilling B_4C reinforced metal matrix composites (MMCs) produced by powder metallurgy. The drilling parameters such as feed rate, spindle speed, drill material and wt.% of B_4C particles were optimized based on multiple performance characteristics including thrust force, torque and surface roughness. Furthermore, average surface roughness of drilled hole decreased with increasing particle content for carbide tools and increased for HSS tools. Generally, short arced and acicular chips were produced with HSS tools, while short arced chips were obtained with carbide tools and the curvature radius of the chips increased as feed rate increased. Additionally, powdery chips also were formed as the weight fraction increased due to workpiece brittleness [17].

S. Magibalan et al. (2017) A composite material is a combination of two or more chemically distinct and insoluble phases; its properties and structural performance are superior to those of the constituents acting independently. Aluminum alloy constitutes a very important engineering material widely employed in the aircraft and aerospace industry for the manufacturing of different parts and components. Various processing techniques for the fabrication of Aluminium matrix composites, testing of their mechanical properties are available. For the new generation of hybrid composites, which involve the use of agro and industrial waste derivatives, improved performance in comparison with the unreinforced alloy have been established [18].

M.K. Sathish Kumar et al. (2015) Aluminium alloy-based metal matrix composites (MMCs) have been by now shown themselves as an appropriate wear resistant material mainly for sliding wear applications. The use of Aluminium MMCs is inevitable in engineering applications such as Automotive, Aerospace, Military, Marine and Electronic Industries. good surface finish can be obtained by controlling the three major process parameters depth of cut, speed, and feed in turning operation with the help of Poly Crystalline Diamond (PCD) insert. e. The information about development of Aluminium with different percentages and materials is presented [19].

S.E. Shin et al. (2016) This study evaluated the mechanical and thermal properties of aluminum alloy 2024 (Al2024) matrix composites reinforced with multi-walled carbon nanotube (MWCNT) or few-layered graphene (FLG) in the temperature range of 250-430 ºC. The Al2024/MWCNT and Al2024/FLG composites were fabricated using powder metallurgy, and the associated microstructures were observed. These novel Al-matrix nanocomposites can meet the requirements of light-weight, high mechanical strength, and low CTE automobile piston materials, comparable with commercial and heat-treated Al alloys [20].

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