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Neuro-mechanistic model for cutting force prediction in helical end milling of metal materials layered in multiple directions

Zuperl, U.[a,*], **Cus, F.**[a], **Zawada-Tomkiewicz, A.**[b], **Stępień, K.**[c]

[a]University of Maribor, Faculty of Mechanical Engineering, Slovenia
[b]Koszalin University of Technology, Department of Mechanical Engineering, Poland
[c]Kielce University of Technology, Faculty of Mechatronics and Mechanical Engineering, Poland

ABSTRACT

In machining of multi-layer metal materials used frequently for the manufacture of transfer sheet-metal forming tools, the cutting edge is often damaged because of cutting force peaks. Therefore, a neuro-mechanistic model, presented in this paper, has been created for accurate prediction of cutting forces in helical end milling of multidirectional layered materials. The generalized model created takes into account the complex geometry of the helical end milling cutter, the instantaneous chip thickness and the direction of depositing of the individual layer of the multidirectional layered material considered in the calculation through predicted specific cutting forces. For the prediction of specific cutting forces for individual layers a neural network is incorporated in the model. The comparison with experimental data shows that the model predicts accurately the flow of cutting force in milling of multidirectional layered metal materials for any combination of cutting parameters, tool engagement angle and directions of depositing three layers of material. The predicted cutting force values agree well with the values obtained, the maximum error of predicted cutting forces is 16.1 % for all comparison tests performed.

ARTICLE INFO

Keywords:
Helical end milling;
Multidirectional layered metal material;
Cutting forces;
Specific cutting forces;
Neuro-mechanistic model;
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**Corresponding author:*
uros.zuperl@um.si
(Zuperl, U.)

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Izvirni znanstveni članek

Nevro-mehanski model za napovedovanje rezalne sile pri finem vijačnem rezkanju kovinskih materialov z večsmerno nanesenimi plastmi

Zuperl, U.[a,*], **Cus, F.**[a], **Zawada-Tomkiewicz, A.**[b], **Stępień, K.**[c]

[a]University of Maribor, Faculty of Mechanical Engineering, Slovenia
[b]Koszalin University of Technology, Department of Mechanical Engineering, Poland
[c]Kielce University of Technology, Faculty of Mechatronics and Mechanical Engineering, Poland

POVZETEK

Pri obdelavi večplastnih kovinskih materialov, ki se pogosto uporabljajo za izdelavo orodij za preoblikovanje pločevine, se rezalni rob pogosto poškoduje zaradi vrhov rezalne sile. Zato je bil v tem prispevku predstavljen nevro-mehanski model za natančno predvidevanje rezalnih sil pri finem vijačnem rezkanju materialov z večsmerno nanesenimi plastmi. Ustvarjeni posplošeni model upošteva zapleteno geometrijo vijačnega rezkalnega orodja, trenutno debelino odrezka in smer nalaganja plasti materiala. Za predvidevanje specifičnih rezalnih sil za posamezne plasti je v model vključena nevronska mreža. Primerjava z eksperimentalnimi podatki kaže, da model natančno napove potek rezalne sile pri rezkanju večsmerno in večplastno nanesenih kovinskih materialov za vsako kombinacijo rezalnih parametrov, vstopnega kota orodja in smeri nalaganja treh plasti materiala. Predvidene vrednosti rezalne sile se dobro ujemajo z dobljenimi vrednostmi, največja napaka predvidenih rezalnih sil je 16,1 % za vse izvedene primerjalne teste.

PODATKI O ČLANKU

Ključne besede:
Fino vijačno rezkanje;
Večsmerno in večplastno nanesen kovinski material;
Rezalne sile;
Specifične rezalne sile;
Nevro-mehanski model;
Modeliranje;
Napoved;
Umetne nevronske mreže

**Kontaktna oseba:*
uros.zuperl@um.si
(Zuperl, U.)

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