Chapter 15
Optimization Design of Process Parameters for Different Workpiece Materials in NMQL Grinding With Different Vegetable Oils

ABSTRACT
This research shows with superior lubricating, heat-conducting properties, and proper market price, Al2O3 and MoS2 nanoparticles have broad application prospects as lubricant additives. This work has been researched, and most researches are restricted to using one kind of lubricants to machine specific workpiece or multiple workpieces. There has been no systematic and detailed analysis of grinding performances from cutting mechanisms and debris formation mechanisms of different workpieces. Therefore, analysis of signal to noise ratio (S/N), variance, microstructure, and morphology analysis were used to study the influence of different typical nanofluid lubricants on the grinding performance of different materials in this chapter. Results showed that the optimal grinding parameters are using nodular cast iron and MoS2 nanofluid. Compared with other lubricants, MoS2 nanofluid can exert a significant effect on reducing wear of grinding wheel. In order to reduce surface roughness, MQL lubricating oils of the following sequence can be used: Al2O3 nanofluid, MoS2 nanofluid, and pure palm oil.

15.1 INTRODUCTION
In order to improve machining performance, scholars have conducted many studies on different nanoparticles (Kalita, Malshe, & Rajurkar, 2012; Li, Zhang, Jia, Wang, & Hou, 2015; Mao et al., 2014; Mao, Tang, Zou, Huang, & Zhou, 2012; Mao et al., 2013; B. Shen, Malshe A P, Kalita P, 2008; B. Shen, Shih, & Tung, 2008; Zhang, Li, Jia, & Zhang, 2015; Zhang, Li, Jia, Zhang, & Zhang, 2015a, 2015b). From the previous chapters, it can be seen that, with superior lubricating, heat-conducting properties...
and proper market price, Al₂O₃ and MoS₂ nanoparticles have broad application prospects as lubricant additives (Ali et al., 2016; Dong, Duc, & Long, 2019; Emami, Sadeghi, Sarhan, & Hasani, 2014; Han, 2006; Jamil et al., 2019; Kumar & Patel, 2018; Ping & Gao, 2010; Sen et al., 2019; Wang et al., 2016; Yang et al., 2017; Yin, Li, Dong, et al., 2018; Zhang et al., 2016; Zhang et al., 2017). Meanwhile, for different workpieces: (1) nickel base alloy (Shi, Wang, Xu, Yu, & Sun, 2019), it is extensively applied to aerospace and chemical engineering departments. The grinding of nickel base alloy is accompanied by large cutting force, high cutting temperature and serious hardening phenomenon due to its high strength and large hardness, so it belongs to typical difficult-to-machine material. (2) nodular cast iron (Fernandes et al., 2018), a new-type high-strength cast iron material with low cost, good casting performance, favorable shock absorption and good wear resistance, and it has been successfully used to cast some parts with complicated stress-bearing condition and high requirements for strength, tenacity and wear resistance, e.g. connecting rod and bent axle in auto parts, etc. (3) 45 steel, it is a kind of typical medium carbon steel with low hardness and good plasticity and favorable mechanical properties, and it has been extensively applied to multiple kinds of important structural parts, especially connecting rod, bolt, gear and bearing working under alternating load. Therefore, it’s very necessary to study machining performance of the above materials.

Different nanofluids have obtained different machining performances when applied to MQL grinding of different workpiece materials (Jia, Li, Zhang, Zhang, & Zhang, 2014; Lee et al., 2009; Lee, Kim, & Lee, 2018; Li, Li, Zhang, Wang, Jia, et al., 2017; Li, Li, Zhang, Wang, Yang, Jia, Zhang, & Wu, 2017; Li, Li, Zhang, Wang, Yang, Jia, Zhang, Wu, et al., 2017; Li et al., 2018; Liu et al., 2018; Wang et al., 2017; Zhang & Xu, 2019). Even though so far, this work has been researched frequently, most researches are restricted to using one kind of lubricants to machine specific workpiece or multiple workpieces. In addition, there has been no systematic and detailed analysis of grinding performances from aspects of cutting mechanisms and debris formation mechanisms of different workpieces. Therefore, a fundamental study of the influence of different typical nanofluid lubricants on grinding performances of different workpiece materials will be carried out in this chapter.

15.2 EXPERIMENTAL PART

15.2.1 Experimental Equipment and Grinding Parameters

Equipment used in this experiment are identical with those in Chapter 11, namely K-P36 NC surface grinder, IDM-III99 three-phase grinding dynamometer, surface roughness coarseness profiling instrument, digital viscosimeter and SEM.

Silicon carbide ceramics-bonded grinding wheel is used, and its concrete model is GC80K12V. Performance parameters of grinding wheel are as follows: dimensions: 300 mm × 20 mm × 76.2 mm; granularity: 80 # with medium soft hardness, and the highest linear velocity is 50m/s.

Grinding parameters and grinding wheel dressing parameters used in the experiment are shown in Table 1. In order to realize controlled grinding process and ensure consistency of grinding wheel sharpness in each experiment, grinding wheel was dressed before experiment, where down-grinding condition was adopted on 30×20 mm workpiece surface in each grinding experiment.