A nanofluid for dissipating friction and heat during machining includes a fluidic vehicle and a plurality of lubricious nanoparticles dispersed throughout the fluidic vehicle. A method for reducing material transfer during machining processes includes reducing a temperature of at least a portion of an article to be machined at least one of prior to machining, during machining, or combinations thereof.
HARDNESS vs. TEMPERATURE

COOLING WORKPIECE MOVES IT TO HIGHER HARDNESS AND AWAY FROM DUCTILE REGION

FIG. 1
DISSIPATING FRICTION AND HEAT DURING MACHINING

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application Ser. No. 60/783,758, filed on Mar. 17, 2006.

TECHNICAL FIELD

[0002] The present disclosure relates generally to dissipating friction and heat, and for reducing material transfer during machining processes.

BACKGROUND

[0003] Dry or Minimum Quantity Lubrication (MQL) machining of metal (e.g., aluminum) castings may be sensitive to a variety of factors, including the composition of the lubricant, the casting composition, the drill bit coatings, the drill speed, and/or the like.

[0004] One cause of tool life reduction or tool failure is that the metal material may transfer and adhere to the tool near the cutting edges. As the metal temperature increases at the cutting site, the ductility of the metal may increase until material transfer begins. At this point, the metal may adhere to the tool rather than being evacuated away from the tool. Generally, material transfer results in the premature failure of the drill bit. Material transfer may, in some instances, be more problematic for MQL than for traditional machining, in part, because of the lack of cooling effect from high volumes of coolants.

[0005] It would be desirable to provide a method for machining metal using MQL, while dissipating friction and heat more effectively than is accomplished generally with MQL, and substantially preventing the onset of material transfer.

SUMMARY

[0006] A lubricious nanofluid for use in MQL applications is capable of dissipating friction and heat during machining. The nanofluid includes a fluidic vehicle and a plurality of lubricious nanoparticles dispersed throughout the fluidic vehicle.

[0007] A method for reducing material transfer during machining processes includes reducing a temperature of at least a portion of an article to be machined at least one of prior to machining, during machining, or combinations thereof.

BRIEF DESCRIPTION OF THE DRAWING

[0008] Features and advantages of the present disclosure will become apparent by reference to the following detailed description and drawing.

[0009] FIG. 1 is a graph depicting hardness of an article vs. temperature of the article.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] Embodiments of the nanofluid described herein include lubricious nanoparticles which substantially increase both the lubricity and the heat transfer capabilities of the fluid. Without being bound to any theory, it is believed that the nanofluid described herein effectively dissipates friction and heat, thus making it suitable for metalworking applications. The nanofluid is generally suitable for use in applications using relatively small fluid volumes (such as, for example, MQL or small metal forming applications), and is also capable of substantially reducing the temperature of articles to be machined, thereby substantially preventing the onset of material transfer during such machining processes.

[0011] The nanofluid includes a fluidic vehicle, and a plurality of lubricious nanoparticles dispersed throughout the fluidic vehicle. Non-limiting examples of the fluidic vehicle include mineral oil, vegetable oil, water, synthetic ester formulations, and/or combinations thereof.

[0012] It is to be understood that the selected nanoparticles add lubricity to the nanofluid and substantially increase the heat dissipation properties of the fluid. Generally, the lubricious nanoparticles are substantially soft materials having lubricious (i.e., smooth or slippery) qualities, which are capable of reducing the coefficient of friction between tool and the article (e.g., workpiece). The lubricity of the fluid may be evaluated with a friction test, such as a pin-and-vee block test or a pin-on-disc test. In an embodiment, the lubricious nanoparticles are metallic or carbonaceous. Non-limitative examples of the lubricious nanoparticles include lead, bismuth, indium, tin, alloys thereof, graphite, and/or combinations thereof. Each of the nanoparticles has at least one dimension that is less than 100 nm. Generally, at least one dimension of the respective nanoparticles ranges from about 1 nm to about 100 nm. In an embodiment, the concentration of the nanoparticles in the fluid ranges from about 0.5% to about 20% by mass. It is to be understood that the concentration may be more or less depending, at least in part, on the desirable characteristics of the fluid.

[0013] The fluid may also contain suitable additives. As a non-limiting example, the fluid may contain dispersants, such as sodium dodecyl sulfate, to aid in dispersal of the nanoparticles in the fluid.

[0014] Also disclosed herein is a method for reducing material transfer during machining processes. An embodiment of the method includes reducing the temperature of at least a portion of an article to be machined prior to machining and/or during machining. FIG. 1 is a graph illustrating that as the article is cooled, its hardness increases. It is believed that the increase in hardness advantageously lowers the article's ductility enough to substantially prevent the onset of material transfer. As such, the machining process may be substantially improved when the temperature of all or a portion of the article is reduced.

[0015] In any of the embodiments of the method disclosed herein, the temperature of the workpiece remains below about 350°C for an aluminum machining application. Generally, temperatures above 350°C result in the aluminum becoming gummy and adhering to the article.

[0016] In one embodiment, the temperature of the portion of the article is reduced/cooled locally by directing an embodiment of the nanofluid to that portion of the article as the article is machined. In another embodiment, the temperature of the portion of the article reduced/cooled locally by directing a cryogenic fluid to that portion of the article as
the article is machined. The cryogenic fluid may be a gas (e.g., CO₂), a liquid (e.g., liquid nitrogen), and/or combinations thereof. Directing such fluids to the article may be accomplished via fluid nozzles external to the machined part, such as those that are used for flood coolants.

[0017] In still another embodiment, the temperature of the article/workpiece is reduced both prior to and during machining processes. Generally, reducing the temperature is accomplished by exposing the article to a predetermined cool temperature (e.g., below about 0°C) prior to machining, and during machining. As a non-limitative example, the article may be stored in a cold locker before machining, and the machining process may also take place in the cold.

[0018] In a further embodiment, the temperature of the article is reduced prior to machining by exposing the article to a predetermined cool temperature (e.g., below about 0°C). After the temperature is reduced, the article is removed from the predetermined cool temperature, and is substantially immediately machined. It is to be understood that in this embodiment, machining takes place before the temperature of the article increases.

[0019] While several embodiments have been described in detail, it will be apparent to those skilled in the art that the disclosed embodiments may be modified. Therefore, the foregoing description is to be considered exemplary rather than limiting.

1. A method for reducing material transfer during machining processes, the method comprising reducing a temperature of at least a portion of an article to be machined at least one of prior to machining, during machining, or combinations thereof.

2. The method as defined in claim 1 wherein the temperature is reduced locally by directing a cryogenic fluid to the at least a portion of the article.

3. The method as defined in claim 2 wherein the cryogenic fluid is selected from a gas, a liquid, and combinations thereof.

4. The method as defined in claim 3 wherein the cryogenic gas is carbon dioxide.

5. The method as defined in claim 3 wherein the cryogenic liquid is liquid nitrogen.

6. The method as defined in claim 1 wherein the temperature is reduced both prior to and during machining, and wherein reducing the temperature is accomplished by exposing the article to a predetermined cool temperature prior to and during machining.

7. The method as defined in claim 1 wherein the temperature is reduced prior to machining by exposing the article to a predetermined cool temperature, and wherein the method further comprises:

removing the article from the predetermined cool temperature; and

substantially immediately machining the article after removing the article from the predetermined cool temperature.

8. The method as defined in claim 1 wherein the temperature is reduced by directing a nanofluid to the at least a portion of the article, the nanofluid including a fluidic vehicle and a plurality of lubricious nanoparticles dispersed throughout the vehicle.

9. The method as defined in claim 8 wherein the plurality of lubricious nanoparticles is selected from lead, bismuth, indium, tin, alloys thereof, graphite, and combinations thereof.

10. A nanofluid for dissipating friction and heat, comprising:

a fluidic vehicle; and

a plurality of lubricious nanoparticles dispersed throughout the vehicle.

11. The nanofluid as defined in claim 10 wherein the plurality of lubricious nanoparticles is selected from lead, bismuth, indium, tin, alloys thereof, graphite, and combinations thereof.

12. The nanofluid as defined in claim 10 wherein each of the plurality of lubricious metallic nanoparticles adds at least one of lubricity or heat dispersal qualities to the nanofluid.

13. The nanofluid as defined in claim 10 wherein each of the plurality of lubricious nanoparticles is less than 100 nm in at least one dimension.

14. The nanofluid as defined in claim 10 wherein the fluidic vehicle is selected from mineral oil, vegetable oil, water, synthetic ester formulations, and combinations thereof.

15. A method for reducing material transfer, the method comprising:

machining at least a portion of an article; and

introducing a nanofluid including lubricious nanoparticles dispersed throughout a vehicle to the at least a portion of the article during the machining process.

16. The method as defined in claim 15 wherein the nanofluid reduces a temperature of the at least a portion of the article, lubricates the at least a portion of the article, or combinations thereof.

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