REDUCTION OF TOOL WEAR AND INCREASE IN TOOL LIFE BY CRYOGENIC COOLING –A CRITICAL REVIEW

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Abstract:Application of a coolant in a cutting process will increase tool life and and decrease the cuttingtemperatures, The cooling applications in machining operations play s vital role and many operations cannot be carried out effectively without cooling. Application of a coolant in a cutting process will decreases the surface roughness and the amount of power consumed in a metal cutting process and therby improves the overall productivity. In this review, cryogenic cooling was analysed in detail , its effects on cutting tool and workpiece material properties, cutting temperature, tool wear and tool life. cryogenic cooling has been determined as one of the most suitable method for metal cutting operations which increases the tool life ,surface finish and reduces the tool wear and cutting temperatures.

Keywords: Cryogenic cooling.Tool life, Tool wear

1. Cryogenic cooling Methods:

1.1 Indirect cryogenic cooling:

In cryogenic cooling Method, cutting Point is cooled through heat conduction from a Liquid nitrogen chamberplaced at the tool face Evans [1]; cooled the tools byimmersing the tool shank in reservoir of liquid nitrogen and found this system was not suitable for a practical machiningprocess.. Similarly, Wang andRajurkar [2,3] designed a liquid nitrogen circulationsystem on the tool for conductive

Cooling of the cuttingedge. Ahmed et al. [4] modified a tool holder with twodesigns for cryogenic machining. In one of their design, thedischarging gas was directed away from the work piece inorder to maintain ductility of materials. Pouring up of nitrogenbelow the insert and thus keeping the tool insert at lowtemperatures and observed that design is suitable for conductive remote cooling of thecutting edge.The machining performance could be improved byindirect cryogenic cooling method because the cooling isrestricted only to the cutting point, Liquidnitrogen does not contactwith the workpiece and it does not cause changein properties of the workpiece, but the effect of this approach ishighly pendent on thermal conductivity of the cuttingtool material, the distance from the Liquid nitrogen source to thehighest temperature point at the cutting edge and tool point thickness. It could be more effective if a larger area of thetool insert is in contact with Liquid nitrogen [5].

1.2. Cryogenic spraying and jet cooling

The aim of this method is to cool cutting zone,exactly in the tool–chip interface with liquid nitrogen byusing nozzles. in a cryogenic jet cooling method, isapplied with micro-nozzles to the tool rake or the toolflank, where the material is cut and maximum temperatureis formed [6]. In such an liquid nitrogen delivery nozzle system, a flat cutting insert is used with an chip breaker and liquid nitrogen is sprayed through anozzle between the chipbreaker and the rake face of thetool insert. The chipbreaker helps to lift up the chips and liquid nitrogen can reach the tool–chip interface freely In design of Dhar et al. [7,8,9], liquid nitrogen jets were pointed along the rake and flank surfaces, parallel to themain and auxiliary cutting edges . In the design,Venugopal et al. [10] used liquid nitrogenliquid nitrogen jets through a nozzle on theface and flank of the cutting toolThis cryogenic cooling method reduces the toolface temperature, improves its hardness, and reducesits wear rate;This cryogenic machining approach eliminates the BUEproblem on tools because the cold temperature reduces thepossibility of chips welding to the tool and the highpressurecryogenic jet also helps to remove possible BUEformation, therefore it will produce better surface quality[11]. In addition, liquid nitrogen cannot be circulated inside themachine tool like the conventional cooling fluids, as liquid nitrogen isreleased into normal atmospheric pressure and absorbsheat during the cutting process; it quickly evaporates [5].In this method, the nitrogen consumption can be so small,for instance, volumetric liquid nitrogen flow rate was measured as0.625 L/min for rake nozzle, 0.53 L/min for flank nozzleand 0.814 L/min for both rake and flank nozzles [12]. So,this process can improve the productivity and reduce theproduction cost significantly [13].

2. The effect of cryogenic cooling on tool wears and tool life:

Most of the studies examined the flank wear formation since in practice; the amount of flank wear is used more frequently in determining the tool life [14]. In machining of some materials, it was obtained reductions in tool flank wears up to five folds as seen in with cryogenic indirect cooling [15,16].Another study similarly showed that the Al_2O_3 ceramic inserts cooled by indirect cooling method significantly outperformed conventional dry PCBN operations [17]. Wang et al. [18] distinctly employed a hybrid machining method in theirindirect cryogenic system with plasma heating enhancedmachining of Inconel 718 and their results indicated animprovement of 156% in tool life when compared withconventional machining.If a comparison is made between cryogenic cooling approaches, a study indicated that cryogenic tool indirect cooling had got about 13 times wear resistance thancryogenic chip cooling [19, 20].

Conclusion:

The objective of this study is to analyze and point out the effect of cooling on cutting performance in material removal operations. However cryogenic cooling could be attempted more with drilling operations. When compared with conventionalcooling Cryogenic cooling enables substantial improvement in tool life, good surface finish and reduction in tool wear at the cutting zone. Cold temperatures were also used for strengthening of the cutting tools by cryogenic treatment.

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