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硕　士　学　位　论　文

通电加热辅助车削技术及其加工过程监测

Electric Hot Assisted Turning and Its Process Monitoring

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摘 要

近年来，机械加工行业中出现了大量耐高温、强度高、硬度大的难加工材料。在这些材料的加工过程中，普遍存在着切削力大、刀具磨损严重、表面质量差等问题。用常规的刀具材料和加工方法很难进行切削加工，也达不到现代工业技术的要求。随着历史的发展，人们提出了许多针对这些难加工材料的加工思路和方法，加热切削就是比较好的思路，而导电加热切削则是其中一种行之有效的方法。

本文对现有导电加热切削技术做出了一些研究，提出了通电加热辅助车削的方法，意在探寻这种方法的可行性和效果。通电加热辅助车削是把低压大电流通入到由电源、加热电极和工件材料构成的回路中，利用电流流经电极—工件间接触电阻时产生的热量，使工件迅速升温从而软化，再进入车削，从而达到提高加工效率，降低切削力，提高刀具耐用度的目的；运用了一种基于通电加热的高温硬度测量方法测量试验材料的高温硬度，探寻了其高温硬度变化规律和合适的软化温度；利用了 ANSYS 有限元软件对通电加热辅助车削过程进行模拟仿真，验证了该方法能够在加工过程中使工件的加热温度保持在软化温度并不影响其内部金相组织；搭建了通电加热辅助车削的试验平台，包括通电加热系统、基于虚拟仪器的加工过程监测系统；采集并分析处理了加工过程中产生的振动信号，以此来评价通电加热辅助车削的加工效果，并优化切削参数及通电加热参数。

以淬火模具钢 Cr12(常温硬度 59HRC)和 304 不锈钢(常温硬度 55HRA)作为切削试验材料，运用单因素试验法进行通电加热辅助车削和传统干车削的对比试验。试验中，详细记录各个参数下刀具的磨损状况；试验后，用提升小波变换处理采集到的振动信号。通过对比，发现通电加热辅助车削淬火模具钢 Cr12 比传统干车削振动幅值降低了 2~10 倍、刀具寿命提高了 6 倍；通电加热辅助车削 304 不锈钢比传统干车削振动幅值降低了 2~8 倍、刀具寿命提高了 9 倍；加工过程都比较平稳，刀具寿命都得到了提高。从而证明了这种方法是切实有效的。

另外还提出了通电加热车削发展的新思路，即电火花和车削的复合加工方法。这种方法是指在交流电源、电极和工件形成通电回路中，用微型振动电机带动电极在工件表面不停的振动，造成回路不停的通断，从而产生电火花。利用电火花的高温蚀除一部分材料后，再进入车削，从而达到降低切削力，辅助车削的

目的；搭建了相应的试验平台；运用了上述基于虚拟仪器的加工过程监测系统，对淬火模具钢 Cr12 的车削进行了初步研究，并分析了试验结果。证明这种方法在原理上是可行的，对加工有一定的好处。

关键词：通电加热辅助车削　振动信号　提升小波变换　电火花车削

Abstract

Recently, lots of high temperature resistance, high strength and high hardness materials has appeared in machining industries. These materials have some problems in the process of machining because of these characteristics, such as high cutting force, serious tool weal and low surface quality. If we use traditional tool or machining methods, we may fail and it could not reach industrial request. With the development of times, people have proposed many machining methods. The electric hot machining is one of effective methods in hot machining.

This article has does some researches about electric hot machining and proposed a new electric hot assisted turning method. The purpose is research it feasibility and effect. The electric hot assisted turning make low voltage and large current enter into a loop which constituted by DC power, heating electrode and workpiece. When the current flows through contact resistances which exist between electrode and workpiece. The resistances can produce quantity of heat. The workpiece is heated to high temperature so the workpiece material hardness decreases. Then we start turning, the cutting force and the tool wear will be reduced. The workpieces' hardness at high temperatures has been tested. Then we measure the workpieces' high temperature hardness based on principle of electric heating. After that, we research the high temperature hardness distribution rule and appropriate softening temperature. We also research the electric hot Assisted Turning process through the finite element simulation based on ANSYS. The result proves that the machining process can keep the workpisce's softening temperature and metallographic structure stability. The paper also found a experimental platform for the electric hot assisted turning. It includes electric hot system and machining monitoring system which is based on virtual instrument. We collect and analyze vibration signals in machining process and then optimizing the cutting parameters and the electric heat parameters.

The article take Cr12 hardened die steel (59HRC) and 304 stainless steel (55HRA) as experimental subjects. Then use single factor experiment method into the

contrast test between electric hot assisted cutting and traditional cutting. We record the tool wear conditions in the experiment. And then we analyze the vibration signals after the experiment which based on lift wavelet transformation. The results show that the vibration amplitude of electric hot assisted turning is 2 to 10 times low than the traditional turning of Cr12 hardened die steel. for another, the tool life is 6 times than the traditional turning. The vibration amplitude of electric hot assisted turning is 2 to 8 times low than the traditional turning of 304 stainless steel, and the tool life is 9 times than the traditional turning. In conclusion, the electric hot assisted cutting is an effective method.

Beside, the article also proposes a new method about electric hot assisted cutting. That is electric spark turning. This method constitutes AC power, electrode and workpiece as a loop, a vibration motor is installed on one of electrode. When the loop is connected, we start the motor; the motor will vibrate the electrode at the same time. The electric spark is appeared as the loop connects or breaks. The paper founds a corresponding experimental platform, makes a experiment on Cr12 hardened die steel. The result shows that this method is feasible in theory. It is good for machining.

Keywords： Electric hot assisted turning; Vibration Signal; lift Wavelet Transform; Electric spark turning.

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