Active Control of Boundary Lubrication

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Interfaces of solid contacts in materials processing and machine elements under severe operation conditions are often lubricated by a thin boundary layer rather than a fluid film. In boundary lubrication, chemical properties of both the contacting solid surfaces and the lubricating media play a vital role in friction and wear. Therefore, most of the researches on boundary lubrication focus on effects of materials and tribochemistry, and not so much attention has been paid to the effects of physical means on boundary lubrication. This article presents some research results of boundary lubrication with the aid of two physical fields. The first approach is to apply an ultrasonic mechanical vibration to the die/workpiece interface in copper wire drawing process under different lubrication conditions. The application of the ultrasonic vibration is helpful for the entraining of lubricant into the diamond die/copper wire contact zone due to intermittent separation between the die conical surface and the wire, and thus resulting in better formation of boundary lubricant film, lower drawing fore and less pick-up scars on the wire surface. The second approach is to apply an external electric field to the contacting surfaces so that the electrical potential of the contacting surface can be shifted from the natural potential (or open circuit potential) to a negative or positive potential within the electrochemical potential window. By changing the electrical potential, the polar components included the lubricant could be attracted to or repelled from the solid surface due to the electrostatic interaction between the charged surface and the polar molecules. In this way, the boundary lubrication can be enhanced or weakened. It has been demonstrated by laboratory tests that such active control of boundary lubrication is possible for water or ester based lubricants with polar additives of surfactants or ionic liquids in a wide range of load condition.