Applying Cryogenic Cooling to Challenging Machining Applications

While dry machining—a method of machining parts without the use of coolant cutting fluid—is being investigated and used in some selected machining applications (see Modern Machine Shop’s article on why Machining Dry is Worth a Try), it has not been widely adopted due to its limitations. Much of the interest in dry machining stems from the potential to reduce costs and workplace environmental issues associated with traditional oil-based or synthetic coolants. However, avoiding coolants altogether raises issues of heat dissipation and material deformation that affect quality. To combat this, Air Products and Chemicals, Inc. developed a system known as ICEFLY® that uses liquid nitrogen, a cryogenic (super-cold) version of the atmospheric gas, that likewise eliminates the need for traditional cutting fluids while still offering heat dissipation for both the part and the tools. Liquid nitrogen is so cold, in fact, that the effects on part and tool materials also enable improved cutting performance on difficult-to-machine materials. A partner company of Air Products and Chemicals, Inc., Industrial Cryogenic Technologies (Industrial CryoTech) has licensed this technology, and is selling an ICEFLY system that can be retrofitted to existing machine tools and tool holders.

What are the advantages of cryogenic cooling? Air Products studies have shown significant improvements in machine tool life when cutting with hardened steel tools and hardened powder metal parts, as well as improved machining quality for flexible polymeric materials that often deform due to heat in traditional systems. In exploring potential applications, Industrial CryoTech has identified several high-value benefits:

- Improved tool life and cycle times for hard-to-cut materials such as Titanium, Inconel, and Monel
- Improved stability of polymers, allowing higher-quality cutting and better chip control
- Allowing heavier cuts with improved surface finish, reduced thermal distress, and reduced burring

With respect to polymer materials specifically, ICEFLY may have particular value in biomedical applications, where compatible plastics such as polyether ether ketone (PEEK), are especially vulnerable to deformation and therefore difficult to machine. By maintaining increased hardness and stability throughout the machining process, cryogenic cooling reducing allows for higher quality and greater cost-effectiveness. In addition, avoiding conventional coolants reduces potential contamination, improving the fit for sensitive applications.

Industrial CryoTech has additional case studies available to show how the technology has performed in several machining applications. Cobalt-Chrome (Co-CR), for example, is an exceptionally strong alloy with high wear-resistance that—with traditional flood cooling—usually demands slow material removal rates. Using liquid nitrogen instead of conventional coolant, Industrial CryoTech demonstrated a 6x increase in cutting speed and a 4x increase in material removal rate with good surface finish. In addition, tool life was increased by 50%.

If you think that this technology can have a significant impact in your business, COE-ASM is interested collaborating to evaluate the efficacy of the technology for your application. If you are interested, contact us at SustMfg@sustainability.rit.edu.