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光学晶体超精密飞切加工的切削力测试

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Cutting force test for ultra-precision flycutting optical crystal

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摘要 建立了光学晶体切削力与加工参数关系的预测模型指导光学加工,以减小光学晶体飞切加工中的冲击现象,改善晶体表面质量,减小刀具磨损。根据飞切加工原理,应用响应曲面法建立了光学晶体的切削力预测模型;采用田口正交设计方法设计实验参数,对光学晶体的切削力进行测试实验。然后,运用实验参数求解出切削力模型,采用方差分析技术、R^2值及残差分析技术分析了切削力预测模型的正确性,以及各参数对切削力的影响。最后,对切削力预测模型进行实验验证。实验结果表明:预测模型完全满足95%的置信水平,具有良好的预测能力,预测精度达2.5%。切削力随着主轴转速的增大而减小,随着进给速度和切削深度的增大而增大,切削深度和主轴转速是切削力的主要影响因素,进给速度带来的影响最小。在精加工过程中,应尽量增大主轴转速,减小切削深度,在180μm/s范围内,进给速度可根据加工效率进行调整。

关键词 : 超精密飞切, 光学晶体, 切削力, 响应曲面法, 预测模型

Abstract : To reduce the impact phenomenon in flycutting machining of an optical crystal and to improve the surface quality of the optical crystal, a prediction model was set up experimentally for the relationship between cutting force and machining parameters. Based on the processing principle of flycutting machining, the prediction model for cutting force was built by response surface methodology(RSM). Then, a cutting force experiment for the optical crystal was conducted under the parameters designed by Taguchi method. After that, the prediction model was achieved by using the experimental data, and the accuracy of the model was analyzed by analysis of variance(ANOVA), R^2 value and residual analysis. In addition, the influences of machining parameters on the cutting force were analyzed. Finally, validation tests were conducted to verify the model. Experimental results demonstrate that the model is adequate at 95% confidence level, and its accuracy is better than 2.5%. Futhermore, the cutting force decreases with the increases of spindle speed, while increases with the increase of feed rate and cutting depth. Moreover, the cutting depth and spindle speed are the main factors on cutting force, whereas the feed rate has the smallest influence. In the finish machining of optical crystal, the spindle speed should be as large as possible, while the cutting depth should be decreased, and the feed rate can be adjusted by processing efficiency under 180μm/s.

Key words : ultra-precision flycutting optical crystal cutting force response surface methodology prediction model

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