Chapter 6

Experimental Research on Minimum Quantity Lubrication Surface Grinding With Different Cooling and Lubrication Conditions

ABSTRACT

Given the increasing attention to environmental and health problems caused by machining, the development of an environmentally friendly grinding fluid has become an urgent task. The cooling and lubricating properties of different cooling and lubricating conditions were analyzed. The influence mechanism of nanofluids minimum quantity lubrication (NMQL) on cooling and lubricating effect was revealed with different nanoparticles (MoS2, CNT, ZrO2) and different volume concentrations of MoS2 nanofluids (1%, 2%, 3%). The experimental results showed that the temperature rise (258 °C) and grinding force (Fn=70 N, Ft=27 N) obtained under NMQL grinding were the closest to the flood grinding. The specific grinding energy of MoS2 nanofluids was the lowest, which was 47 J/mm³. When the volume concentration was 2%, the best cooling and lubricating effect was obtained. The surface roughness of the workpiece was the lowest (Ra = 0.283 μm; Rz = 0.424 μm).

6.1 INTRODUCTION

Surface grinding, which is a very important machining force in the grinding technology, has high requirements for machining precision and surface integrity of workpiece surface, so it belongs to precision machining technology (Jawahir et al., 2011; Li & Zhao, 2003). There are two major parameters influencing workpiece surface quality in the grinding process namely grinding force and grinding temperature. Cooling and lubricating conditions at the grinding interface influences grinding force and grinding temperature. When lubrication is sufficient, friction coefficient will be reduced, good surface
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quality and superior cooling effect will be finally formed and maximum temperature rise on workpiece surface can be lowered, thus avoiding grinding burning and guaranteeing workpiece surface integrity. Therefore, studying the influence of cooling and lubricating effect on workpiece surface quality in the grinding process will be of great significance (Ding et al., 2014; Guitouni, Chaieb, Ben Rhouma, & Ben Fredj, 2016; Krolczyk, Nieslony, Maruda, & Wojciechowski, 2017; Setti, Sinha, Ghosh, & Rao, 2015). This chapter is mainly about grinding experimental study for different cooling and lubricating conditions with the emphasis laid on studying NMQL conditions. Evaluation parameters like energy proportionality coefficient, specific grinding energy and workpiece surface quality are used to verify simulation results based on experimental results. An experimental program is formulated and the best cooling and lubricating conditions is selected according to experimental results.

6.2 EXPERIMENTAL EQUIPMENT AND MATERIALS

6.2.1 Experimental Equipment

Equipment used in the grinding experiment is shown in Fig. 1, where experimental platform is K-P36 NC surface grinder produced by German Schleifring. Built-in grinding program and grinding wheel dressing program are used in the grinding experiment. Main parameters include: maximum power output by spindle is 4.5 kW, range of spindle speed is 45–4800 r/min, transverse feed speed of workbench is 30–30000 mm/min, longitudinal feed speed of workbench is 4–4000 mm/min and workbench size is 1000×950 mm. Grinding wheel used in the experiment is 80# white corundum ceramic bond grinding wheel, grinding wheel model is WA80MV12P and its dimensions are 300×20×76.2 mm.

Liquid supply forms used in the grinding experiment include flood grinding and MQL as shown in Fig. 1 (a) and Fig. 1 (b). MQL liquid supply device in this experiment is Bluebe MQL liquid supply system produced by Fuji company. An impulse is used to convey grinding fluid, regulate air pressure, control flow quantities of conveyed oil fluid and compressed air and regulating ratio of gas to liquid sprayed from the nozzle for the sake cooling and lubricating. As a general rule, air pressure is set as 4 bar~6.5 bar, compressed air and MQL grinding fluid are sprayed out of nozzle and enter machining area through high-pressure air after being mixed and atomized, and quantity of grinding fluid consumed is 30-100 ml/h per unit width of grinding wheel(HEISEL, LUTZ, WASSMER, & WALTER, 1998).

6.2.2 Experimental Materials

Experimental materials used in the experiment mainly include: workpiece material, water-based grinding fluid, MQL oil and nanoparticles.

(1) Workpiece Material

Workpiece material selected in this experiment is high-temperature nickel base alloy GH4169 and close marks include Inconel718 (US) and NC19FeNb (France). GH4169 nickel base alloy has favorable comprehensive performance within the temperature range of -253–700 °C, it is mainly applied to aerospace, nuclear energy, petroleum industries and extrusion dies, and it belongs to difficult-to-machine material(Niu, Qu, & Li, 2018; Zeng, Qin, Chang, & Luo, 2018). Grinding performance of high-temperature nickel base
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