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Analysis and optimization of micro-milling parameters for improving part quality in ultrafine graphite with varying workpiece inclination angles

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ABSTRACT

Micro-milling is recognized as one of the most important manufacturing technologies for producing micro-components/products. Amongst various materials, graphite has an important role in conventional micro-electrical discharge machining electrodes. This paper is focused on the investigation of the effect of micro-milling process parameters on the dimensional accuracy and surface quality of ultrafine grain graphite TTK-4. Depth of cut, spindle speed, stepover distance and feed rate have been considered as process variables of micro ball-end milling in experimental design. Moreover, the influence of the workpiece's inclination angle was also investigated. Taguchi's L_9 (3^4) orthogonal array was chosen to design the experiments, whereas grey relational analysis (GRA) was utilized for the multi-objective optimization of the micro ball end milling process with minimum dimensional deviation and minimum arithmetic mean roughness as objective functions. Furthermore, principal component analysis (PCA) was used to extract principal components and identify the corresponding weights for performance characteristics. In order to determine the significance of micro-milling parameters on overall machining performance, analysis of variance (ANOVA) was performed. The result of the study revealed that the proposed approach is adequate to address the multi-objective optimization of micro-milling parameters.

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Analiza in optimizacija parametrov mikrorezkanja za izboljšanje kakovosti izdelkov iz ultrafinega grafita pri različnih kotih nagiba obdelovanca

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P O V Z E T E K

Mikrorezkanje velja za eno ključnih proizvodnih tehnologij za izdelavo mikrokomponent oziroma mikroizdelkov, pri čemer grafit predstavlja enega najpomembnejših materialov za izdelavo elektrod v klasični mikroelektroerozijski obdelavi. V članku je predstavljena raziskava vpliva procesnih parametrov mikrorezkanja na dimenzijsko natančnost in kakovost površine ultrafinega grafita TTK-4. Eksperimentalno načrtovanje mikrorezkanja s krogličnim orodjem je temeljilo na štirih procesnih spremenljivkah: globini reza, hitrosti vretena, širini reza in hitrosti podajanja, dodatno pa je bil preučen tudi vpliv kota nagiba obdelovanca. Za načrtovanje eksperimentov je bila uporabljena Taguchijeva ortogonalna matrika L_9 (3^4). Večkriterijska optimizacija postopka mikrorezkanja je bila izvedena s sivo relacijsko analizo (GRA) z namenom doseganja čim manjše dimenzijske napake in aritmetične srednje hrapavosti površine. Analiza glavnih komponent (PCA) je bila uporabljena za določitev uteži posameznih kazalnikov kakovosti, analiza variance (ANOVA) pa za oceno pomembnosti posameznih procesnih parametrov na skupno učinkovitost obdelave. Rezultati so potrdili, da je predlagani pristop učinkovit za večkriterijsko optimizacijo parametrov mikrorezkanja.

P O D A T K I O Č L A N K U

Ključne besede:
Mikrorezkanje;
Grafit;
Kot nagiba obdelovanca;
Optimizacija;
Dimenzijska natančnost;
Kakovost površine;
Taguchijeva metoda;
Siva relacijska analiza

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