



Waterjet Cutting

UNDER PRESSURE

By Lynn Stanley



How water pump technology powers waterjet line for demilitarization of high-explosive munitions

October 2012 - Disposal of excess, obsolete and unserviceable military ammunition and explosives continues to prove challenging for the Department of Defense. The last few decades have seen the DoD move away from sea disposal, open burn and detonation techniques. To help the U.S. Army tackle its growing stockpile of surplus ordnance, Paul Miller, a former explosives engineer for Honeywell Defense Systems and director of advanced technologies systems for Gradient Technology, Elk River, Minn., worked with KMT Waterjet Systems Inc., Baxter Springs, Kan., to test his concept for an automated abrasive waterjet demilitarization system. Miller studied explosive chemistry and shaped charge weapon mechanics but says he was inspired by NASA's research on raindrop impact erosion of metals. Miller's performance data and choice of a KMT waterjet pump to power the system also was verified by an independent DoD-funded study conducted by the Missouri University of Science and Technology, Rolla, Mo.

"Very few tools can cut hazardous materials without running the risk of ignition," Miller says. Low water pressure made early waterjet applications inefficient. The high-volume equipment consumed large amounts of water and required open settling ponds, a potential environmental risk. The introduction of high-pressure waterjets with pumps capable of higher psi and significantly lower water usage helped to pave the way for Gradient Technology's innovative approach. The engineering company participates in a wide variety of commercial, petrochemical and government projects including synthetic fuel production, autothermal hydrogen generation, munitions demilitarization and chemical conversion of explosive materials.

Cutting solution

"I was in Germany in 1990 on business talking with a group of German engineers about what they were going to do with the Soviet ammunition abandoned during the 1989 pullout of East Germany by the Russian Army," Miller recalls. "I thought, 'How do you safely remove explosives out of high-explosive shells?' I was familiar with the research on raindrop impact on aircraft. I knew that liquid impact mechanics could be modeled in much the same way as a shape charge. To anchor the system I needed a high-pressure pump, so I looked through Thomas Register and found that

KMT already had a pre-engineered pump." KMT Waterjet, which formerly was an Ingersoll-Rand company, is a global manufacturer of ultra-high pressure waterjet pumps, cutting nozzles and waterjet components.

In addition to the pump, Miller sourced other components for the system that was set up and tested at KMT in 1991. By 1992, Miller had cut more than 170,000 projectiles using the waterjet system and published the results with the DoD Explosives Safety Board.

"We ran impact and cutting tests on live explosives at KMT to see how far we could go before detonating a projectile," Miller says. "We were able to test up to 147,000 psi without incident, demonstrating that the waterjet process is completely safe on a variety of explosives. Our operation became the first commercial high-pressure demilitarization system." In this context, high pressure means anything above 40,000 psi.

"The water pump was a critical element to the line's successful operation," adds Miller. "The KMT pump's dependability was essential. The pump produces the water pressure. Without water pressure you can't cut. If you are cutting a round [explosive projectile] you have to be able to rely on the pump and have confidence it won't quit halfway through the process."

KMT's high-pressure pumps are equipped with an accumulator, also known as a pressure peak compensator, that ensures the high pressure signal at the pump's outlet remains constant during the change of direction of the hydraulic piston. "Minimizing pressure pulsations from the pump is very important," Miller says.

Proving performance

In 2000, Gradient Technology won the rights in open competition to design, manufacture and install a high-speed projectile accessing system for the U.S. Army. The recently upgraded system consists of two 200 hp KMT pumps and one 100 hp KMT pump that simultaneously power four 55,000 psi abrasive waterjet cutting units and four high pressure washout stations. The automated system provides a nontraditional tool for the safe and environmentally friendly demilitarization of high-explosive munitions.

The KMT pump also was exposed to scrutiny during testing conducted by David Summers, Ph.D, and Greg Galecki, Ph.D, at the Missouri University of Science and Technology. Summers is a curators' professor of mining engineering and was then director of the university's Rock Mechanics and Explosives Research Center.

"When I came to the U.S. in 1968, we were looking for safer and faster methods for drilling coal and rock in mining applications," Summers says. "There were virtually no manufacturers using waterjet technology at that time. We began working with KMT in 1972 and got our first KMT pump in the early 1980s to explore different applications. There was quite a bit of crossover between mining applications and machine tool-type interactions for cutting different

types of metal. We began to look at using waterjets on machine tools because of the ability to keep them cooler during processing.”

Summers’ research includes developing waterjet-driven methods for mining coal, drilling rock and removing a variety of military-related energetic materials from different surfaces and containers. Between 1986 and 2006, DoD-funded work performed by Summers for the U.S. Navy established and independently duplicated the results of tests performed by Gradient Technology and KMT. “The question was raised, ‘If you have a bomb that’s been lying there 40 years, how do you cut into that casing without setting the bomb off?’” says Summers. “We were the first to demonstrate an abrasive waterjet’s capability to cut through live detonators and explosives. We also were asked to define pressures at which the explosives would react by testing U.S. and Russian explosives at different impact pressures of up to 10 million psi. Additionally, Greg and I evaluated each water pump, cutting head and waterjet nozzle on the market to determine the best components to build an optimal system. The resulting system we supplied to DoD was made up of the KMT pump and components.”

Reclamation and recycling

“Because the waterjet head’s efficiencies are continually being improved, acceptance of the waterjet for through and through cutting is growing,” says Skip Reynolds, manager of emerging technologies for KMT. “Dr. Summers’ tests revealed that our abrasive autoline cutting head also is the fastest and most economical. Another contributing factor to greater economies for the customer is the pump’s design and function. Our largest pump, the largest in the industry, is 200 hp. One of the biggest leaps in development has been the Streamline series 90,000 psi machine. This capability really advanced the ball because customers can cut so much faster.”

Through Gradient Technology’s public-private partnership with the U.S. Army, the company runs and maintains its waterjet system at the Army’s facility in the Midwest. In addition to operating the line, Gradient Technology has equipped a mobile unit that can perform clean-up work at military facilities. The company also has invested capital into building a chemical conversion system that recycles explosives removed from munitions into fertilizer for the local farmers’ co-op and produces a commodity chemical for making brown leather dyes.

At the Army facility, KMT pumps are positioned 135 ft. from the waterjet system. Gradient Technology operates the system from a booth. “A lot of manufacturers can make pumps that generate water pressure,” Miller says. “We needed a waterjet pump that could deliver 20 hours a day, five days a week, 52 weeks out of the year. The pumps are designed to allow us to tie into them from our computers so we don’t have to send a guy out to check on them.”

Cost savings

The system can process two large projectiles per pallet on two stations at a time. Smaller projectiles are processed four per pallet. Larger projectiles are processed one per pallet.

Projectiles are moved from an infeed conveyor onto the two cutting locations. One of four high-pressure abrasive waterjet units cuts through the projectile's base and removes its fuzes. The projectiles are then moved onto two 55,000 psi washout stations to remove the explosive filler before being transferred to the system's outfeed conveyor. Processing and collection takes place in a stainless steel containment booth behind concrete blast walls for safety. Explosive materials are moved to Gradient Technology's chemical conversion plant for recycling. "We try to recycle as close to 100 percent of all metals and chemical materials as possible," says Miller.

For the 105-lb. U.S. Navy 6-in./47-caliber HC explosive projectiles, Miller says Gradient Technology is able to use the waterjet to cut through 2-in.-thick steel without initiating the base fuze or high explosive. "Navy projectiles can have up to three fuzes in them, unlike the single-fuze Army projectiles," he says. "The abrasive waterjet system does the job safely and reliably. We chose the KMT pump for its reliability, along with ease of maintenance. We're running nearly around the clock, so we can't afford to have the system shut down. In a 10-hour shift, one person is moving up to 38,000 lbs. of steel."

On-site waterjet cutting permits demilitarization of munitions at a fraction of the cost of alternative methods and is expected to be more widely adopted. Gradient Technology's next steps include using the waterjet technology for underwater demilitarization and reclamation.

"KMT has been a great vendor to work with," says Miller. "They've contributed their expertise to the development of this technology and continue to help us identify ways to use the system more efficiently, more cost-effectively and faster. The pumps are the best value for the money and that fact has only been reinforced over time."