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Experimental Study on Ultrasonic Use in Dry Creep-Feed Up-Grinding of Aluminum 7075 and Steel X210Cr12

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Ultrasonic vibration has shown capability of reducing friction forces in shearing within the material and on the contacting faces of pieces. To decrease the risk of thermal damages in creep-feed grinding, ultrasonic vibration (as a lubricant) was given to Aluminum 7075 and to Steel X210Cr12 workpieces in the direction of feed movement in dry creep-feed up-grinding while using vitrified aluminum oxide wheel. Grinding forces and surface quality are compared. It was found that under ultrasonic, without using coolant, the grinding forces were reduced and surface quality was improved. Under no ultrasonic sever thermal over-cut and burns were observed on steel, whilst there was no sign of such effects on aluminum.

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1. Introduction

Thermal damage of heat produced at the cutting zone is a serious problem in creep-feed grinding. In addition, high grinding force and excessive wheel wear are created when there is a poor heat transfer from the grinding zone.[1] Although application of lubricants and coolants is effective in preventing thermal damage, but their use is limited for health reasons.[2,3] As a result, alternative solutions must be found. One solution is optimizing grinding parameters to decrease thermal damages.[4,5] Although this can be an effective step but for having a substantial cure to this problem other measures must be observed.

Various researches have shown substantial advantages earned from employment of low-amplitude high-frequency vibration (i.e. ultrasonic) with forming and machining processes. Recent studies indicate that proper application of high-power ultrasonic in metal forming processes can reduce internal forming forces (flow stress)[6-11] and external frictional forces at the interface of workpiece and tool.[12,13] Reduction in flow stress has been attributed to acoustic softening and absorption of acoustic energy at dislocations.[6-11] Local thermal softening at contact zone of tool and workpiece by ultrasonic is another possible reason.[8,9] Findings stated that influence of each parameter depends on nature of metal forming process, ultrasonic intensity, and direction of application of ultrasonic.

Decreased frictional force coefficient on contact faces of the tool and workpiece as well as on shearing layers within the machined material along with material softening due to very concentrated local heat generated by ultrasonic at the contact zone of the tool and workpiece, result in easier relative movement of them.[14-16] Some theoretical analyses conclude that ultrasonic employment in grinding reduces the size of the chips and makes fracturing much easier.[17,18]

Mult et al. in 1996[19] reported that ultrasonic gives enormously reduced normal forces in creep-feed grinding of sintered silicon nitride and alumina components. Uhlmann in 1998[20] analyzed the surface characteristics of advanced ceramics in creep-feed grinding with and without ultrasonic using analogy tests of simulation of engagement of single grains with the surface. He found that superimposed ultrasonic leads to altered mechanisms of surface formation as well as wear behavior of the grains. Y. Wu et al. in 2004[17] investigated the effects of employment of ultrasonic in conventional grinding at constant cutting depth on stainless steel plates. His theoretical and empirical investigations indicated that decrease in grinding force is due to formation of smaller chips as well as easier fracturing. Zhang et al. in 2006[21] theoretically showed that by introducing ultrasonic vibration along the grinding wheel axial direction, the cutting trace length is increased and the grinding force is decreased. Tawakoli et al. in 2008[16] investigated ultrasonically assisted dry grinding by experiments. He showed improvement of surface roughness, reduction of grinding forces and thermal damage while ultrasonic was used in grinding of soft material, 100Cr6. Experimental results of Y. Peng et al. in 2010[22] on ultrasonic assisted poly-silicon grinding showed that the grinding forces and surface roughness are much less than those in conventional