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综述评论

难加工材料切削机理研究的新进展

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摘要 航空发动机重要零件如机匣、压气机风扇叶片等广泛采用钛、镍基合金等先进结构材料. 钛、镍基合金材料切削加工性较差, 主要表现在材料热硬度和热强度很高, 所需切削力很大, 工件、刀具容易产生较大变形; 材料热扩散率低; 刀具切削深度线位置缺口现象严重, 以及形成锯齿状切屑等几个方面. 深入研究此类难加工材料的切削机理, 对于实现薄壁件高效精密数控加工技术至关重要. 本文重点介绍了关于高硬度金属材料锯齿状切屑的形成机制; 非连续切屑形成过程的有限元数值模拟关键技术, 包括自适应网格细化、切屑与工件之间的分离准则, 以及用以描述单元网格中裂纹形核与扩展的断裂准则和算法; 切削区域高温、高应变率条件下材料屈服流动行为的准确描述, 系统考虑应变、应变率和温度三者之间的相互影响作用; 切削温度场、工件表层残余应力场的分布规律, 以期消除残余扭曲变形对航空工业中普遍使用的薄壁结构件加工精度的显著影响.

关键词 金属切削加工 锯齿状切屑 断裂准则 屈服流动模型 残余应力 钛、镍基合金

分类号

NEW PERSPECTIVES ON THE CUTTING MECHANISM OF DIFFICULT-TO-MACHINE MATERIALS

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Abstract

Advanced aeroengine alloys such as titanium and nickel-based alloys are widely used for casing and compressor blades. Poor machinability of titanium and nickel-based alloys are due to their inherent characteristics, including high hot hardness and strength, causing sinificant deformation of the cutting tool and workpiece during machining, low thermal diffusivity, rapid work hardening, causing a severe wear at the depth of cut line, and the saw-tooth chip formation. For efficient and precise NC machining of these difficult-to-machine materials, an understanding of the cutting mechanism is essential. This paper provides an overview of the theories of saw-tooth chip formation mechanism and the fracture criteria for the FEM simulation of segmented chips. How to determine the flow stress at high deformation rates and temperatures in the cutting zone is then discussed. The interaction between strain, strain rate and temperature should be sufficiently considered. The temperature and residual stress have a considerable influence on the distortion and machining precision for thin-wall structures as used in the aerospace industry, which are also analyzed in this paper.

Key words serrated chip fracture criteria flow stress modeling residual stress titanium nickel-based alloys

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