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Optimization of machining parameters in turning of Al−SiC−Gr hybrid metal matrix composites using grey-fuzzy algorithm

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Abstract: Metal matrix composites reinforced with graphite particles provide better machinability and tribological properties. The present study attempts to find the optimal level of machining parameters for multi-performance characteristics in turning of Al−SiC−Gr hybrid composites using grey-fuzzy algorithm. The hybrid composites with 5%, 7.5% and 10% combined equal mass fraction of SiC−Gr particles were used for the study and their corresponding tensile strength values are 170, 210, 204 MPa respectively. Al−10%(SiC−Gr) hybrid composite provides better machinability when compared with composites with 5% and 7.5% of SiC−Gr. Grey-fuzzy logic approach offers improved grey-fuzzy reasoning grade and has less uncertainties in the output when compared with grey relational technique. The confirmatory test reveals an increase in grey-fuzzy reasoning grade from 0.619 to 0.891, which substantiates the improvement in multi-performance characteristics at the optimal level of process parameters setting.
Key words: hybrid composite; turning; optimization; grey-fuzzy algorithm

1 Introduction

Metal matrix composites (MMCs) offer interesting opportunities for new product design due to enhanced properties. Some of the beneficial properties of MMCs are high strength and stiffness, increased wear resistance, lower coefficient of thermal expansion and dimensional stability at a higher temperature. In aluminium metal matrix composites (AMCs), the matrix material is aluminium/aluminium alloy and the other phases are reinforcement which are Gr, SiC, Al_2O_3, B_4C, etc [1,2]. The incorporation of ceramic particles in Al alloy increases both mechanical strength and wear resistance of the composite. The hard abrasive SiC particles in Al−SiC composite complicate the machining operation. Thus the machinability of particulate MMCs is improved by reinforcing soft particles like graphite along with hard ceramic particles [3]. The composites with combined reinforcement of SiC and Gr particles are referred to Al−SiC−Gr hybrid composite. The superiority of Al−SiC−Gr composite is self-lubricating property, enabled by the presence of graphite and its strength is enhanced by SiC ceramic phase. This hybrid composite substitutes materials for pistons, cylinder liners, brake drums in automotive and aerospace applications [4,5].

Although most composite materials are molded or formed to near net shape, the machining process could not be eliminated entirely because it provides the preferred dimensions, shape and surface finish. PALANIKUMAR and KARTHIKEYAN [6] indicated that on machining Al−SiC composite, the surface roughness is influenced by the feed rate, cutting speed and volume fraction of SiC particles. BASHEER et al [7] reported that in precision machining of MMCs, the roughness of the machined surface is significantly influenced by the size of particles. It is been known that its magnitude depends on feed rate and tool nose radius. LIN et al [8] observed that the material removal rate of aluminium composite seems to be high when the feed rate is higher and cutting speed is lower. The tool wear normally occurred on flank and rake surfaces, with flank wear being most dominant. HOCHENG et al [9] observed the machining characteristics such as discontinuous chips, low cutting forces, less tool wear and low power consumption during machining of

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