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水基能场辅助激光加工微孔的研究进展及发展趋势

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高效率高质量高精度微孔加工在国家航空制造业中有重大需求。航空发动机热端零件微孔加工的方法主要包括电火花打孔和激光制孔。电火花打孔加工质量较高，但加工速度慢，加工成本高，而且不能加工非导电材料。激光制孔是一种无接触式加工，加工材料范围广，加工环境适应性强，加工速度快，制孔精度高，经济效益高、自动化程度高，适于数量多高密度的群孔加工，可实现倾斜面和曲面上的微孔加工。高效率高质量激光精密制孔是高性能航空发动机研制过程中遇到的一个亟待解决的挑战性难题。然而，光致等离子体和材料蒸气会对入射激光束产生屏障效应。而且，在激光加工微孔的过程中，通常会产生重铸层和微裂纹等缺陷。如果使用超快激光提高微孔的加工质量，制孔效率会大幅下降。上述这些相互矛盾的难题很难通过一种传统的激光器同时解决。因此，在保证微孔加工精度的前提下，为了同时提升激光制孔的质量与效率，作者研究团队近年来主要围绕水介质和能场辅助激光制孔开展了大量的探索研究工作。本报告将主要汇报作者研究团队近年来在水基能场辅助激光加工微孔方向开展的探索研究工作及后续研发趋势，例如，水基超声振动辅助激光加工微孔方法（图 1）、水下磁场辅助高频高功率飞秒激光层进式螺旋切孔新方法等。

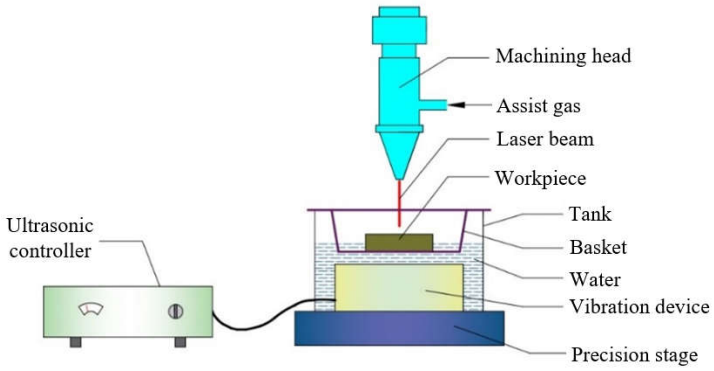

Fig. 1 Schematic for laser-based hole generation assisted by water-based ultrasonic vibrations

关键词： 激光切孔；激光打孔；超声；磁场；水

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