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Femtosecond laser helical drilling of nickel-base single-crystal super-alloy: Effect of machining parameters on geometrical characteristics of micro-holes

Yin, C.P.[a], **Wu, Z.P.**[a], **Dong, Y.W.**[a,b,*], **You, Y.C.**[a], **Liao, T.**[a]

[a]School of Aerospace Engineering, Xiamen University, Xiamen, P.R. China
[b]Shenzhen Research Institute, Xiamen University, Shenzhen, P.R. China

ABSTRACT

Laser micro-hole processing has been widely used in industry. Many laser processing parameters can affect the processing results. The relationship between the geometrical shapes of micro-holes and the laser processing parameters has not been determined accurately. In this paper, experiments on the femtosecond laser drilling of the nickel-base single-crystal super-alloy (DD6) materials were conducted to determine the relationship between the parameters, such as the laser single-pulse energy, rotation rate, and downward focus rate, and the geometrical characteristics of the micro-holes, such as the diameter, and roundness. A group of orthogonal experiments were conducted to determine the effects of the comprehensive influencing factors on the geometrical characteristics of the micro-holes. After the experiments were conducted and analysed, the experimental results were modelled by a backpropagation neural network, and the mapping relationship between the laser parameters and the geometrical morphologies of the micro-holes was constructed. The model established by the backpropagation neural network could obtain accurate prediction results, and the predictions of the diameters of the micro-holes were better than those of the roundness.

ARTICLE INFO

Keywords:
Femtosecond laser;
Micro-hole machining;
Helical drilling;
Nickel-base single-crystal super-alloy (DD6);
Orthogonal experiment;
Artificial neural networks (ANN)

**Corresponding author:*
yiweidong@xmu.edu.cn
(Dong, Y.W.)

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Izvirni znanstveni članek

Spiralno vrtanje monokristalne superzlitine na osnovi niklja s femtosekundnim laserjem: Vpliv obdelovalnih parametrov na geometrijske značilnosti mikrolukenj

Yin, C.P.[a], Wu, Z.P.[a], Dong, Y.W.[a,b,*], You, Y.C.[a], Liao, T.[a]

[a]School of Aerospace Engineering, Xiamen University, Xiamen, P.R. China
[b]Shenzhen Research Institute, Xiamen University, Shenzhen, P.R. China

POVZETEK

Laserska izdelava mikrolukenj se v industriji pogosto uporablja. Številni parametri laserske obdelave lahko vplivajo na rezultate obdelave. Razmerje med geometrijskimi oblikami mikrolukenj in parametri laserske obdelave niso natančno določeni. V tem prispevku so bili izvedeni poskusi na femtosekundnem laserskem vrtanju monokristalne superzlitine niklja (DD6) za določitev razmerja med parametri, kot so impulzna energija laserja, hitrost vrtenja in stopnja globinske osredotočenosti ter geometrijskimi značilnostmi mikrolukenj, kot sta premer in krožnost. Izvedena je bila skupina pravokotnih eksperimentov za določitev vplivov parametrov na geometrijske značilnosti mikrolukenj. Po izvedbi in analizi eksperimentov smo eksperimentalne rezultate modelirali z nevronsko mrežo z vzvratnim razširjanjem in konstruirali povezavo med laserskimi parametri in geometrijskimi morfologijami mikrolukenj. Model, ki ga je vzpostavila nevronska mreža, je natančno napovedal rezultate, napovedi premerov mikrolukenj pa so bile boljše od napovedi krožnosti.

PODATKI O ČLANKU

Ključne besede:
Femtosekundni laser;
Obdelava mikrolukenj;
Spiralno vrtanje;
Monokristalna super-zlitina na osnovi niklja (DD6);
Pravokotni eksperiment;
Umetne nevronske mreže (ANN)

**Kontaktna oseba:*
yiweidong@xmu.edu.cn
(Dong, Y.W.)

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