

# Low-Cost Machining Without Cutting Fluids

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## Environmental Problem

Cutting fluids decrease the temperature of both the cutting tool and the part during the machining process; the coolant fluid is sprayed into the machining zone during cutting, increasing tool life and improving the quality of the parts produced. Cutting fluids, however, are expensive, can be toxic, and produce a significant waste stream. Responsible handling of waste fluid is needed to avoid the contamination of lakes, rivers, and groundwater. Additionally, dermal exposure to these fluids and inhalation of airborne fluid particulates pose health concerns. Because of these drawbacks, there has been a recent shift toward dry cutting, but it is not an ideal solution. Dry cutting increases energy and per part costs and can require a significant upfront investment that is too high for many manufacturers.

## SBIR Technology Solution

With support from EPA's Small Business Innovation Research (SBIR) Program, Creare, Inc. has developed the Indirect Cooling System (ICS), which indirectly cools the cutting tool without the use of cutting fluids. Creare's ICS approach is a low-cost system that prevents the environmental and occupational health problems caused by cutting fluids, and has several advantages over both dry cutting and jet

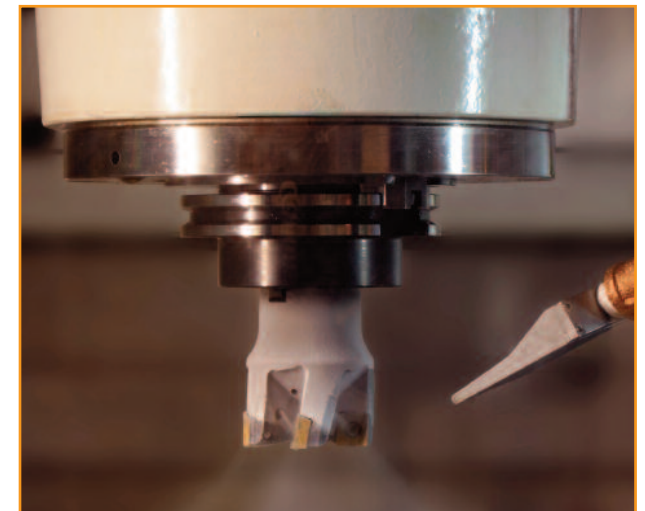
cooling with a synthetic coolant. For turning operations with 416 stainless steel, the ICS approach has resulted in tool life increases of 700 percent at low and 50 percent at high cutting speeds, and decreases part production costs by a minimum of 20 percent while improving final part quality and reduces the environmental cost of the process by a factor of two compared to use of a synthetic coolant.

The ICS cools the cutting tool indirectly using an inert working fluid. This provides several additional environmental and cost benefits, including zero toxic emissions. The system produces only inert gas that can be vented easily into the environment without further treatment, and the gas is produced at a flow rate 250 times lower than with conventional direct cooling. Additional environmental benefits include reduced energy usage, ability to reuse waste materials, and reduced generation of wastewater. ICS for lathe turning offers a low-cost option for cooling because no significant modification of the cutting tool is needed and cutting fluid-associated costs can be eliminated. For turning, Creare's approach uses only 20 liters (L) of working fluid (versus 2,400 L of synthetic coolant required for conventional machining operation) for one machine in constant operation during an 8-hour shift. Additionally, Creare's ICS provides the same clean finished parts produced by dry cutting, but at a lower cost.

The system has been tested on a range of materials both at Creare and offsite. During the lathe turning of a titanium alloy (Ti-6Al-4V), the ICS extended tool life by more than 160 percent, and equaled or bettered the performance of standard coolants on tests of Aluminum 6061. A portable version of the ICS for lathe turning has been developed for use in small machine shops.

## Commercialization Information

Creare received federal non-SBIR funding from the U.S. Army Armament Research and Development Center to support development and onsite testing during Phase II of Creare's project, with the goal of eliminating the use of machining coolants in its Prototype Manufacturing Center. After the conclusion of the work with EPA and the U.S. Army, Creare received a U.S. Navy SBIR award related to the integration of their ICS approach with milling operations in 2004. For that program, Creare was teamed with Bell Helicopter-Textron to improve processing speed and tool life for the milling of titanium alloys for the V-22 aircraft. After the completion of the Navy Phase II project, the company received Phase III



The Creare ICS Integrated With a Plunge Milling Operation. Using this technology, substantial increases in the material removal rate for Ti-6Al-4V and other materials have been demonstrated for lathe turning, end milling, and plunge milling.



funding from the F-35 program, with the assistance of Lockheed Martin Aeronautics, for technology transition. The transition effort is focused on the complete integration and demonstration of Creare's ICS approach on a production milling machine. Based on Creare's approach, significant cost savings can be achieved for titanium machining on the Joint Strike Fighter Program, enhancing the affordability of the aircraft. Based on its strong intellectual property position developed through this Navy SBIR project, Creare has signed a licensing agreement with MAG Industrial Automation System, (IAS), the world's largest U.S.-based machine tool company. MAG IAS is the global leader in metal cutting machine tools and automated composites equipment for the aerospace industry.

### Company History and Awards

Creare, Inc. is an engineering research and development firm located in Hanover, New Hampshire. Founded in 1961 to allow innovative engineers the freedom to expand the boundaries of their engineering disciplines, Creare continues this tradition of innovation and exploration today. Its founding objectives include performing technically excellent work, focusing on results, providing an optimum environment for creative people, and commercializing innovations by the creation of autonomous product companies or licensing technology to existing organizations. Members of the senior management team are recognized leaders in their fields, and current areas of research and development are at the cutting edge of technological and scientific development.

Creare has been highly successful in the commercialization of SBIR-developed technology. Creare has commercialized SBIR technology internally via sales of custom or specialized hardware and software and engineering services contracts as well as externally through the creation of spin-off organizations and licensing of technology to third parties. To date, the firm can trace more than \$670 million of revenues at Creare, the

firm's spin-offs, and technology licensees to commercialization of Creare SBIR projects. In the last 12 years, Creare has averaged about 40% of total revenues from Phase III commercialization activities related to past SBIR projects. These activities were primarily in the form of contract development, fabrication, and testing of specialized hardware and software.

## SBIR Impact

- Cutting fluids used during the machining process pose risks to the environment and human health.
- Creare, Inc. has created the Indirect Cooling System (ICS), which is a low-cost system that indirectly cools the cutting tool without the use of cutting fluids. ICS increases tool life by up to 700 percent and decreases part production costs while improving final part quality.
- Creare's ICS prevents the environmental and occupational health problems caused by conventional cutting fluids and reduces the cost of the process compared to both dry cutting and jet cooling with a synthetic coolant.
- Creare has developed its ICS for lathe turning (EPA, Army) and milling (Navy) and has commercialized its approach by licensing the technology to MAG IAS, a world leader in machine tool, automation, and composites manufacturing systems.

