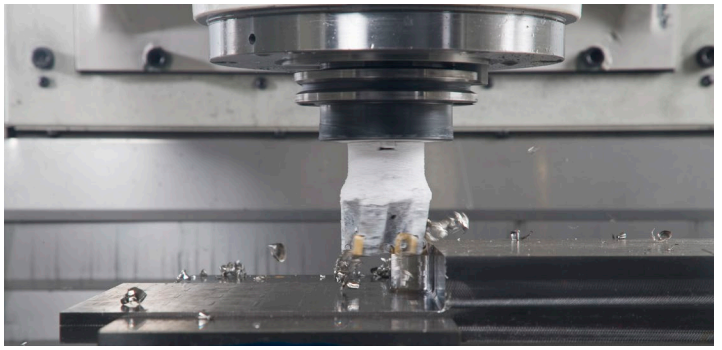
Innovative Technology and Product Development

Cryogenic Machining

A Case Study

Challenge

The aerospace, automotive, and medical device industries are making greater use of titanium because of its high strength and low weight. The removal of heat during the machining of titanium parts is very challenging. Ineffective heat removal limits the achievable cutting speed and quickly wears out cutting tools. Standard liquid flood cooling is inadequate and creates environmental health and safety concerns. These issues result in high production cost for products like military aircraft and prohibit the use of high performance materials in cost-sensitive applications such as automotive parts. A new, more effective method for cooling titanium during the machining process is needed.

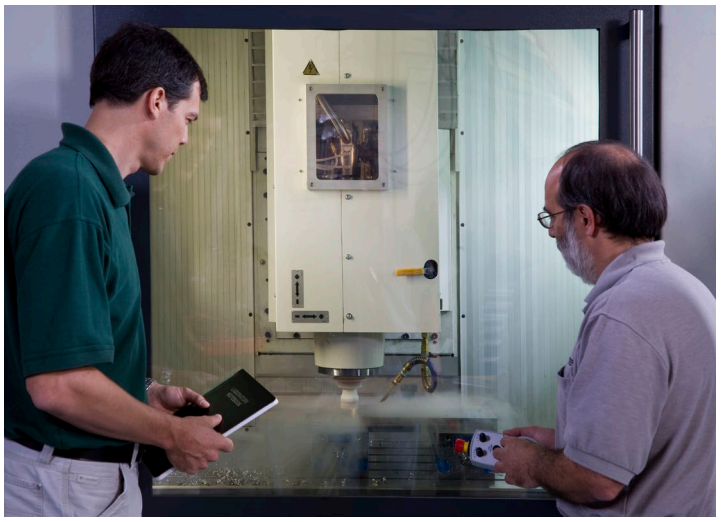


Cryogen-cooled machining of titanium

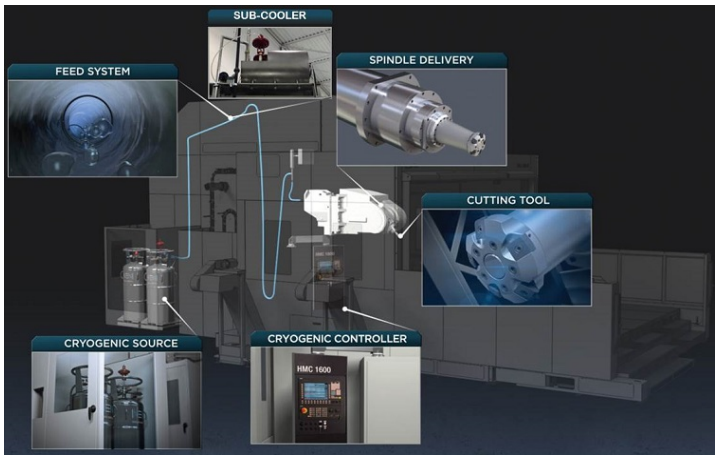
Creare Solution

Under funding from the US EPA, the US Navy, and the US Army, Creare applied its heat transfer expertise, cryogenic knowledge, and experience in machine design to devise a novel cryogenic machining approach. A small quantity of inexpensive liquid nitrogen at -321°F (-200°C) flows through the machine tool spindle and out through the cutting tool. The design delivers cooling close to the cutting edge where the heat is generated. Tests show that the process significantly outperforms standard flood coolant. The performance benefits include increased cutting speeds (2X or more), metal removal rates, and tool life. The by-product of this process is nitrogen gas — an inert, non-greenhouse gas. The thru-tool cryogenic cooling technology provides great cost savings and the potential to use advanced materials more widely.

Creare continued development of this technology with US Air Force funding, and designed a robust, repeatable system that could be implemented into a production environment.



Creare engineers test the cryogenic machining system



5ME's Cryogenic Machining System, using technology licensed from Creare

Cryogenic Machining

Impact

The thru-tool cryogenic machining technology has been licensed to 5ME LLC. 5ME has further developed the cryogenic system and markets it as 5ME® Cryogenic Machining Technology. The system can be used to optimize the performance, sustainability, and part quality of steel, aluminium, and other alloys as well as composite materials.

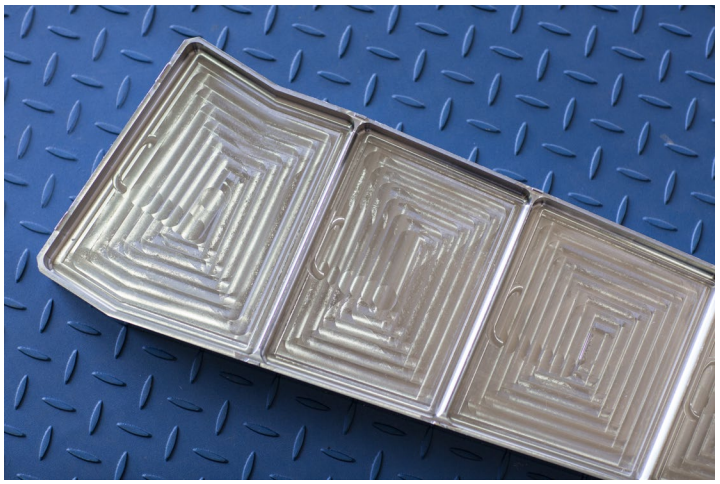
Lockheed Martin is using the cryogenic machining technology to cut titanium parts for the F-35 Joint Strike Fighter, significantly increasing efficiency and lowering costs. Lockheed's Value Engineering team estimates the cost savings/avoidance as over $500 million for the program.

The technology has applications in other fields, such as medical device manufacturing, where the use of conventional cutting fluids poses bio-compatibility concerns.

Working with a prototype cryogenic-enabled machine tool

About Creare

Founded in 1961, Creare LLC is an innovative technology and product development company located in Hanover, New Hampshire. We serve government and industrial clients with engineering R&D services that include analysis, prototype design, fabrication, and testing. Our clients include large and small companies and government agencies in the aerospace, defense, medical, energy, and process industries. Creare means "to create" – we create value for our clients when we solve their most difficult problems. We also help integrate new technologies into their products, systems, and processes.



Lockheed Martin Ti6Al4V structure component. Utilizing 5ME cryogenics, cycle time was reduced by 52% and piece cost reduced by 30% (Image courtesy of 5ME)

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