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PROCEEDINGS

Numerical Investigation on the Ductile Machining of Calcium Fluoride Single Crystal Enhanced by Laser Assistance

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ABSTRACT

Calcium fluoride (CaF_2) exhibits excellent optical properties, making it a promising candidate for preparing optical components. The actual applications underscore the importance of enhancing the ductile machining of such a difficult-to-machine material. This study starts by investigating the influence of thermal gradient fields on the mechanical behaviors of CaF_2 single crystal experimentally and theoretically, revealing the potential deformation mechanisms under various thermal additions. On this basis, a novel laser-assisted machining (LAM) scheme was proposed to enhance the deformability and machinability of CaF_2 single crystal by tailoring local thermal fields. The laser heating spot within the work material was adjusted to control the local machinability and guide the local plastic flow. Finally, atomic simulations were conducted to assess the feasibility of the proposed heating approach. Molecular dynamics (MD), due to the advantages in simulating plastic behaviors such as dislocation activities and slip motions, was employed here to analyze the effect of laser assistance on the machinability of work material and further uncover the plastic strengthening mechanisms under LAM. The simulation results show that LAM enhances the ductility of CaF_2 and reduces the cutting forces. Additionally, the introduction of a laser heat source maximizes the positive effects of thermal softening while minimizing the negative effects of thermal expansion. The corresponding findings provide a theoretical support for studying the thermal effects of CaF_2 and accelerate the development of LAM.

KEYWORDS

Molecular dynamics; laser assistance; calcium fluoride; thermal gradient; ductile machining

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