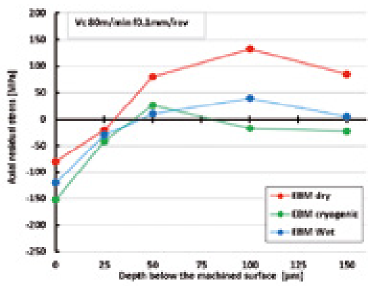
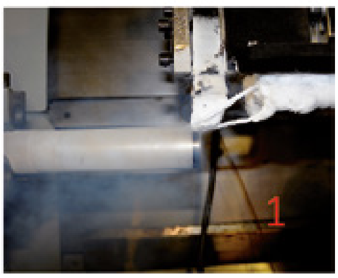
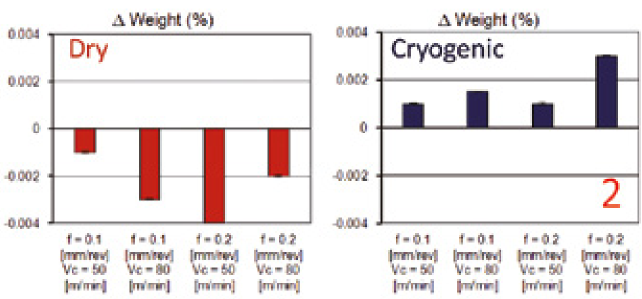
Cryogenic machining for enhancing surface characteristics

Metal cutting operations are traditionally realised applying lubricoolants made by mixing small volumes of synthetic or natural oil with water, to limit high cutting temperatures and forces arising during machining. These emulsions are hazardous for the human body, causing serious skin and breathe health problems due to long exposures of machine operators; furthermore they are environmental contaminants damaging waters and soils if wrongly handled. With regard to the biomedical field, these problems are even amplified because chemical residuals and pollutants left on the machined surgical replacements raise the costs for cleaning and sterilizing operations. On these bases, cryogenic machining appears to be the ideal answer to all these issues, consisting in machining by applying a high pressure, clean and non-toxic cryogenic fluid such as liquid nitrogen to the cutting zone. In this context, the main contribution of this research consists in evaluating the effects of applying liquid nitrogen to machine the biomedical alloy Ti6Al4V produced by Additive Manufacturing techniques, focusing on the induced surface integrity and its applicability in the biomedical industry. Turning tests are performed comparing cryogenic cooling with standard dry and wet cooling strategies. The surface integrity generally improves under cryogenic machining, finding lower values of surface roughness, higher values of surface compressive residual stresses (see Figure 1) and of surface hardness compared to dry cutting. These enhanced surface material properties induce higher wear resistance under loads and chemical conditions typical of the human body. Worn pins machined under cryogenic cooling manifest an increment of the final weight due to a prevalent adhesion wear mechanism, rather than a final weight loss observed on dry machined pins due to a release of metallic particles (see Figure 2), therefore provoking less release of hazardous metal ions that can cause adverse tissue reactions.







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Main research topics:

- Manufacturing systems and processes
- Micro-technologies and precision technologies
- Shaping of metallic materials
- Processing of polymeric materials
- Geometric metrology