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Modeling and optimization of parameters for minimizing surface roughness and tool wear in turning Al/SiCp MMC, using conventional and soft computing techniques

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ABSTRACT

Aluminium alloy with silicon carbide particulate (Al/SiCp) reinforced metal matrix composite (MMC) are used within a variety of engineering applications due to their excellent properties in comparison with non-reinforced alloys. This presented work attempted the development of predictive modeling and optimization of process parameters in the turning of Al/SiCp MMC using a titanium nitride (TiN) coated carbide tool. The surface roughness R_a as product quality and tool wear *VB* for improved tool life were considered as two process responses and the process parameters were cutting speed *v*, feed *f*, and depth of cut *d*. Two modeling techniques viz., response surface methodology (RSM) and artificial neural network (ANN) were employed for developing R_a and *VB* predictive models and their predictive capabilities compared. Four different RSM models were tried out viz., linear, linear with interaction, linear with square, and quadratic models. The linear with interaction model was found to be better in terms of predictive performance. The optimum operating zone was identified through an overlaid contour plot generated as a response surface. Parameter optimization was performed for minimizing R_a and *VB* as a single objective case using a genetic algorithm (GA). The minimum R_a and *VB* obtained were 2.52 μm and 0.31 mm, respectively. Optimizations of multi-response characteristics were also performed employing desirability function analysis (DFA). The optimal parameter combination was obtained as v = 50 m/min, f = 0.1 mm/rev and d = 0.5 mm being the best combined quality characteristics. The prediction errors were found as 4.98 % and 3.82 % for R_a and *VB*, respectively, which showed the effectiveness of the method.

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Izvirni znanstveni članek

Modeliranje in optimizacija obdelovalnih parametrov za minimizacijo površinske hrapavosti in obrabe orodja pri struženju Al/SiCp MMC z uporabo konvencionalnih in mehkih računalniških pristopov

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POVZETEK

Aluminijeve zlitine, s karbidnimi delci (Al/SiCp) okrepljeni kompoziti s kovinsko osnovo (MMC), se uporabljajo pri številnih inženirskih aplikacijah zaradi odličnih lastnosti v primerjavi z neokrepljenimi zlitinami. Ta raziskava je bila namenjena razvoju modeliranja in optimizacije procesnih parametrov pri struženju Al/SiCp MMC s karbidnim orodjem, prevlečenim s titanovim nitridom (TiN). Odziva sistema sta bila površinska hrapavost R_a in obraba orodja *VB*. Procesni parametri so bili rezalna hitrost *v*, podajanje *f* in globina reza *d*. Za razvoj napovedovalnih modelov R_a in *VB* sta bili uporabljeni dve tehniki modeliranja, in sicer metodologija odzivnih površin (RMS) in umetne nevronske mreže (ANN). Preizkušeni so bili štirje različni modeli RSM, in sicer liearni, linerani s soodvisnostjo, linerano-kvadratni in kvadratni. Linearni model s soodvisnostjo je pokazal dobre lastnosti glede kakovosti napovedovanja. Optimalno delovno področje je bilo določeno s pomočjo konturnih grafov ustvarjenih kot odzivne površine. Narejena je bila enokriterijska optimizacija parametrov za minimizacijo R_a in *VB* z uporabo genetskega algoritma (GA). Najmanjši dobljeni R_a oziroma *VB* sta bili 2.52 μm oziroma 0.31 mm. Narejena je bila tudi optimizacija značilnosti pri več odzivih s pomočjo metode DFA. Optimalna kombinacija parametrov je bila: v = 50 m/min, f = 0.1 mm/rev in d = 0.5 mm. Napaka pri napovedovanju je bila 4.98 % oziroma 3.82 % za R_a oziroma *VB*, kar kaže na učinkovitost predlagane metode.

PODATKI O ČLANKU

Ključne besede:
Kompoziti s kovinsko osnovo
Obraba orodja
Metodologija odzivnih površin
Umetne nevronske mreže
Genetski algoritem
Analiza funkcije koristnosti

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