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P. Lequien, G. Poulachon, J.C. Outeiro, J. Rech

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Hybrid experimental/modelling methodology for identifying the convective heat transfer coefficient in cryogenic assisted machining

P. Lequien¹, G. Poulachon¹, J.C. Outeiro¹, J. Rech²

¹Arts et Metiers, LaBoMaP, 71250 Cluny, UBFC, France

²Univ Lyon, ENISE LTDS, CNRS UMR5513, 58 Rue Jean Parot, 42023 Saint-Etienne cedex 2, France

HIGHLIGHTS

- Investigation of heat transfer coefficient between LN₂ and titanium alloy
 - Influence of LN₂ projection parameters on temperature distribution in the workpiece
 - Determination of h (W/m².K) with temperature measurement and CFD simulations
 - Results highly depends on LN₂ projection parameters (pressure and nozzle diameter)
 - Mathematical development for predicting convective heat transfer coefficient
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ABSTRACT

Cryogenic assisted machining has become a very popular method in the metal cutting industry, as it enables the cooling of a cutting zone for improving surface integrity or/and tool life without contaminating the machined part. However, the thermal interaction between liquid nitrogen (LN₂) and a hot cutting zone remains unclear. The main objective of this work is to analyse the thermal phenomena occurring at the LN₂ jet/workpiece interface. The nitrogen liquid/gas phase proportion has a significant influence on the heat transfer. To determine the influence of LN₂ jet parameters on the convective heat transfer coefficient, a model based on the projection of an LN₂ jet on a workpiece instrumented with thermocouples is proposed. The most influential parameters of the thermal distribution and heat transfer coefficient are LN₂ pressure, nozzle diameter, projection angle and the distance between the nozzle and the workpiece surface.

Keywords:

Liquid nitrogen
Cryogenic machining
Convective heat transfer coefficient
Ti6Al4V

1 INTRODUCTION

The heat generated during machining operations is particularly significant when cutting difficult-to-cut materials such as Ti6Al4V alloy because

of its poor thermal conductivity [1] and its high friction coefficient combined with strong adhesion [2]. Thus, tool wear is accelerated, and the surface integrity becomes deteriorated.

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