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Machinability analysis and multi-response optimization using NGSA-II algorithm for particle reinforced aluminum based metal matrix composites

Umer, U.[a,*], Mohammed, M.K.[a], Abidi, M.H.[a], Alkhalefah, H.[a], Kishawy, H.A.[b]

[a]Advanced Manufacturing Institute, King Saud University, Riyadh, Saudi Arabia
[b]Machining Research Laboratory, University of Ontario Institute of Technology, Oshawa, ON, Canada

A B S T R A C T

In this study the effects of reinforcement particle size and cutting parameters on machining performance variables like cutting force, maximum tool-chip interface temperature and surface roughness of the machined surface have been investigated while machining Aluminum based metal matrix composites (MMCs). MMC bars with silicon carbide reinforcement having 10 % volume fraction and particle sizes of 5 μm, 10 μm and 15 μm are machined with polycrystalline diamond (PCD) inserts. Experiments are performed using central composite design (CCD) having four parameters with three levels. Response surfaces for each performance variables are generated using polynomial models. Single variable and interaction effects have been investigated using principal component analysis and 3D response charts. Multi-response optimization has been performed to minimize surface roughness and maximum tool-chip interface temperature using non-dominated sorting genetic algorithm II (NSGA-II). In addition, constraints have been applied to the optimization search to filter design points with high cutting forces and low material removal rate. Most of the optimal solutions are found to be with moderate cutting speeds, low feed rate and low depth of cuts.

A R T I C L E I N F O

Keywords:
Metal Matrix Composites (MMC);
Machining;
Reinforcement particle;
Machinability;
Multi-objective optimization;
Non-dominated sorting genetic algorithm (NSGA-II)

**Corresponding author:*
uumer@ksu.edu.sa
(Umer, U.)

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Analiza obdelovalnosti in večkriterijska optimizacija z algoritmom NGSA-II z delci ojačanih kompozitov s kovinsko matrico na osnovi aluminija

Umer, U.[a,*], Mohammed, M.K.[a], Abidi, M.H.[a], Alkhalefah, H.[a], Kishawy, H.A.[b]

[a]Advanced Manufacturing Institute, King Saud University, Riyadh, Saudi Arabia
[b]Machining Research Laboratory, University of Ontario Institute of Technology, Oshawa, ON, Canada

P O V Z E T E K

V tej študiji so bili raziskani vplivi velikosti ojačitvenih delcev in rezalnih parametrov na kazalnike učinkovitosti strojne obdelave, kot so rezalna sila, največja površinska temperatura odrezkov ter površinska hrapavost obdelane površine, med obdelavo kompozitov s kovinsko matrico (MMC) na osnovi aluminija. Palice MMC z ojačitvijo iz silicijevega karbida z 10-odstotnim volumskim deležem in velikostjo delcev 5 µm, 10 µm in 15 µm so strojno obdelane s ploščico iz polikristalnega diamanta (PCD). Poskusi so izvedeni na podlagi centralne kompozitne zasnove (CCD) s štirimi spremenljivkami in tremi ravnmi. Odzivne površine za vsako spremenljivko so ustvarjene z uporabo polinomskih modelov. Vplive spremenljivk in interakcijske vplive smo raziskali z analizo glavnih komponent in tridimenzionalnimi diagrami odziva. Za zmanjšanje hrapavosti površine in največje površinske temperature odrezkov je bila izvedena večkriterijska optimizacija z uporabo genetskega algoritma z nedominiranim sortiranjem II (NSGA-II). Pri optimizacijskem iskanju so bile uporabljene omejitve za izločitev rešitev z visokimi rezalnimi silami in nizko stopnjo odstranjevanja materiala. Večina optimalnih rešitev je najdena pri zmernih rezalnih hitrostih, nizkih podajalnih hitrostih in majhnih globinah rezanja.

P O D A T K I O Č L A N K U

Ključne besede:
Kompoziti s kovinsko matrico (MMC);
Strojna obdelava;
Ojačitveni delci;
Obdelovalnost;
Večkriterijska optimizacija;
Genetski algoritem z nedominiranim sortiranjem (NSGA-II)

**Kontaktna oseba:*
uumer@ksu.edu.sa
(Umer, U.)

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