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Wire electro discharge machining of metal matrix composites: A review

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Abstract

Wire electrical discharge machining (WEDM) is a particular thermal non-contact technique of machining. Within the past decade, the WEDM process is a competitive and economical machining option fulfilling the demanding machining requirements from a mere tool to complex die making process. Now a day's WEDM process is commonly used for machining of materials from conventional materials to nascent materials like Metal Matrix Composites, ceramic composites, which have vast applications in automobile, aircraft, railway sectors, defence, aerospace, micro systems industries, agriculture farm machinery, etc. Metal matrix composites (MMCs) are advanced materials having properties such as light weight, high specific strength, good wear resistance, a low thermal expansion coefficient, low density. These materials can be machined by non-conventional methods like water jet, laser cutting but these processes are restricted to linear cutting only. Wire Electrical discharge machining (WEDM) shows higher ability for cutting complex shapes with high precision for MMCs. Conventional machining of MMC's causes serious tool wear due to greater hardness and the existence of abrasive reinforcement particles. Numerous studies and research are going on in modelling of WEDM since its inception. Most of the researchers thoroughly worked on process modelling, process parameters, materials of electrodes/tool-work-piece, dielectric medium, etc. The process modelling of WEDM is considered as prime objective. There is need to categorize the variety of research for better understanding of research done in this area. This paper reviews machining of MMCs, techniques used, responses, findings and summery of review. The paper also discusses the future trends of research work in the same area.

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Keywords: Electro Discharge Machining, Wire Electro Discharge Machining, Metal Matrix Composites, Modeling of Wire Electro Discharge Machining process

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1. Introduction

A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal and other material may be a different metal or another material, such as a ceramic or organic compound. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. The matrix is usually a lighter metal such as aluminium, magnesium, or titanium, and provides a compliant support for the reinforcement. The reinforcement can be either continuous, or discontinuous. MMCs are taking over conventional materials in most of the application areas. Table 1 shows different types of MMCs, reinforcements, properties and applications of the same.

Table. 1. Types of MMCs, reinforcement, properties and applications of MMCs

Sr. No.	Type of MMC	Reinforcements	Properties	Applications
1	Aluminum Matrix Composites	Alumina (Al_2O_3) or silicon carbide (SiC) particles	High strength even at elevated temperatures; High stiffness (modulus of elasticity); Low density; High thermal conductivity; Excellent abrasion resistance.	Automotive parts (pistons, pushrods, brake components), brake rotors for high speed trains, bicycles, golf clubs, electronic substrates, cors for high voltage electrical cables
2	Magnesium Matrix Composite	Silicon carbide (SiC) particles	Low density; High stiffness (modulus of elasticity); High wear resistance; Good strength even at elevated temperatures; Good creep resistance.	Components for racing cars, lightweight automotive brake system, aircraft parts for: gearboxes, transmissions, compressors and engine
3	Titanium Matrix Composite	Continuous monofilament silicon carbide fiber; Titanium boride (TiB_2) and titanium carbide (TiC) particles	High strength; High stiffness (modulus of elasticity); High creep resistance; High thermal stability; High wear resistance.	Structural components of the F-16 jet's landing gear, turbine engine components (fan blades, actuator pistons, synchronization rings, connecting links, shafts, discs), automotive engine components, drive train parts, general machine components.
4	Copper Matrix Composites	Continuous fibers of carbon (**C**), silicon carbon (SiC), tungsten (W), stainless steel 304; Silicon carbide particles	Low coefficient of thermal expansion; High stiffness (modulus of elasticity); Good electrical conductivity; High thermal conductivity; Good wear resistance.	Manufacturing hybrid modules, electronic relays, electrically conducting springs and other electrical and electronic components

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2. Literature Review

MMC's can be machined by many conventional machining processes such as turning, milling, drilling, tapping, grinding, honing, sawing, etc. But results shows huge amount of tool wear, poor machineability, poor surface quality, low accuracy, more cutting force required which restricts MMC's to be machined by conventional manufacturing processes so, most of authors recommended non conventional machining processes for machining of